Advances in Intelligent Systems and Computing 444

Álvaro Rocha
Ana Maria Correia
Hojjat Adeli
Luis Paulo Reis
Marcelo Mendonça Teixeira *Editors*

New Advances in Information Systems and Technologies

Volume 1

Springer

Advances in Intelligent Systems and Computing

Volume 444

Series editor

Janusz Kacprzyk, Polish Academy of Sciences, Warsaw, Poland
e-mail: kacprzyk@ibspan.waw.pl

About this Series

The series "Advances in Intelligent Systems and Computing" contains publications on theory, applications, and design methods of Intelligent Systems and Intelligent Computing. Virtually all disciplines such as engineering, natural sciences, computer and information science, ICT, economics, business, e-commerce, environment, healthcare, life science are covered. The list of topics spans all the areas of modern intelligent systems and computing.

The publications within "Advances in Intelligent Systems and Computing" are primarily textbooks and proceedings of important conferences, symposia and congresses. They cover significant recent developments in the field, both of a foundational and applicable character. An important characteristic feature of the series is the short publication time and world-wide distribution. This permits a rapid and broad dissemination of research results.

Advisory Board

More information about this series at http://www.springer.com/series/11156

Álvaro Rocha · Ana Maria Correia
Hojjat Adeli · Luis Paulo Reis
Marcelo Mendonça Teixeira
Editors

New Advances in Information Systems and Technologies

Volume 1

Springer

Editors
Álvaro Rocha
DEI/FCT
Universidade de Coimbra
Coimbra
Portugal

Luis Paulo Reis
DSI
Universidade do Minho
Guimarães
Portugal

Ana Maria Correia
ISEGI
Universidade Nova de Lisboa
Lisbon
Portugal

Marcelo Mendonça Teixeira
Universidade Federal Rural de Pernambuco
Recife
Brazil

Hojjat Adeli
College of Engineering
The Ohio State University
Columbus, OH
USA

ISSN 2194-5357 ISSN 2194-5365 (electronic)
Advances in Intelligent Systems and Computing
ISBN 978-3-319-31231-6 ISBN 978-3-319-31232-3 (eBook)
DOI 10.1007/978-3-319-31232-3

Library of Congress Control Number: 2016934044

Printed on acid-free paper

This Springer imprint is published by Springer Nature
The registered company is Springer International Publishing AG Switzerland

Preface

This book contains a selection of papers accepted for presentation and discussion at The 2016 World Conference on Information Systems and Technologies (WorldCIST'16). This Conference had the support of the Federal Rural University of Pernambuco, IEEE Systems, Man, and Cybernetics Society, AISTI (Iberian Association for Information Systems and Technologies/Associação Ibérica de Sistemas e Tecnologias de Informação), and GIIM (Global Institute for IT Management). It took place at Recife, Pernambuco, Brazil, March 22–24, 2016.

The World Conference on Information Systems and Technologies (WorldCIST) is a global forum for researchers and practitioners to present and discuss recent results and innovations, current trends, professional experiences, and challenges of modern Information Systems and Technologies research, technological development and applications. One of its main aims is to strengthen the drive toward a holistic symbiosis between academy, society, and industry. WorldCIST'16 built on the successes of WorldCIST'13, held at Olhão, Algarve, Portugal, WorldCIST'14 held at Funchal, Madeira, Portugal, and WorldCIST'15 which took place at São Miguel, Azores, Portugal.

The Program Committee of WorldCIST'16 was composed of a multidisciplinary group of experts and those who are intimately concerned with Information Systems and Technologies. They have had the responsibility for evaluating, in a 'blind review' process, the papers received for each of the main themes proposed for the Conference: (A) Information and Knowledge Management; (B) Organizational Models and Information Systems; (C) Software and Systems Modeling; (D) Software Systems, Architectures, Applications and Tools; (E) Multimedia Systems and Applications; (F) Computer Networks, Mobility and Pervasive Systems; (G) Intelligent and Decision Support Systems; (H) Big Data Analytics and Applications; (I) Human–Computer Interaction; (J) Health Informatics; (K) Information Technologies in Education; (L) Information Technologies in Radiocommunications.

WorldCIST'16 also included workshop sessions taking place in parallel with the conference ones. Workshop sessions covered themes such as (i) Communication

and Journalism in Online Social Networks, (ii) Computer Supported Qualitative Analysis, (iii) Emerging Trends and Challenges in Business Process Management, (iv) Healthcare Information Systems Interoperability, Security and Efficiency, (v) Human–Machine Interfaces in Automation, Robotics and Mechanics, (vi) Innovation in Information Management, (vii) Intelligent Systems, (viii) Internet, Business and Social Networks, Pervasive Information Systems, (ix) Semantics for Humanities Resources.

WorldCIST'16 received contributions from 41 countries around the world. The papers accepted for presentation and discussion at the Conference are published by Springer (this book) and by AISTI (another e-book) and will be submitted for indexing by ISI, EI-Compendex, SCOPUS, DBLP and/or Scholar Google, among others. Extended versions of selected best papers will be published in relevant journals, including SCI/SSCI and Scopus indexed journals.

We acknowledge all those who contributed to the staging of WorldCIST16 (authors, committees, and sponsors); their involvement and support is very much appreciated.

Pernambuco
March 2016

Álvaro Rocha
Ana Maria Correia
Hojjat Adeli
Luís Paulo Reis
Marcelo Mendonça Teixeira

Organization

Conference

General Chairs
Álvaro Rocha, University of Coimbra, PT
Ana Maria Correia, University of Sheffield, UK
Hojjat Adeli, The Ohio State University, US
Luis Paulo Reis, University of Minho, PT

Local Chairs
Marcelo Mendonça Teixeira, Federal Rural University of Pernambuco, BR
Ivaldir H. de Farias Júnior, Federal Rural University of Pernambuco, BR
Tiago Alessandro E. Ferreira, Federal Rural University of Pernambuco, BR

Advisory Committee
Alessandra Russo, Imperial College, London, UK
Chris Kimble, KEDGE Business School and MRM, UM2, Montpellier, FR
Cihan Cobanoglu, University of South Florida Sarasota-Manatee, US
Constantine Stephanidis, University of Crete, GR
Eva Onaindia, Polythecnic University of Valencia, ES
Frada Burstein, Monash University, AU
Florin Gheorghe FILIP, Romanian Academy, RO
Gerry Stahl, Drexel University, US
Janusz Kacprzyk, Polish Academy of Sciences, PL
Jeroen van den Hoven, Delft University of Technology, NL
João Tavares, University of Porto, PT
Karl Stroetmann, Empirica Communication and Technology Research, DE
Ladislav Hluchý, Slovak Academy of Sciences, SK
Robert Kauffman, Singapore Management University, SG
Sandra Costanzo, University of Calabria, IT
Shi-Kuo Chang, University of Pittsburgh, US

Program Committee

Adnan Amin, Institute of Management Sciences Peshawar, PK
Adrian Florea, 'Lucian Blaga' University of Sibiu, RO
Adriana Fernandes, ISCTE-IUL, PT
Ahmad Bakhtiyari Shahri, IR
Ahmed El Oualkadi, Abdelmalek Essaadi University, MA
Alberto Freitas, University of Porto, PT
Alexandra Martínez, University of Costa Rica
Ana Paiva, University of Porto, PT
Anabela Tereso, University of Minho, PT
Anacleto Correia, CINAV-EN, PT
André Fabiano de Moraes, Federal Institute Catarinense, BR
André Marcos Silva, UNASP, BR
António Abelha, University of Minho, PT
António Gonçalves, Polythecnic Institute of Setúbal
Antonio Jiménez-Martín, Technical University of Madrid, ES
Armando Mendes, University of the Azores, PT
Arun Sundararaman, Accenture, IN
Avireni Srinivasulu, V.F.S.T.R. University (Vignan's University), IN
Babak Darvish Rouhani, Payame Noor University, IR
Benedita Malheiro, Polytechnic Institute of Porto, PT
Bernard Grabot, ENIT, FR
Bin Zhou, University of Maryland, Baltimore County, US
Carla Pinto, Polytechnic Institute of Porto, PT
Carlos J. Costa, ISCTE-IUL, PT
Cédric Gaspoz, University of Applied Sciences Western Switzerland, CH
Cristian García Bauza, PLADEMA—UNCPBA—CONICET, AR
Christos Bouras, University of Patras, GR
Ciro Martins, University of Aveiro, PT
Conceição Tavares, University of Minho, PT
Cristian Mateos, ISISTAN-CONICET, AR
Cristina Alcaraz, University of Malaga, ES
Daniel Castro Silva, University of Porto, PT
David Cortés-Polo, Fundación COMPUTAEX, ES
Dirk Thorleuchter, Fraunhofer INT, DE
Dohoon Lee, Pusan National University, KR
Donald Davendra, VŠB-Technical University of Ostrava, CZ
Dorgival Netto, Federal University of Pernambuco, BR
Dusan Petkovic, Faculty of Computer Science, Rosenheim, DE
Zahoor Jan, Islamia College University Peshawar, PK
Dumitru Dan Burdescu, University of Craiova, RO
Edna Dias Canedo, University of Brasilia, BR
Eduardo Santos, Pontifical Catholic University of Parana, BR
Eriks Sneiders, Stockholm University, SE
Evandro Costa, Federal University of Alagoas, BR

F.G. Filip, The Roumanian Academy of Sciences, RO
Fabrizio Montezi, University of Southern Denmark, DK
Farhan Siddiqui, Walden University, US
Fernando Bobillo, University of Zaragoza, ES
Fernando Moreira, University Portucalense, PT
Fernando Ribeiro, Polytechnic Institute of Castelo Branco, PT
Filipe Portela, University of Minho, PT
Fionn Murtagh, University of London, UK
Francesco Bianconi, Università degli Studi di Perugia, IT
Francisco Ortin, University of Oviedo, ES
Frederico Branco, University of Trás-os-Montes e Alto Douro, PT
Fu-Chien Kao, Da-Yeh University, TW
Gamini Perhakaran, Universiti Tenaga Nasional, MY
George Suciu, University Politehnica of Bucharest, RO
Gonçalo Paiva Dias, University of Aveiro, PT
Goreti Marreiros, Polytechnic Institute of Porto, PT
Habiba Drias, LRIA/USTHB, DZ
Hanlie Smuts, MTN, ZA
Hartwig Hochmair, University of Florida, US
Hector Fernando Gomez Alvarado, Technical University of Loja, EC
Hélia Guerra, University of the Azores, PT
Hemilis Joyse Barbosa Rocha, Federal Institute of Alagoas, BR
Herlina Jayadianti, UPN "Veteran" Yogyakarta, ID
Hernani Costa, University of Malaga, ES
Hing Kai Chan, University of Nottingham Ningbo China, CN
Igor Aguilar Alonso, Technical University of Madrid, ES
Inés María González Vida, Federal University of Alagoas, BR
Isabel Lopes, Polytechnic Institute of Bragança, PT
Isabel Pedrosa, Polytechnic Institute of Coimbra, PT
Ivan Luković, University of Novi Sad, RS
Jason Ding, Hewlett Packard Enterprise, US
João Carlos Silva, Polytechnic Institute of Cávado e Ave, PT
João Paulo Pereira, Polytechnic Institute of Bragança, PT
Joao Tavares, University of Porto, PT
Jorge Esparteiro Garcia, Polytechnic Institute of Viana do Castelo, PT
Jorge Gomes, University of Lisboa, PT
Jorge da Silva Correia-Neto, Federal Rural University of Pernambuco, BR
José Braga de Vasconcelos, Universidade Atlântica, PT
Jose C. Valverde, University of Castilla-La Mancha, ES
José João Almeida, University of Minho, PT
Jose Luis Garrido, University of Granada, ES
José Luis Herrero Agustin, University of Extremadura, ES
José Luís Pereira, University of Minho, PT
José Luís Reis, ISMAI, PT
José Machado, University of Minho, PT

José Martins, University of Trás-os-Montes e Alto Douro, PT
José Neves, University of Minho, PT
Kevin Ho, University of Guam, GU
Khalid Benali, LORIA—Université de Lorraine, FR
Kuan Yew Wong, Universiti Teknologi Malaysia, MY
Laura Alcaide Muñoz, University of Granada, ES
Lea Skorin-Kapov, University of Zagreb, HR
Leonardo Botega, UNIVEM, BR
Linchuan Chen, Google Inc., US
Luis Mendes Gomes, University of the Azores, Portugal
Marius Cioca, "Lucian Blaga" University of Sibiu, RO
Manuel Mazzara, Innopolis University, RU
Manuel Perez-Cota, University of Vigo, ES
Manuel Silva, Polytechnic Institute of Porto, PT
Maria José Sousa, BRU-ISCTE/IUL, PT
Maria Lee, Shih Chien University, TW
Mário Antunes, Polytechnic Institute of Leiria, PT
Martin Henel, Stockholm University, SE
Martín López Nores, University of Vigo, ES
Martin Zelm, INTEROP-VLab, BE
Matthias Galster, University of Canterbury, NZ
Mijalche Santa, Ss Cyril and Methodius University, MK
Mircea Georgescu, "Al. I. Cuza" University of Lasi, RO
Miroslav Bures, Czech Technical University in Prague, CZ
Mohammed Serrhini, University of Mohammed First Oujda, MA
Mounir Kehal, American University in the Emirates, AE
Mu-Song Chen, Da-Yeh University, TW
Noemi Emanuela Cazzaniga, Politecnico di Milano, IT
Nuno Melão, Polytechnic Institute of Viseu, PT
Panos Balatsoukas, University of Manchester, UK
Paula A. Rego, Polytechnic Institute of Viana do Castelo, PT
Paulo Maio, Polytechnic Institute of Porto, PT
Paulo Novais, University of Minho, PT
Patricia Zachman, National University of the Chaco Austral, AR
Paweł Karczmarek, The John Paul II Catholic University of Lublin, PL
Pedro Henriques Abreu, University of Coimbra, PT
Pedro Sousa, University of Minho, PT
Phoey Lee Teh, Sunway University, MY
Radouane Yafia, Ibn Zohr University, MA
Radu-Emil Precup, Politehnica University of Timisoara, RO
Rahim Rahmani, University of Stockholm, SE
Ramayah T., Universiti Sains Malaysia, MY
Ramiro Gonçalves, University of Trás-os-Montes e Alto Douro, PT
Raul M.S. Laureano, ISCTE-IUL, Portugal
Riccardo Cognini, e-Lios, IT

Roberto Montemanni, University of Applied Sciences of Southern Switzerland, CH
Roman Popp, TU Wien, AT
Ruben Gonzalez, International University of La Rioja, ES
Rui Jose, University of Minho, PT
Rui Pitarma, Polytechnic Institute of Guarda, PT
Rui S. Moreira, University Fernando Pessoa, PT
Sajid Anwar, Institute of Management Sciences Peshawar Pakistan, PK
Salama Mostafa, Universiti Tenaga Nasional, MY
Salim Bitam, University of Biskra, DZ
Sandra Costanzo, University of Calabria, IT
Sarvjit Singh, Panjab University, IN
Sathish Kumar, Coastal Carolina University, US
Sergio Albiol-Pérez, University of Zaragoza, ES
Shaowu Cheng, Harbin Institute of Technology, CN
Slawomir Zolkiewski, Silesian University of Technology, PL
Sugam Sharma, Iowa State University, US
Tzung-Pei Hong, National University of Kaohsiung, TW
Victor Alves, University of Minho, PT
Vitalyi Igorevich Talanin, Zaporozhye Institute of Economics and Information Technologies, UA
Wolf Zimmermann, Martin Luther University Halle-Wittenberg, DE
Yair Wiseman, Bar-Ilan University, IL
Yuhua Li, University of Salford, UK
Yuwei Lin, University for the Creative Arts, UK
Yves Rybarczyk, University Nova de Lisboa, PT

Workshops

Communication and Journalism in Online Social Networks—CJOSN Organizing Committee
Andrea Valencia, University of Santiago of Compostela, Spain
Francisco Campos Freire, University of Santiago of Compostela, Spain

Program Committee
Ana Isabel Rodríguez Vázquez, University of Santiago of Compostela, Spain
Ana López Cepeda, University of Castilla-La Mancha, Spain
Eva Amboaxe, University of A Coruña, Spain
Ivan Puentes Rivera, University of Vigo, Spain
Jenny Yaguache, Technical University of Loja, Equator
Nancy Ulloa Erazo, Pontifical Catholic University of Ibarra, Equator
Óscar Juanatey, University of A Coruña, Spain
Sabela Direito Rebollal, University of Santiago of Compostela, Spain
Valentín Alejandro Martínez Fernández, University of A Coruña, Spain

Xosé Antón Vila Sobrino, University of Vigo, Spain
Xosé López García, University of Santiago of Compostela, Spain
Xosé Rúas Araujo, University of Vigo, Spain

Computer Supported Qualitative Analysis—CSQA
Organizing Committee
António Pedro Costa, University of Aveiro, Portugal
Francislê Neri de Souza, University of Aveiro, Portugal
Luís Paulo Reis, University of Minho, Portugal

Program Committee
António Moreira, University of Aveiro, Portugal
Brígida Mónica Faria, Polytechnic Institute of Porto, ESTSP-IPP, Portugal
Catarina do Vale Brandão, University of Porto, Portugal
Celina Leão, University of Minho, Portugal
César Cisneros Puebla, University of Metropolitan Autonomous, Mexico
David Lamas, Universidade of Tallinn, Estonia
Dayse Neri de Souza, Universidade de Aveiro, Portugal
Deise Juliana, Federal University of Alagoas, Brazil
Jaime Ribeiro, Polytechnic Institute of Leiria, Portugal
Pericles Loucopoulos, University of Manchester, UK

Emerging Trends and Challenges in Business Process Management—ETCBPM
Organizing Committee
Rui Dinis Sousa, University of Minho, Portugal
José Luis Pereira, University of Minho, Portugal
Pascal Ravesteijn, HU University, Netherlands

Program Committee
Ana Almeida, School of Engineering—Polytechnic of Porto, Portugal
Armin Stein, University of Muenster, Germany
Barry Derksen, NOVI University of Applied Sciences, Netherlands
Daniel Chen, Texas Christian University, USA
Daniel Pacheco Lacerda, UNISINOS University, Brazil
Edward van Dipten, NOVI University of Applied Sciences, Netherlands
Elsa Cardoso, ISCTE Business School, Portugal
Fernando Belfo, ISCAC Coimbra Business School, Portugal
João Varajão, University of Minho, Portugal
Jorge Coelho, University of Minho, Portugal
Jorge Oliveira Sá, University of Minho, Portugal
José Camacho, NOVA Information Management School, Portugal
Luis Miguel Ferreira, University of Aveiro, Portugal
Marie-Claude Boudreau, University of Georgia, USA
Manoel Veras, Federal University of Rio Grande do Norte, Brazil
Marcello La Rosa, Queensland University of Technology, Australia

Marlon Dumas, University of Tartu, Estonia
Pedro Malta, Lusófona University, Portugal
Rafael Paim, Federal Center for Technical Education (Cefet-RJ), Brazil
Ramiro Gonçalves, University of Trás-os-Montes e Alto Douro, Portugal
Raffaele Conforti, Queensland University of Technology, Australia
Renato Flórido Cameira, Federal University of Rio de Janeiro, Brazil
Sílvia Inês Dallavalle de Pádua, University of São Paulo, Brazil

Healthcare Information Systems Interoperability, Security and Efficiency—HISISE
Organizing Committee
José Machado, University of Minho, Portugal
António Abelha, University of Minho, Portugal

Program Committee
Anastasius Mooumtzoglou, European Society for Quality in Health-Care, Greece
Ana Azevedo, Polythecnic Institute of Oporto, Portugal
Brígida Mónica Faria, Polythecnic Institute of Oporto, Portugal
Costin Badica, University of Craiova, Romania
Daniel Castro Silva, University of Oporto, Portugal
Filipe Portela, University of Minho, Portugal
Hasmik Osipyan, Université de Genève, Switzerland
Joaquim Gonçalves, Polytechnic Institute of Cavado e Ave, Portugal
José Neves, University of Minho, Portugal
Juliana Zinaider, INF UFG, Brazil
Júlio Duarte, University of Minho, Portugal
Helia Guerra, University of Açores, Portugal
Henrique Vicente, University of Évora, Portugal
Luís Mendes Gomes, University of Açores, Portugal
Manuel Filipe Santos, University of Minho, Portugal
Mas Sahidayana Mohktar, University of Malaya, Malaysia
Mauricio Almeida, UFMG, Brazil
Renato Rocha Souza, Fundação Getulio Vargas, Brazil
Victor Alves, University of Minho, Portugal
Wilfred Bonney, University of Dundee, Scotland

Human–Machine Interfaces in Automation, Robotics and Mechanics—HMIARM
Organizing Committee
Slawomir Zolkiewski, Silesian University of Technology, Poland
Leszek Chybowski, Szczecin Maritime University, Poland

Program Committee
Artur Bejger, Maritime University of Szczecin, Poland
Jakub Montewka, Aalto University, Finland
Jean-Bernard Tritsch, Ecole Polytechnique Universitaire de Lille, France

Katarzyna Gawdzińska, Maritime University of Szczecin, Poland
Krzysztof Jamroziak, Gen. Tadeusz Kosciuszko Military Academy of Land Forces
Leszek Chybowski, Maritime University of Szczecin, Poland
Mariusz Ptak, Wroclaw University of Technology, Poland
Mariusz Pyrz, Warsaw University of Technology, Poland
Nikolaos Ventikos, National Technical University of Athens, Greece
Niksa Fafandjel, University of Rijeka, Croatia
Piotr Michalski, Silesian University of Technology, Poland
Piotr Moncarz, Stanford University, USA
Ricardo Alves de Sousa, University of Aveiro, Portugal
Robert Banasiak, Lodz University of Technology, Poland
Robert Zalewski, Warsaw University of Technology, Poland
Serhiy Prokhorenko, Lviv Polytechnic National University, Ukraine
Slawomir Zolkiewski, Silesian University of Technology, Poland
Tanguy Messager, Université Lille 1, France

Internet, Business, and Social Networks—IBSN
Organizing Committee
Ramiro Gonçalves, Universidade de Trás-os-Montes e Alto-Douro, Portugal
José Martins, Universidade de Trás-os-Montes e Alto-Douro, Portugal

Program Committee
Frederico Branco, Universidade de Trás-os-Montes e Alto Douro, Portugal
Henrique Mamede, Universidade Aberta, Portugal
Jezreel Miranda, CIMAT, Mexico
Jorge Pereira, Infosistema S.A., Portugal
Luis Barbosa, Universidade de Trás-os-Montes e Alto Douro, Portugal
Manuel Cota, University of Vigo, Spain
Maximino Bessa, Universidade de Trás-os-Montes e Alto Douro, Portugal
Tânia Rocha, Universidade de Trás-os-Montes e Alto Douro, Portugal
Vítor Santos, NOVA Information Management School—New University of Lisbon, Portugal

Innovation in Information Management—IIM
Organizing Committee
Jorge Oliveira e Sá, Universidade do Minho, Portugal
Vitor Santos, NOVA IMS/European University, Portugal

Program Committee
Aldemar Santos, UFPE, Brazil
Claudio Sapateiro, EST-IPS, Portugal
Claus Kaldeich, TTC, Saudi Arabia
Hermano Perreli, UFPE, Brazil
Jairo Dornelas, UFPE, Brazil
Jorge Correia, UFPE, Brazil
Jose Cavalcanti, Universidade Federal de Pernambuco, Brazil

José Luís Pereira, University of Minho, Portugal
Luís Amaral, University of Minho, Portugal
Manuel Cota, University of Vigo, Spain
Maria Jose Sousa, Universidade Europeia, Portugal
Pedro Ruivo, NOVA IMS, Portugal
Ramiro Gonçalves, UTAD, Portugal
Tiago Oliveira, NOVA IMS, Portugal

Intelligent Systems—IS
Organizing Committee
Brígida Mónica Faria, Polytechnic Institute of Porto, Portugal
Pedro Henriques Abreu, University of Coimbra, Portugal
Daniel Castro Silva, University of Porto, Portugal

Program Committee
Armando Sousa, University of Porto, Portugal
Alan Kalton, University of Nairobi, Quénia
Alessandra Alaniz Macedo, University of São Paulo, Brazil
Antonio Moreno, Universitat Rovira i Virgili, Tarragona, Spain
Artur Pereira, University of Aveiro, Portugal
Germán Rodríguez-Bermudez, Centro Universitario de la Defensa, Spain
Henrique Lopes Cardoso, University of Porto, Portugal
João Fabro, University Federal Tenológica do Paraná, Brazil
Joaquim Gonçalves, IPCA, Portugal
João Mendes-Moreira, University of Porto, Portugal
José Manuel Torres, University Fernando Pessoa, Portugal
Josemar Rodrigues de Souza, State University of Bahia, Brazil
Luís Mota, ISCTE—University Institute of Lisboa, Portugal
Luís Paulo Reis, University of Minho, Portugal
Marcelo Petry, University Federal of Santa Catarina, Brazil
Marcelo Becker, University of São Paulo (São Carlos), Brazil
Nuno Lau, University of Aveiro, Portugal
Nuno Silva, Polytechnic Institute of Porto, Portugal
Paulo Novais, University of Minho, Portugal
Pedro Martins, University of Coimbra, Portugal
Pedro Miguel Moreira, Polytechnic Institute of Viana do Castelo, Portugal
Rosaldo Rossetti, University of Porto, Portugal

Pervasive Information Systems—PIS
Organizing Committee
Carlos Filipe Portela, University of Minho, PT
Manuel Filipe Santos, University of Minho, PT

Program Committee
Achilles D. Kameas, Hellenic Open University, Greece
Alexandre Santos, University of Minho, Portugal

António Abelha, University of Minho, Portugal
Carlo Giannelli, University of Bologna, Italy
Christos Tjortjis, Int'l Hellenic University, Greece
Cristina Alcaraz, University of Malaga, Spain
Daniele Riboni, University of Milano, Italy
Fabio A. Schreiber, Politecnico Milano, Italy
Filipe Mota Pinto, Polytechnic Institute of Leiria, Portugal
Frederico Lopes, Federal University of Rio Grande do Norte, Brazil
Frederique Laforest, Télécom Saint-Etienne, France
Gabriel Pedraza Ferreira, Universidad Industrial de Santander, Colombia
Jorge Sá Silva, University of Coimbra, Portugal
José Machado, University of Minho, Portugal
Juan-Carlos Cano, Universidad Politécnica de Valencia, Spain
Klaus de Geus, Universidade Federal do Paraná, Brazil
Kostas Kolomvatsos, University of Athens, Greece
Manuele Kirsch Pinheiro, University of Paris 1, France
Muhammad Younas, Oxford Brookes University, UK
Nervo Xavier Verdezoto, Aarhus University, Denmark
Nuno Marques, New University of Lisboa, Portugal
Paulo Cortez, University of Minho, Portugal
Rajeev Kumar Kanth, University of Turku, Finland
Saravanan Muthaiyah, Multimedia University, Malaysia
Sergio Ilarri, University of Zaragoza, Spain
Somnuk Phon-Amnuaisuk, Institut Teknologi Brunei, Brunei
Spyros Panagiotakis, Technological Educational Institution of Crete, Greece
Teh Phoey Lee, Sunway University, Malaysia
Víctor Hugo Medina García, Universidad Distrital Francisco José de Caldas, Colombia

Semantics for Humanities Resources—SHR
Organizing Committee
Giovani Rubert Librelotto, Universidade Federal de Santa Maria, Brazil
José Carlos Ramalho, Universidade do Minho, Portugal
Alberto Simões, IPCA and Universidade do Minho, Portugal
Ricardo Giuliani Martini, Universidade do Minho, Portugal

Program Committee
Alda Lopes Gançarski, TELECOM SudParis, Evry, France
José João Almeida, Universidade do Minho, Portugal
Maria João Varanda Pereira, Instituto Politécnico de Bragança, Portugal
Mario Marcelo Berón, Universidad Nacional de San Luis, Argentina
Mónica Guimarães, Arquivo Municipal de Fafe, Portugal
Nuno Carvalho, Universidade do Minho, Portugal
Pedro Rangel Henriques, Universidade do Minho, Portugal
Rosario Girardi, Universidade Federal do Maranhão, Brazil

Contents

Part I Information and Knowledge Management

The Main Critical Success Factors of Contractual and Relational Governances in Outsourcing Relationships 3
Victor Diogho Heuer de Carvalho, Thiago Poleto and Ana Paula Cabral Seixas Costa

Temporal Data in Relational Database Systems: A Comparison 13
Dušan Petkovic

Governance of Higher Education Institutions in Brazil: An Exploratory Study Based on Supply and Demand Conditions 25
Sílvia Regina Machado de Campos, Roberto Henriques and Mitsuru Higuchi Yanaze

The Role of Information, Experience and Participation in Building Brand Equity on Social Media 39
Bih-Huang Jin and Yung-Ming Li

Using Social Media for Business Process Improvement: A Systematic Review 47
Ademir Macedo Nascimento and Denis Silva da Silveira

A Knowledge Management Approach for Software Engineering Projects Development 59
Paulo Carreteiro, José Braga de Vasconcelos, Alexandre Barão and Álvaro Rocha

Our SIHE: e-Collaboration in Academic Management 69
Joel Alves de Lima Júnior, Marcelo Mendonça Teixeira, Jorge S. Correia-Neto, Guilherme Vilar and Marcelo Brito Carneiro Leão

Model Accreditation for Learning in Engineering Based on Knowledge Management and Software Engineering 79
Víctor Hugo Medina García, Germán Andrés Méndez Giraldo and José Fernando López Quintero

An Approach to Relevancy Detection: Contributions to the Automatic Detection of Relevance in Social Networks 89
Alvaro Figueira, Miguel Sandim and Paula Fortuna

Intelligent System for Soccer Referee's Position Analysis 101
Carlos Moreira Rego, Luís Paulo Reis, Filipe Meneses and Brígida Mónica Faria

Bat Algorithm for Efficient Query Expansion: Application to MEDLINE 113
Ilyes Khennak and Habiba Drias

Email Answering by Matching Question and Context-Specific Text Patterns: Performance and Error Analysis 123
Eriks Sneiders, Jonas Sjöbergh and Alyaa Alfalahi

Review of the Main Approaches to Automated Email Answering 135
Eriks Sneiders

Towards Semantic Fusion Using Information Quality Awareness to Support Emergency Situation Assessment 145
Valdir Amancio Pereira Junior, Mathues Ferraroni Sanches, Leonardo Castro Botega and Caio Saraiva Coneglian

Antiphospholipid Syndrome Risk Evaluation 157
João Vilhena, Henrique Vicente, M. Rosário Martins, José M. Grañeda, Filomena Caldeira, Rodrigo Gusmão, João Neves and José Neves

Using Bayesian Networks for Knowledge Representation and Evaluation in Intelligent Tutoring Systems 169
Ramirez-Noriega Alan, Juarez-Ramirez Reyes, Martinez-Ramirez Yobani, Jimenez Samantha and Inzunza Sergio

Interoperability of Systems and Monitoring for Alert Itajaí River Basin—SaDPreai v.3 179
Luis Augusto Silva, Francielle M.F. Vieira and André Fabiano de Moraes

Cognitive Learning Strategies of Information Technology Students in UAE University 187
Nabeel Al-Qirim, Aishah Rashid Yammahi and Maraim Ahmed Yammahi

IoT in Education: Integration of Objects with Virtual Academic Communities 201
Jack Marquez, Jhorman Villanueva, Zeida Solarte and Alexander Garcia

The Use of Information Systems in the Context of Indigenous Cultures 213
Joselice Ferreira Lima, Dener Guedes Mendonça, Suzana Alves Escobar, Claudio Alexandre Gusmão and Gustavo Teixeira

Graph Colouring and Branch and Bound Approaches for Permutation Code Algorithms 223
Roberto Montemanni, János Barta and Derek H. Smith

Clustering Binary Signature Applied in Content-Based Image Retrieval 233
Thanh The Van and Thanh Manh Le

Tridimensional Scenes Management and Optimization for Virtual Reality Simulators 243
Juan P. D'Amato, Cristian García Bauza, Marcos Lazo and Virginia Cifuentes

A Survey on Open Source Data Mining Tools for SMEs 253
Pedro Almeida and Jorge Bernardino

Functionalities as Superior Predictor of Applications Privacy Threats 263
Alessio De Santo, Brice Quiquerez and Cédric Gaspoz

Technologies and Information Systems: A Contribution to the Sustainability of the Agri-Food Sector 275
José Luís Reis

Use of Standard and Model Based on BOK to Evaluate Professional and Occupational Profiles 287
Pablo Quezada, Juan Garbajosa and Liliana Enciso

Extending BPMN Model for Improving Expressiveness and Machine-Understandability 297
Mateo Ramos Merino, Luis M. Álvarez Sabucedo, Juan M. Santos Gago and Víctor M. Alonso Rorís

Ontological Semantic Agent in the Context of Big Data: A Tool Applied to Information Retrieval in Scientific Research 307
Caio Saraiva Coneglian, Elvis Fusco, José Eduardo Santarém Segundo, Valdir Amancio Pereira Junior and Leonardo de Castro Botega

Designing an IT Artifact: Framework for the Entire Process of IT Demand Management 317
Igor Aguilar Alonso, José Carrillo Verdún and Edmundo Tovar Caro

Open Source vs Proprietary Project Management Tools 331
Veronika Abramova, Francisco Pires and Jorge Bernardino

Dimensioning Virtual Organizations Based on Risk Levels 341
Jonathan Emannoel Ferreira and Adriano Fiorese

Analysis of Application Integration and Portals 351
Leonardo Grandinetti Chaves and Rodrigo Baroni de Carvalho

A Descriptive Tour of the Semantic Structures Apply to Video Surveillance Systems 359
Héctor F. Gómez Alvarado, Silvia Elena Malo Martínez and Claudia Paola Cartuche Flores

An Agile Approach to Developing an Information System for Anti-doping Control in Brazil 369
Francisco Medeiros, Juliana Medeiros, Fausto Ayres, Caio Viana, Josemary Rocha, Victor Viegas, Eder Mendes and Ana Santos

A Framework to Assess Information Security Quality of Service Based on a Communicative Action Way of Thinking 379
António Gonçalves, Anacleto Correia, Rui Matos and Bruno Fragoso

A Business and IT Architecture Model Supporting Public Organizations Introducing Language Technologies 389
Martin Henkel, Erik Perjons and Eriks Sneiders

A Reduced CRM-Compatible Form Ontology for the Virtual Emigration Museum 401
Ricardo G. Martini, Cristiana Araújo, Giovani R. Librelotto and Pedro R. Henriques

The Role of Information Technologies in Receivables Management 411
Lubos Smrcka, Dagmar Camska and Jan Placeke

Proposal of Content and Security Controls for a CSIRT Website 421
Jezreel Mejía, Mirna Muñoz, Heltton Ramírez and Adriana Peña

Cloud Healthcare-Records Manager 431
Asma Sultan AlShamsi and Nabeel AlQirim

Identification of Semantic Focal Groups for Tourist Packages Based on The Semantic Orientation of Opinions 441
Natalia Soledad Bustamante Sánchez, Susana Alexandra Arias Tapia, Silvia Elena Malo Martínez, Javier Sanchez Guerrero and Hernando Buenaño Valencia

Large Project Management in the Automotive Industry: A Flexible and Knowledge Based Approach 455
Filipe Ferreira, Ana Luísa Marques, José Faria and Américo Azevedo

Part II Organizational Models and Information Systems

IT Governance—Models and Application 467
Fernando Molina Granja, Raúl Lozada Yánez, Edison Fernando Bonifaz and Edmundo Cabezas Heredia

Cloud Computing as an Alternative Solution for South African Public Sector: A Case for Department of Social Development 481
Simon Motlatsi Maluleka and Nkqubela Ruxwana

Architecture of Information Security Policies: A Content Analysis 493
Isabel Lopes and Pedro Oliveira

The Information Value: Perception of the Problem 503
Maria Aparecida Lopes da Cruz and Henrique Manuel Dinis dos Santos

Project Management in 2016 Olympic Games 511
Maria José Sousa, Fabiano Lima and Jair Martins

Acceptance Factors of ERP Systems 523
Bayona Sussy, Ventura Saul and Morales Vicente

IT as a Driver for New Business 535
Maria José Sousa

Improving the Success of IS/IT Projects in Healthcare: Benefits and Project Management Approaches 547
Jorge Gomes and Mário Romão

Simulation of BPMN Process Models: Current BPM Tools Capabilities 557
José Luís Pereira and António Paulo Freitas

Towards an Evaluation Model for the Quality of Local Government Online Services: Preliminary Results 567
Filipe Sá, Joaquim Gonçalves, Álvaro Rocha and Manuel Pérez Cota

webBPMN: A Language to Design Web Applications Regulated by Workflows 579
Riccardo Cognini, Michelangelo Marani, Alberto Polzonetti and Barbara Re

Verification of Business Processes Against Business Rules Using Object Life Cycles 589
Ralph Hoch, Michael Rathmair, Hermann Kaindl and Roman Popp

Promoting Modularity in a Requirements Engineering Process for Software Product Lines 599
Dorgival Netto and Carla Silva

Core Ontology to Aid the Goal Oriented Specification for Self-Adaptive Systems 609
Monique Soares, Jéssyka Vilela, Gabriela Guedes, Carla Silva and Jaelson Castro

Business Process Modeling Languages: A Comparative Framework 619
José Luís Pereira and Diogo Silva

An Analysis of Opinions About Tourist Services Based on the Semantic Orientation of Texts 629
Rosario Estefania Sanchez Cevallos, Susana Alexandra Arias Tapia, Alex Paúl Ludeña Reyes and Victor Hernandez del Salto

Building a Generic Model for Early Warning Information Systems (EWIS) 639
Mohamed Saadeldin and Hegazy M. Zaher

User and Context Information in Context-Aware Recommender Systems: A Systematic Literature Review 649
Sergio Inzunza, Reyes Juárez-Ramírez and Alan Ramírez-Noriega

A Telematic Based Approach Towards the Normalization of Clinical Praxis 659
Víctor M. Alonso Rorís, Juan M. Santos Gago, Luis Álvarez Sabucedo, Mateo Ramos Merino and Javier Sanz Valero

Part III Software and Systems Modeling

An Implementation on MATLAB Software for Stability Analysis of Proportional Controllers in Linear Time Invariant Control Systems 671
Hau H. Vo, Pavel Brandstetter, Chau S.T. Dong, Tri Q. Thieu and Duy H. Vo

Software for Simulation of Vehicle-Road Interaction 681
Francisco Duarte, Adelino Ferreira and Paulo Fael

Implementation of Techniques, Standards and Safety Recommendations to Prevent XSS and SQL Injection Attacks in Java EE RESTful Applications 691
Daniel Guamán, Franco Guamán, Danilo Jaramillo and Roddy Correa

The Difference Operation Between Templates of Binary Cellular Automata 707
Zorandir Soares, Maurício Verardo and Pedro P.B. de Oliveira

Design and Evaluation of a Personalized Cancer Treatment System Using Human-Computer Interaction Techniques 717
Alexandra Martinez, Rodrigo Mora, Gustavo López, Constantino Bolaños, Daniel Alvarado, Andrés Solano, Mariana López, Steve Quirós and Andrés Báez

Part IV Software Systems, Architectures, Applications and Tools

3D Markerless Motion Capture: A Low Cost Approach 731
Yves Rybarczyk

Energy Implications of Common Operations in Resource-Intensive Java-Based Scientific Applications 739
Cristian Mateos, Ana Rodriguez, Mathias Longo and Alejandro Zunino

Analysis of Materials Emissivity Based on Image Software 749
Rui Pitarma, João Crisóstomo and Luís Jorge

DDT: An IDE for an Aspect Oriented Software Development Platform 759
Fernando Alvarez, Jesus Perez and Luis Vinuesa

A Predictive Model for Exception Handling 767
João Ricardo Lourenço, Bruno Cabral and Jorge Bernardino

Reasoning Service Enabling SmartHome Automation at the Edge of Context Networks 777
Hasibur Rahman, Rahim Rahmani, Theo Kanter, Magnus Persson and Stefan Amundin

ROTA: A Smart City Platform to Improve Public Safety 787
Jazon Coelho, Nélio Cacho, Frederico Lopes, Emiliano Loiola, Tyago Tayrony, Thiago Andrade, Marcel Mendonça, Maychell Oliveira, Daniela Estaregue and Brunna Moura

Open Drugstores Mobile App 797
Liliana Enciso, Pablo Quezada, Luis Barba-Guamán, Lida Solano and Pedro-Pablo Alarcón

A Platform Approach to Personalizing Web Applications with Social Network User Profiles 807
Reinhard Klemm

Social Smart Destination: A Platform to Analyze User Generated Content in Smart Tourism Destinations 817
Andrea Cacho, Mickael Figueredo, Arthur Cassio, Maria Valeria Araujo, Luiz Mendes, José Lucas, Hiarley Farias, Jazon Coelho, Nélio Cacho and Carlos Prolo

An Automated Approach for Requirements Specification Maintenance 827
Jorge Esparteiro Garcia and Ana C.R. Paiva

A Visualization-Based Approach for Project Portfolio Selection 835
Celmar Guimarães da Silva, João Meidanis, Arnaldo Vieira Moura, Maria Angélica Souza, Paulo Viadanna Jr., Gabriel A. Costa Lima and Rafael S.V. de Barros

A Personal Assistant for Health Care Professionals Based on Clinical Protocols 845
Tiago Oliveira, António Silva, José Neves and Paulo Novais

A Proposal for Automatic Evaluation by Symbolic Regression in Virtual Learning Environments 855
Adriano Lino, Álvaro Rocha and Amanda Sizo

Part V Multimedia Systems and Applications

TweeProfiles3: Visualization of Spatio-Temporal Patterns on Twitter 869
André Maia, Tiago Cunha, Carlos Soares and Pedro Henriques Abreu

RetweetPatterns: Detection of Spatio-Temporal Patterns of Retweets 879
Tomy Rodrigues, Tiago Cunha, Dino Ienco, Pascal Poncelet and Carlos Soares

Adaptive Filtering Techniques for Improving Hyperspectral Image Classification 889
Paulo Amorim, Thiago Moraes, Jorge Silva and Helio Pedrini

Part VI Computer Networks, Mobility and Pervasive Systems

Managing Enterprise Network Resilience Through the Mimicking of Bio-Organisms 901
Sami Habib and Paulvanna N. Marimuthu

Simulation and Test of Communication in Multi-robot Systems Using Co-simulation 911
Alisson Brito and Thiago Oliveira

An Evaluation of Distributed Processing Models for Random Walk-Based Link Prediction Algorithms Over Social Big Data 919
Alejandro Corbellini, Cristian Mateos, Daniela Godoy, Alejandro Zunino and Silvia Schiaffino

Part VII Intelligent and Decision Support Systems

Integrating Client Profiling in an Anti-money Laundering Multi-agent Based System 931
Claudio Alexandre and João Balsa

A Nearby Expert Discovering Mechanism: For Social Support 943
Ting-Kai Hwang, Yung-Ming Li and Bih-Huang Jin

Implementation of Multiple Criteria Decision Analysis Approaches in the Supplier Selection Process: A Case Study 951
Dmitry Kisly, Anabela Tereso and Maria Sameiro Carvalho

Computer-Aided Support System for Metal Diagnosis of Patrimonial Objects 961
Antoine Rosselet, Marcel Grosjean, Christian Degrigny and Cédric Gaspoz

Multiple Case Study of the Supplier Selection Decision Process 973
Dmitry Kisly, Anabela Tereso and Maria Sameiro Carvalho

Decision Support in Big Data Contexts: A Business Intelligence Solution 983
José Luís Pereira and Marco Costa

Cloud Computing in Smart Educational Environments: Application in Learning Analytics as Service 993
Manuel Sánchez, Jose Aguilar, Jorge Cordero, Priscila Valdiviezo-Díaz, Luis Barba-Guamán and Luis Chamba-Eras

Specification of a Smart Classroom Based on Agent Communities 1003
Jose Aguilar, Luis Chamba-Eras and Jorge Cordero

Part VIII Big Data Analytics and Applications

Characterizing User-Generated Text Content Mining: A Systematic Mapping Study of the Portuguese Language 1015
Ellen Souza, Dayvid Castro, Douglas Vitório, Ingryd Teles, Adriano L.I. Oliveira and Cristine Gusmão

Gender Classification of Twitter Data Based on Textual Meta-Attributes Extraction 1025
José Ahirton Batista Lopes Filho, Rodrigo Pasti and Leandro Nunes de Castro

Part IX Human-Computer Interaction

Measure the Usability of Graphical User Interface 1037
Altynbek Sharipbay, Alibek Barlybayev and Talgat Sabyrov

The Role of Touchscreens for Learning Process in Special Education 1047
Diego Antonio Beltramone, Marcela Fabiana Rivarola and María Luz Quinteros Quintana

A Neurocognitive Virtual Rehabilitation System for Children with Cerebral Palsy: A Preliminary Usability Study 1057
Sergio Albiol-Pérez, Edwin-Patricio Pruna-Panchi, Ivón-Patricia Escobar-Anchaguano, Marco-Antonio Pilatasig-Panchi, Luis-Enrique Mena-Mena, Janeth Segovia-Chávez, Aracne Bernis and Paulina Zumbana

Acceptance and Suitability of a Novel Virtual System in Chronic Acquired Brain Injury Patients 1065
Sergio Albiol-Pérez, Edwin-Patricio Pruna-Panchi, Ivón-Patricia Escobar-Anchaguano, José-Gioberty Bucheli-Andrade, Marco-Antonio Pilatasig-Panchi, Luis-Enrique Mena-Mena, Janeth Segovia-Chávez, Aracne Bernis and Paulina Zumbana

Patient-Centred Transparency Requirements for Medical Data Sharing Systems 1073
Dayana Spagnuelo and Gabriele Lenzini

A Web Platform of Serious Games for Cognitive Rehabilitation: Architecture and Usability Study 1085
Rui Rocha, Paula Alexandra Rego, Brígida Mónica Faria, Luís Paulo Reis and Pedro Miguel Moreira

Blind Students' Learning Experiences—Challenges and Opportunities in Design for Inclusion 1097
Graziela Sombrio, Lane Primo, Vânia Ulbricht and Vilma Villarouco

Gamification Approaches to Learning and Knowledge Development: A Theorical Review 1107
Raul Inácio Busarello, Vania Ribas Ulbricht, Luciane Maria Fadel and Andiara Valentina de Freitas e Lopes

An Affective Learning Ontology for Educational Systems 1117
Samantha Jimenez, Reyes Juarez-Ramirez, Víctor H. Castillo
and Alan Ramírez-Noriega

Author Index 1127

Part I
Information and Knowledge Management

The Main Critical Success Factors of Contractual and Relational Governances in Outsourcing Relationships

Victor Diogho Heuer de Carvalho[1], Thiago Poleto[1], Ana Paula Cabral Seixas Costa[1]

[1] Universidade Federal de Pernambuco, Av. Prof. Moraes Rego, 1235, Cidade Universitária, Recife, Pernambuco, 50670-901, Brazil
victorheuer@gmail.com, {thiagopoleto, apcabral}@hotmail.com

Abstract. The relationship between organizations involved in Information and Communication Technology Outsourcing is a key factor for the success of the provision of services. When all parties involved work together, they achieve a high level of cooperation and create a partnership marked by mutual trust and intensive exchange of experiences and knowledge sharing. This work aims to present the results of a survey conducted in one of the greatest information and communication technology poles of Brazil. Several concepts related to contractual and relational governances in outsourcing were identified and allocated within two sets of constructs. Finally, Spearman's correlation tests were performed to check the strength of the correlations within each set.

Keywords: Information and Communication Technology. Outsourcing. Contractual Governance. Relational Governance.

1 Introduction

Many times, organizations opt to transfer the execution of certain activities to other companies receiving benefits ranging from the cost reduction to the focus on internal efforts in order to obtain better results in their core business. This transfer is designated as outsourcing, where there is an intense exchange of experiences and knowledge sharing among the parties involved: the outsourcer and the service provider [1].

It is clear that outsourcing can be considered a strategic action that organizations adopt to become competitive and maintain their competitiveness in a market that increasingly requires integration as well as represents a major opportunity for economic advancement and inclusion in the global economy [2, 3].

Throughout the outsourcing process, the parties must be concerned regarding the contractual and relational governances. Based on these two governances, the outsourcing process leads to the formation of a relationship between the parties that is initially dictated by contractual aspects. After a few cycles of interactions, mutual trust begins to be established, enabling an exchange of experiences that ensures an increase in innovation and productivity rates in organizations [4, 5].

In this context, this article presents the first results of a survey conducted in a great Brazilian information and communication technology (ICT) pole. It also conceptually defines sets of constructs of contractual and relational governances, which acts in favor

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_1

of strengthening the relationship between the outsourcer and provider of ICT services. The study of correlations within the sets of constructs helped to determine the main contractual aspects and critical success factors respectively linked to contractual and relational governances along outsourcing processes.

The rest of this article is organized as follows: Section 2 defines the research methodology; Section 3 presents and conceptualizes the constructs of contractual and relational governances used in research; Section 4 discusses the results; and, finally, Section 5 presents the conclusions of this work and some perspectives for future works.

2 Methodology

An extensive bibliographical research on the key concepts related to ICT outsourcing and contractual and relational governances was necessary. With the subsequent reading of the articles found, those with closer alignment to the thematic explored here were chosen. These articles supported the foundations about contractual and relational governance and their respective sets of constructs. Section 3 explores, along with Tables 1, 2 and 3, these constructs and lists the chosen works that are best aligned with them.

For the survey, two questionnaires were used: one specifically for outsourcers and the other for provider companies. Both questionnaires had questions with scales of importance using five points, adopting 1 (one) for "insignificant" and 5 (five) for "very important." Respondents calibrated intermediate values.

These companies are entirely located in the metropolitan region of Recife, Brazil, where one of the most important ICT poles of this country is situated. Therefore, two distinct populations were utilized for defining the samples, of which 34 responses were obtained from the outsourcers and 16 from the providers in the time defined for the data collection. It is noteworthy that the application of the questionnaire with the outsourcers occurred in 2012, and it occurred with the providers in 2014. The questionnaire that was applied in 2014, although based on that applied in 2012, took into consideration the need for readjustment of some constructs to the reality of provider companies.

The nonparametric Spearman's correlation test was applied with the support of the R language to verify the strength of the correlations within each of the two sets of constructs, thus identifying the interrelated factors that cause a greater impact on a contractual perspective represented by contractual aspects and on a relational perspective represented by the critical success factors. It is worth mentioning that the tests were only done within the individual point of view of the outsourcer and provider and were not being performed between them in this work.

3 Constructs of contractual and relational governances

Both forms of governance are relevant to the outsourcing process, considering that the contractual governance dictates the initial moments when a legal support is necessary to guide the relationship between the parties always seeking to comply with contractual determinations concerning the details, type, duration and contract size [6–8]. With the

consolidation of this conduct, relational governance drives the relationship. Although this governance still considers the contractual aspects, it is more focused on social norms, exchange of experiences, knowledge sharing, trust and cooperation [6, 9].

The contractual governance can be conceptualized as a management tool that allows the implementation of a formal contract guiding the production process – where the development of services or products is included – such that both parties establish a relationship guided initially by the contractual definitions [10]. In turn, the relational governance can be understood as that based on the relationship between the parties involved in a transaction, thus improving and strengthening the relationship through the compliance with social norms [11].

The bibliographical research sought to define which constructs could be employed, and they are described along the tables of the subsections that follow. As mentioned in the methodology section, after reading the articles found, those with closer relation to the constructs were chosen to compose the foundations of the present work.

3.1 Contractual Aspects

Contractual aspects (CA) are all the constructs related to the composition and execution of outsourcing contracts [4]. Table 1 below determines which CA was identified and applied and also indicates which works are related to them.

Table 1. Contractual aspects identified and used for both cases of Outsourcers and Providers.

Contractual Aspect	Description	Related works
CA1 – Service Level Agreement	Related to the description of the services, goals and objectives, and defining the roles and responsibilities between the parties of an outsourcing contract.	[4, 6, 12]
CA2 – Detailed Contract	The definition of the detailed and complete contract as a legal document.	[4, 6, 13]
CA3 – Incorporate Procedures to Flexibility	The ability of all parties to adapt themselves to possible changes in the course of the outsourcing relationship.	[4, 6, 12, 14, 15]
CA4 – Definition of penalties for low performance and information violations	Determining punishments for all parties if they do not comply with contractual determinations for the service delivery.	[4, 6, 16, 17]
CA5 – Duration of Contract	Determining how long the contract will last and setting deadlines for its beginning and end.	[4, 6, 16, 18]
CA6 – Costs	Determining the costs involved for the service development and delivery.	[4, 6, 15, 19, 20]

3.2 Critical Success Factors

The Critical Success Factors (CSF) are all the approaches, activities and practices that should be considered to ensure effective management and maintenance between the

parties involved in a relationship in favor of the success of a project [21]. We highlight that the CSF set, initially adopted for the outsourcers, was smaller than the one adopted for the providers, and this is justified by the restructuring of the questionnaire applied to the perspective of providers. To distinguish each specific set, the following acronyms were adopted: O.CSF for the case of outsourcers and P.CSF for the case of providers. Table 2 presents the CSF adopted for the outsourcers' point of view.

Table 2. Critical Success Factors identified and used in the research for the case of outsourcers.

Critical Success Factor	Description	Related works
O.CSF1 – Selection of the Correct Provider	Aims to evaluate the ITC provider's skills in order to ensure effectiveness in the activities that will be performed.	[22–24]
O.CSF2 – Alignment of outsourcers' and providers' objectives	Refers to analyzing the strategic alignment between outsourcers and providers.	[25]
O.CSF3 – Clear vision of outsourcer's objectives	Refers to understanding outsourcers' objectives for the services provided.	[26–30]
O.CSF4 – Clear and well-structured outsourcing contract	The accomplishment of a set of contractual aspects defined previously.	Derived from CA set.
O.CSF5 – Outsourcer-provider relationship	Characterized by the adequacy and cooperation between outsourcer and provider.	[31–33]

Table 3 below presents the CSF adopted for the providers' point of view.

Table 3. Critical Success Factors identified and used in the research for the case of providers.

Critical Success Factor	Description	Related works
P.CSF1 – Commitment by managers of outsourcer company	Commitment by managers of outsourcer company to warrant that contractual determinations will be accomplished.	[4, 6, 17, 34]
P.CSF2 – Well-structured planning for services to be provided	Development of planning with a complete and detailed description of the services that will be provided, with participation of both outsourcer and provider.	[4, 17, 35, 36]
P.CSF3 – Flexibility of staff to develop activities related to services	Capacity of the staff to adapt to any kind of activity related to the services that the provider will develop.	[4, 6, 37, 38]
P.CSF4 – Adaptability to possible changes of the services	Capacity of the providers' staff to adapt to changes on the activities definition for the development of the services.	[34, 38]
P.CSF5 – Providers' staff training	Level of training/education of the providers' staff related to the services that will be provided.	[4, 39, 40]
P.CSF6 – Documentation of all activities performed and services provided (Organizational Memory)	Register of all elements and procedures performed to obtain the service, composing a set of operational reports and increasing Organizational Memory.	[4, 41, 42]

P.CSF7 – Customer Relationship Management (CRM)	Use of CRM strategies by provider companies to create a portfolio of clients, keeping them closer and ensuring their loyalty.	[4, 17, 43, 44] and related to O.CSF5 in Table 2.
P.CSF8 – Use of the information system for Customer Relationship Management	Use of CRM Information Systems, supporting P.CSF7 strategies.	Derived from P.CSF7
P.CSF9 – Evaluation of Customer Satisfaction	It is necessary to evaluate the customers' satisfaction to maintain the relationship with them.	Derived from P.CSF7
P.CSF10 – Supplier Relationship Management (SRM)	Use of SRM strategies by outsourcers to create a portfolio of suppliers/providers, keeping them closer.	Derived from P.CSF7
P.CSF11 – Use of the information system for Supplier Relationship Management	Use of SRM Information Systems, supporting P.CSF10 strategies.	Derived from P.CSF7
P.CSF12 – Provide adequate services and structured contract	The accomplishment of a set of contractual aspects defined previously (Similar to O.CSF4 in Table 2).	Derived from CA set and O.CSF4 in Table 2.
P.CSF13 – Advertising Strategies	Strategies related to the advertising by both companies in order to build their image in the market.	[45]
P.CSF14 – Maintaining the companies' image in the market	After constructing their image, both companies must keep it using maintenance strategies.	[46]
P.CSF15 – Sharing knowledge and experiences	Creation of an inter-organizational environment conducive to knowledge and experience sharing.	[4, 6, 16, 34, 39]
P.CSF16 – Internal communication between the parties involved	Creation of inter-organizational communication channels to ensure information, knowledge and experience sharing.	[4, 6, 17, 44]
P.CSF17 – Conducting self-assessment of performance in service delivery	Self-assessment in order to obtain measures about companies' own performance and knowledge acquisition in service delivery.	[47]

In Table 3, the conceptual relations between P.CSF7 and P.CSFs 8, 9, 10 and 11 may be seen. In addition, there is a conceptual relation between P.CSF12 and all the CA; however, these relations will not be tested once the focus here is the tests inside each set of constructs and not between them. The next section will proceed with the correlation test results and discussions.

4 Results and Discussion

For the application of Spearman's correlation test on the set of data collected through the survey applied on Recife's ICT pole, a significance level of $\alpha = 0{,}05$ was defined. For the discussion, only strong (*rho* coefficient between 0.6 and 0.8) or very strong (*rho*

coefficient between 0.8 and 1) correlations between the constructs of each set will be considered. Figure 1 below presents the correlograms for the case of outsourcers.

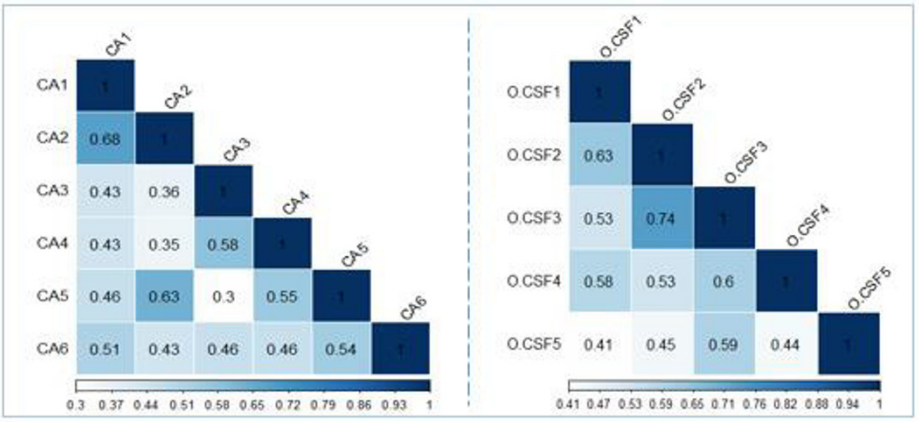


Fig. 1. Correlograms with Spearman's test results. Color scale indicates the strengths of the correlations in the outsourcers' point of view: left, the CA pairs; right, the O.CSF pairs.

From the results shown in the correlograms of CA and CSF in the outsourcers' case, it is clear that all values for the coefficients are positive. This indicates that for a specific increase in a construct of the compared pair, the other construct will have a proportional increase. We may infer that all constructs inside each set work together so that the contractual and relational governances fulfill their goals in ICT outsourcing processes, according to the outsourcers' opinions captured by the questionnaires.

Remarkably, the pairs CA1-CA2 and CA2-CA5 are the only ones that have strong correlations. For CA2 – *Detailed Contract*, the CA1 – *Service Level Agreement* is a fundamental element that also allows the definition of other elements such as contract duration, costs, penalties etc. Therefore, it is notable that CA5 – *Duration of Contract* has a strong correlation with CA2 once the duration is well-defined in a detailed contract.

By the correlogram of O.CSF, three pairs are highlighted as having strong correlations: O.CSF2-O.CSF3, O.CSF1-O.CSF2 and O.CSF3-O.CSF4. The O.CSF2 – *Alignment of outsourcers' and providers' objectives* and the O.CSF3 – *Clear vision of outsourcer's objectives* address the issue of understanding the outsourcer's objective by providers, which is critical to the strategic alignment between them, thus ensuring the success of the outsourcing process and even the relationship and, consequently, the knowledge sharing.

The relation between O.CSF1 – *Selection of the Correct Provider* and O.CSF2 refers to the fact that the providing company, when properly chosen, has the ability to understand its contractor and meet the goals established by it, thus aligning the outsourcing process with the expectations of both parties.

Finishing the point of view of the outsourcers, we have O.CSF3 and O.CSF4 – *Clear and well-structured outsourcing contract*. These two factors define a relation that refers

to the fact that the provider must clearly understand the outsourcer's objectives that are explicit in the contract in order to answer any questions that might cause problems in the execution of defined activities.

Figure 2 below presents the correlograms for the case of providers.

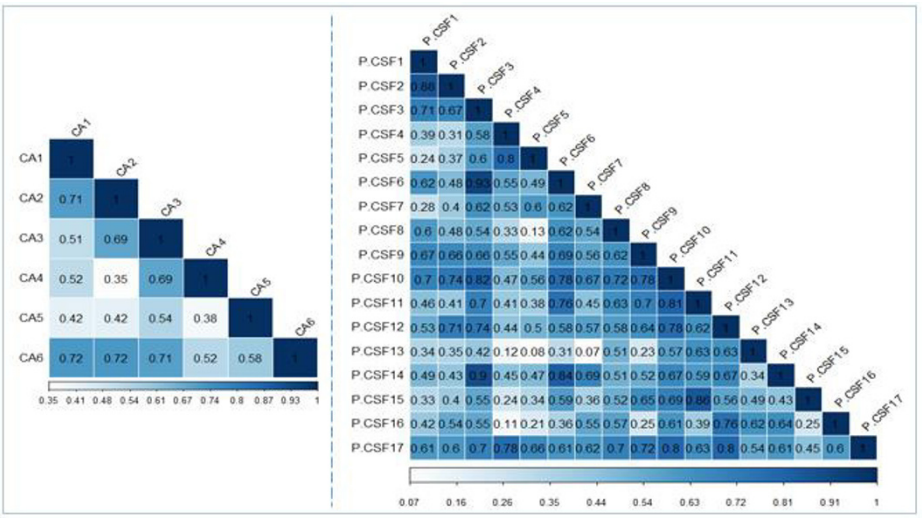


Fig. 2. Correlograms with Spearman's test results. Color scale indicates the strengths of the correlations in the providers' point of view: left, the CA pairs; right, the P.CSF pairs.

The same remark made earlier about the positive correlations is valid for the point of view of providers. In this case, the correlogram of CA presents six strong correlations: CA1-CA2, CA1-CA6, CA2-CA3, CA2-CA6, CA3-CA4 and CA3-CA6. The same considerations about the pairs CA1-CA2 made for the case of outsourcers are valid for the providers.

The strong relationship of CA1 – *Service Level Agreement* with CA6 – *Costs* is justified by the fact that the agreement containing the details of the services provides the basis for the detailing of service costs, thus culminating in the total cost of outsourcing. The understanding of the relationship between CA2 – *Detailed Contract* and CA3 – *Incorporate Procedures to Flexibility* and CA6 – *Costs* is direct and does not deserve much explanation, apart from the fact that the detailed contract should incorporate these two topics. Lastly, we have the relation between CA3 and CA6 that refers to the fact that bequeathing greater flexibility in the provision of services may result in some additional costs at first but can ensure that human resources have fewer difficulties in performing their roles in the future, which could generate cost savings later in this context.

Regarding P.CSF, two pairs were prominently figured to obtain coefficients above 0.9, which indicates very strong correlations: P.CSF3-P.CSF6 and P.CSF3-P.CSF14. We have the relation between P.CSF3 – *Flexibility of staff to develop activities related to services* and P.CSF6 – *Documentation of all activities performed and services provided (Organizational Memory)*, which seems to be quite logical since flexibility is

made possible by a good understanding of what will be developed by the work teams. This is quite favored by an organizational memory containing descriptions of elements related to this work and showing how to resolve possible problems. The same P.CSF3 also has a very strong relationship with P.CSF14 – *Maintaining the companies' image in the market*, which can be explained by the need that both parties (but principally the providers) have in maintaining their good image to attract versatile professionals to work in them, thus ensuring the existence of flexible teams.

5 Conclusions

We consider that this work has two groups of important results. The first was the definition of the constructs' sets of CA and CFS supported by the literature. The second refers to the results of the application of correlation tests on the judgements of importance of the outsourcers and service providers based on data collected with the survey applied on Recife's ICT pole. It is very important to clarify this because the first group of results enabled the second, thus allowing visualization of the correlations within the CA and CSF sets and corroborating the logical links that were theoretically supposed.

Both results highlight the idea that, with the increase of maturity in the relationship, the contractual aspects cease to be the only concern between the two parties. If at first there was concern focused solely on the provision of ICT services established in the contract, with the maturing of the outsourcer-provider relationship, gains can arise beyond the service execution through the exchange of experiences and knowledge sharing between the parties.

Various relationships, especially among CSF pairs and from the perspective of providers, obtained coefficients that show strong correlations, especially some related to knowledge management, organizational memory, communication channels between the parties and the conducting of self-assessments. This emphasizes the idea that a mature relationship between the parties also brings the need for improved management models.

For future work, we propose to carry out tests between sets of constructs, thus adding a new set with risk factors for the outsourcing relationship. Two other interesting proposals to extend the results obtained with the research are: 1) the creation of an internal ranking for each set of constructs worked, providing a view of which constructs are more important in the outsourcing of ICT services and 2) test the strength of correlations by crossing the outsourcers and providers point of views.

References

1. Silvius, G. a J., Turkiewicz, J., Keratsinov, A., Spoor, H.: The relationship between it outsourcing and business and it alignment: An explorative study. Comput. Sci. Inf. Syst. 10, 973–998 (2013).
2. Fink, L.: Information technology outsourcing through a configurational lens. J. Strateg. Inf. Syst. 19, 124–141 (2010).

3. Kang, M., Wu, X., Hong, P., Park, Y.: Aligning organizational control practices with competitive outsourcing performance. J. Bus. Res. 65, 1195–1201 (2012).
4. Power, M., Desouza, K., Bonifazi, C.: The outsourcing handbook. Koogan Page, London and Philadelphia (2006).
5. Freytag, P. V., Clarke, A.H., Evald, M.R.: Reconsidering outsourcing solutions. Eur. Manag. J. 30, 99–110 (2012).
6. Lacity, M.C., Khan, S.A., Willcocks, L.P.: A review of the IT outsourcing literature: Insights for practice. J. Strateg. Inf. Syst. 18, 130–146 (2009).
7. Xu, L.X.L., Sun, Y.S.Y.: Research on economic models with contract management mechanism in grid. Inf. Sci. Eng. (ICISE), 2010 2nd Int. Conf. (2010).
8. Kähler, L.: Contract-Management Duties As a New Regulatory Device. Law Contemp. Probl. 76, 89–103 (2013).
9. Lumineau, F., Henderson, J.E.: The influence of relational experience and contractual governance on the negotiation strategy in buyer-supplier disputes. J. Oper. Manag. 30, 382–395 (2012).
10. Rai, A., Keil, M., Hornyak, R., Wüllenweber, K.: Hybrid Relational-Contractual Governance for Business Process Outsourcing. J. Manag. Inf. Syst. 29, 213–256 (2012).
11. Poppo, L., Zenger, T.: Do formal contracts and relational governance function as substitutes or complements? Strateg. Manag. J. 23, 707–725 (2002).
12. Willcocks, L., Lacity, M., Fitzgerald, G.: Information technology outsourcing in Europe and the USA: Assessment issues. Int. J. Inf. Manage. 15, 333–351 (1995).
13. Furlotti, M.: There is more to contracts than incompleteness: A review and assessment of empirical research on inter-firm contract design. J. Manag. Gov. 11, 61–99 (2007).
14. Boulaksil, Y., Grunow, M., Fransoo, J.C.: Capacity flexibility allocation in an outsourced supply chain with reservation. Int. J. Prod. Econ. 129, 111–118 (2011).
15. Beimborn, D., Joachim, N., Weitzel, T.: Do service-oriented IT architectures facilitate business process outsourcing? Zeitschrift für Betriebswirtschaft. 82, 77–108 (2012).
16. Lee, J.N., Miranda, S.M., Kim, Y.M.: IT outsourcing strategies: Universalistic, contingency, and configurational explanations of success. Inf. Syst. Res. 15, 110–131 (2004).
17. Goo, J., Huang, C.D.: Facilitating relational governance through service level agreements in IT outsourcing: An application of the commitment-trust theory. Decis. Support Syst. 46, 216–232 (2008).
18. Goo, J., Kishore, R., Nam, K., Rao, H.R., Song, Y.: An investigation of factors that influence the duration of IT outsourcing relationships. Decis. Support Syst. 42, 2107–2125 (2007).
19. Dias Ferreira, A.M., Barbin Laurindo, F.J.: Outsourcing decision-making aspects considered by IT departments in Brazilian companies. Int. J. Prod. Econ. 122, 305–311 (2009).
20. Gottschalk, P., Solli-Sæther, H.: Maturity model for IT outsourcing relationships. Ind. Manag. Data Syst. 106, 200–212 (2006).
21. Kumaraswamy, M.M., Ling, F.Y., Rahman, M.M., Phng, S.T.: Constructing Relationally Integrated Teams. J. Constr. Eng. Manag. 131, 1076–1086 (2005).
22. Chen, Y.-H., Wang, T.-C., Wu, C.-Y.: Strategic decisions using the fuzzy PROMETHEE for IS outsourcing. Expert Syst. Appl. 38, 13216–13222 (2011).
23. Aloini, D., Dulmin, R., Mininno, V.: a Hybrid Fuzzy-Promethee Method for Logistics Service Selection: Design of a Decision Support Tool. Int. J. Uncertainty, Fuzziness Knowledge-Based Syst. 18, 345–369 (2010).
24. Chen, Y.-H., Chao, R.-J.: Supplier selection using consistent fuzzy preference relations. Expert Syst. Appl. 39, 3233–3240 (2012).

25. Zhang, C., Xue, L., Dhaliwal, J.: Alignments between the depth and breadth of inter-organizational systems deployment and their impact on firm performance. Inf. Manag. 1–27 (2015).
26. Prasad, A., Heales, J., Green, P.: A capabilities-based approach to obtaining a deeper understanding of information technology governance effectiveness: Evidence from IT steering committees. Int. J. Account. Inf. Syst. 11, 214–232 (2010).
27. Ko, D., Fink, D.: Information technology governance: an evaluation of the theory-practice gap. Corp. Gov. 10, 662–674 (2010).
28. McKenzie, J., van Winkelen, C., Grewal, S.: Developing organisational decision-making capability: a knowledge manager's guide. (2011).
29. Ferguson, C., Green, P., Vaswani, R., Wu, G.: Determinants of Effective Information Technology Governance. Int. J. Audit. 17, 75–99 (2013).
30. Turksel Kaya Bensguir, Tekneci, A.: An Evaluiation of the outsourcing IS/ICT activities in Turkish Ministerial Computer Departments. Public Adm. Dev. 28, 94–104 (2008).
31. Kern, T., Willcocks, L.: Exploring information technology outsourcing relationships: theory and practice. J. Strateg. Inf. Syst. 9, 321–350 (2000).
32. Janssen, L.A., Luciano, E.M., Gregianin Testa, M.: The influence of organizational culture on IT Governance: Perception of a group of IT managers from Latin American companies. Proc. Annu. Hawaii Int. Conf. Syst. Sci. 4485–4494 (2013).
33. Jyoti, J., Arora, H.: Impact of Client-Vendor Relationship on Firm's Financial Performance: A Study of Outsourcing Firms. Glob. Bus. Rev. 14, 691–709 (2013).
34. Chou, S.W., Techatassanasoontorn, a. a., Hung, I.H.: Understanding Commitment in Business Process Outsourcing Relatonships. Inf. Manag. (2014).
35. Gadatsch, A.: IT Controlling–Concepts and Transformation into Practice. Bus. Inf. Syst. Eng. 51, 295–305 (2009).
36. Gorla, N., Somers, T.M.: The impact of IT outsourcing on information systems success. Inf. Manag. 51, 320–335 (2014).
37. Urbach, N., Würz, T.: How to Steer the IT Outsourcing Provider. Bus. Inf. Syst. Eng. 4, 247–259 (2012).
38. Patil, S., Patil, Y.S.: A Review on Outsourcing with a Special Reference to Telecom Operations. Procedia - Soc. Behav. Sci. 133, 400–416 (2014).
39. Luo, Y., Zheng, Q., Jayaraman, V.: Managing Business Process Outsourcing. Organ. Dyn. 39, 205–217 (2010).
40. Vasil'ev, R.B., Kalyanov, G.N., Levochkina, G. a.: Directions of strategic IT consulting. Autom. Remote Control. 71, 1718–1726 (2010).
41. Polo, M., Piattini, M., Ruiz, F.: Integrating outsourcing in the maintenance process. Inf. Technol. Manag. 247–269 (2002).
42. Aydin, M.N., Bakker, M.E.: Analyzing IT maintenance outsourcing decision from a knowledge management perspective. Inf. Syst. Front. 10, 293–305 (2008).
43. Oza, N. V., Hall, T., Rainer, A., Grey, S.: Trust in software outsourcing relationships: An empirical investigation of Indian software companies. Inf. Softw. Technol. 48, 345–354 (2006).
44. Liu, Q., Ma, H., Chen, E., Xiong, H.: A Survey Of Context-Aware Mobile Recommendations. Int. J. Inf. Technol. Decis. Mak. 12, 139–172 (2013).
45. He, X., Prasad, A., Sethi, S.P., Gutierrez, G.J.: A survey of Stackelberg differential game models in supply and marketing channels. J. Syst. Sci. Syst. Eng. 16, 385–413 (2007).
46. Kasulis, J.J., Morgan, F.W., Griffith, D.E., Kenderdine, J.M.: Managing Trade Promotions in the Context of Market Power. J. Acad. Mark. Sci. 27, 320–332 (1999).
47. Komporozos-Athanasiou, A.: Information Technology Outsourcing in the Service Economy: client maturity and knowledge/power asymmetries. In: Barrett, M., Davidson, E., Middleton, C., and DeGross, J.I. (eds.) Information Technology in the Service Economy: Challenges and Possibilities for the 21st Century. pp. 301–310. Springer US, Toronto, ON (2008).

Temporal Data in Relational Database Systems: A Comparison

Dušan Petkovic[1]
[1] University of Applied Sciences
Hochschulstr. 1, Rosenheim, 83024, Germany
petkovic@fh-rosenheim.de

Abstract. Several database systems have implemented temporal data support, partly according to the model specified in the last SQL standard and partly according to other, older temporal models. In this article we use the most important temporal concepts to investigate their implementations in enterprise database systems. Also, we discuss strengths and weaknesses of these implementations and give suggestions for future extensions.
Keywords: database systems, temporal data, temporal concepts

1 Introduction

Research of temporal data in relation to database systems has a very long history. For this reason, many temporal data models have been introduced. The current versions of enterprise database systems support either the temporal model of the SQL:2011 standard [3] or have implemented concepts according to other temporal models. Hence, we will evaluate these systems in relation to the following general concepts:

- Time dimensions
- Temporal key constraints
- Coalescing
- PERIOD data type
- Implicit vs. explicit timestamps

1.1 Time Dimensions

There are three different forms of time dimensions: user-defined time, valid time, and transaction time. User-defined time is a time representation designed to meet specific needs of users. Valid time concerns the time when an event is true in the real world. For this reason, an event is independent of time when it is stored and can concern past, present and future snapshots of it.

Transaction time concerns the time when an event was present in the database as stored data. Therefore, transaction time of an event presents the correct database image of the modelled world. Timestamps of transaction time are defined according to the schedule adopted by the operating system. According to this, we can build the

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_2

history of all such timestamps in relation to the past and current time, but not in relation to future. Furthermore, only current values may be updated, and these updates cannot be retroactive, as in case of valid time.

A data model that supports only valid time is called valid-time model and one that supports only transaction time is called transaction-time model. If a data model supports both of them, it is called bitemporal.

1.2 Temporal Key Constraints

There are two temporal key constraints: one in relation to primary key (PK) and the other in relation to referential integrity (RI). The requirements concerning temporal primary key depend whether the table captures valid or transaction time. In the case of valid time, the convenient primary key of relational tables is not sufficient and the primary key has to include time-variant attributes, because each value of the relational PK must be unique at any given point in valid time. On the other hand, tables capturing transaction time always include only one tuple concerning current time, and (possibly) several history rows, which cannot be modified. For this reason, in case of transaction time, relational PK is also the temporal PK of the corresponding table.

In the case of temporal referential integrity, each value of the relational foreign key in the child table must correspond to some value of the relational primary key in the parent table *at any given point in time*. Therefore, it must be possible to forbid a tuple in a child table whose valid time is not contained in the valid time period of the corresponding tuple in the parent table [15].

1.3 Coalescing

A tuple is coalesced, if overlapped or consecutive value-equivalent tuples are disallowed. When timestamps of tuples have temporal elements as values, the requirement of coalescing is identical to the requirement that there will be no value-equivalent tuples. The goal of coalescing is that the “merge” operation of the corresponding tuples should be done by the system and not by users applications.

The need for coalescing happens when a projection or union operation is performed during retrieval of data or INSERT i.e. UPDATE statements are executed. The general approach for implementation of coalescing is similar to the problem of computation of the transitive closure of a graph, with the subsequent deletion of non-maximal paths [2].

1.4 PERIOD Data Type

The PERIOD data type is specified as a time interval which comprises the set of subsequent units. These units use a closed-open concept, meaning that the starting granule of the time period is included, while the end granule is excluded. The main advantage of the PERIOD data type is that it can be used to represent time intervals in natural way [7].

The use of the PERIOD data type requires specification and implementation of corresponding functions i.e. methods. A temporal constructor with the same name as the data type is implicitly defined, when a time-variant column of that type is specified. A database system supporting this data type usually implements several temporal functions. The following are examples of such functions: CONTAINS, EQUALS and OVERLAPS. A proposal, how this type can be specified is given in [14]. The functions of the data type are based upon so called Allen's operators [1].

1.5 Implicit vs. Explicit Timestamps

The association of time with facts is different for existing temporal data models. Some of them specify that this association is explicit, meaning that temporal facts are handled in the same way as all other table's columns. Other models treat time-variant columns as special columns. This issue has also consequences in relation to update languages in the following way: While transaction times of facts are supplied by the system itself, update operations in transaction time models treat the temporal aspect of facts implicitly. On the other hand, the user must supply valid times of facts. Therefore, updating facts in valid time and bitemporal data models must treat time explicitly and are forced to represent, how valid times of facts should be specified.

Roadmap. The rest of the paper is organized as follows. Section 2 describes the implementation of temporal concepts in the IBM DB2 database system, while Section 3 explains how these concepts are implemented in Teradata. The next section discusses which concepts are supported in Oracle. The structure of this section is identical to the structure of the previous two. Section 6 describes temporal concepts in the future version of MS SQL Server. The last section summarizes the results and shows our conclusions.

2 IBM DB2

IBM DB2 supports temporal data since Version 10 [9]. The syntax and semantics of the underlying model is, besides a couple of insignificant differences, identical to the temporal model specified in the SQL:2011 standard.

2.1 IBM DB2: Time Dimensions

DB2 supports valid time as well as transaction time. The union of valid and transaction time is supported, ie. bitemporal tables are supported by DB2.

Support of Valid Time. Tables with valid time contain two time-variant columns, one for the start and the other for the end of valid time. The CREATE (ALTER) TABLE statement is extended with the PERIOD clause, which specifies the time interval. Example 1 shows the creation of a table with valid time.

Example 1

```
CREATE TABLE V_Emp(ENo INTEGER NOT NULL, EDept INTEGER,
  EStart DATE NOT NULL, EEnd DATE NOT NULL,
  PERIOD BUSINESS_TIME (EStart, EEnd),
  PRIMARY KEY (ENo, BUSINESS_TIME WITHOUT OVERLAPS));
```

Temporal columns **EStart** and **EEnd** are explicitly specified and used in the PERIOD clause. Additionally, the clause defines implicitly that **startdate** < **enddate.** In contrast to the SQL:2011 specification, the name for the PERIOD clause is given and cannot be specified by the user.

The insertion of tuples in a table with valid time corresponds to the convenient insertion of rows in a relational table. In other words, the syntax of INSERT has not been changed. Besides the convenient syntax for the UPDATE statement, DB2 supports the FOR PORTION clause, which specifies an additional temporal condition (see Example 2).

Example 2

```
UPDATE V_Emp
   FOR PORTION OF BUSINESS_TIME FROM '01.07.2013' TO '01.07.2014'
     SET EDept = 4   WHERE Eno = 12345;
```

ENO	EDEPT	ESTART	EEND
12345	3	2013-01-01	2014-01-01
12345	4	2014-01-01	9999-12-31

(The content of table before UPDATE has been executed.)

ENO	EDEPT	ESTART	EEND
12345	4	2013-07-01	2014-01-01
12345	4	2014-01-01	2014-07-01
12345	3	2013-01-01	2013-07-01
12345	4	2014-07-01	9999-12-31

The tuples in Example 2 are modified in the following way: the column with the value **Edept**=4 will be divided in two columns, one with the time period (1.1.2014, 1.7.2014) and the other with the time period (1.7.2014, 31.12.9999).
The FOR PORTION clause can be used in the similar ways with DELETE.

IBM DB2 uses the convenient syntax to query a table with valid time. Additionally, there are three options that are part of the FROM clause:

a) FOR BUSINESS_TIME AS OF …
b) FOR BUSINESS_TIME BETWEEN … AND …
c) FOR BUSINESS_TIME FROM … TO …

The first form of this clause displays all tuples with a time interval that contains the specified time granule. In contrast to the first form, the second and the third form specify time periods. The BETWEEN … AND … form specifies a closed time interval, while the FROM … TO … form defines a closed-open one. In both cases, all tuples with time periods, which overlaps the specified one, are selected.

Support of Transaction Time. IBM DB2 supports transaction time. Similarly to valid time, these tables include two columns, one for the start and the other for the end of transaction time (see Example 3). The data type of these columns has to be TIMESTAMP.

Example 3

```
CREATE TABLE T_Emp(ENo INT PRIMARY KEY NOT NULL,EDept INT
 ,sys_start TIMESTAMP(12) GENERATED ALWAYS AS ROW BEGIN,
    sys_end TIMESTAMP(12) GENERATED ALWAYS AS ROW END,
    trans_start TIMESTAMP(12) GENERATED ALWAYS AS
      TRANSACTION START ID, PERIOD SYSTEM_TIME (sys_start, sys_end));
```

The specification of time-variant attributes contains additional clauses. The GENERATED ALWAYS AS ROW BEGIN and GENERATED ALWAYS AS ROW END clauses specify the columns for the start and end time, respectively. The GENERATED ALWAYS AS TRANSACTION START clause specifies the transaction start time.

The definition of transaction time involves altogether two tables: The first one (see Example 4) stores only tuples with current time, while the second one, called history table, stores old versions of current tuples. Therefore, there are three steps in creation of tables with transaction time:

a) Create a base table
b) Create a history table
c) Alter the base table to enable versioning and name the history table

Example 4

```
CREATE TABLE H_Emp LIKE T_Emp;
ALTER TABLE T_Emp ADD VERSIONING USE HISTORY TABLE H_Emp;
```

The INSERT statement has the same syntax as convenient INSERT. Note that only values of time-invariant columns have to be explicitly specified, while the system implicitly inserts all time-variant values.

After execution of an UPDATE statement, the non-current part of each tuple is moved from the current to the corresponding history table. (The same is true for the DELETE statement.)

The syntax and semantics of convenient SELECT statements remain unchanged in relation to transaction time. To query old versions of tuples, DB2 supports three options in the FROM clause of the SELECT statement, which are identical to the same options for the valid time. (The only difference is that instead of phrase “BUSINESS_TIME”, “SYSTEM_TIME” is used.

Bitemporal Tables. A bitemporal table is a union of tables with valid and transaction time (see Example 5).

Example 5

```
CREATE TABLE BI_Emp(ENo INTEGER NOT NULL, EDept INT,
    EStart DATE NOT NULL, EEnd DATE NOT NULL,
sys_start TIMESTAMP(12) GENERATED ALWAYS AS ROW BEGIN NOT NULL,
sys_end TIMESTAMP(12) GENERATED ALWAYS AS ROW END NOT NULL,
    t_start TIMESTAMP(12) GENERATED ALWAYS AS TRANSACTION START ID
IMPLICITLY HIDDEN, PERIOD SYSTEM_TIME (sys_start,
     sys_end),  PERIOD BUSINESS_TIME (EStart, EEnd),
      PRIMARY KEY (ENo, BUSINESS_TIME WITHOUT OVERLAPS));
```

2.2 IBM DB2: Temporal Key Constraints and Coalescing

IBM DB2 supports the WITHOUT OVERLAPS clause in the PRIMARY KEY option of the CREATE (ALTER) TABLE statement [4]. This clause ensures that each value of the relational primary key is unique at any given point in valid time (see Example 1). The system does not support coalescing.

2.3 IBM DB2: Implicit vs Explicit Timestaps and PERIOD Type

IBM DB2 supports explicit as well as implicit timestamps. Explicit timestamps are supported by default, while implicit timestamps can be specified using the IMPLICITLY HIDDEN option. In that case, "SELECT * FROM table_name" does not display values of time-variant columns. These values must be explicitly named in to be displayed (see Example 14). DB2 does not support the PERIOD type.

3 Teradata

Teradata supports temporal data since Version 10. Teradata's temporal model is based upon the TSQL2 model [13] and contains three general features: time dimensions, the PERIOD data type and temporal qualifiers.

3.1 Teradata: Time Dimensions

Support of Valid Time. Time-variant attributes in Teradata's valid time tables are specified using the PERIOD data type. An attribute of the PERIOD type can be DATE or TIMESTAMP (see Example 6).

Example 6

```
CREATE MULTISET TABLE Emp( ENo INTEGER NOT NULL, EDept INTEGER NOT NULL,
    Emp_period PERIOD(DATE) NOT NULL AS VALIDTIME)  PRIMARY INDEX (ENo);
```

The **Emp** table contains the time-variant attribute **Emp_Period**, of the PERIOD data type. The VALIDTIME option specifies the attribute as valid time period.

All Teradata's DML statements can contain one of four temporal qualifiers, which are used for specification of conditions in relation to time-variant columns:

a) CURRENT
b) AS OF
c) SEQUENCED
d) NONSEQUENCED

All qualifiers can be specified with the VALIDTIME keyword, and with the TRANSACTION keyword. The CURRENT qualifier selects only the current tuples, i.e. tuples with valid time values related to the current time The SEQUENCED qualifier selects the tuples with the time interval that is contained in the time period specified with the qualifier. The NONSEQUENCED qualifier specifies that the time

dimension will be ignored and the involved table is considered as a non-temporal table. A query with AS OF expression retrieves tuples where the time period overlaps the time period of the specified expression. The Teradata's AS OF qualifier in relation to queries corresponds logically to the DB2 option with the same name. Also, the SEQUENCED qualifier corresponds to the BUSINESS_TIME FROM … TO … option in DB2. NONSEQUENCED does not have any logical equivalent in DB2.

Example 7

```
SEQUENCED VALIDTIME
INSERT INTO Emp (Eno, EDept, Emp_period)
    VALUES(12345, 4, PERIOD(DATE '2014-01-01', UNTIL_CHANGED));
```

The INSERT statement in Example 7 contains values of the DATE type, which define the start and end of valid time. For this reason each INSERT statement must be prefixed with the SEQUENCED VALIDTIME clause. Teradata supports the special value „UNTIL_CHANGED" for the „forever" value. The UPDATE statement in Example 8 is semantically equivalent to UPDATE in Example 2. The DELETE statement can be specified in the same way.

Example 8

```
SEQUENCED VALIDTIME PERIOD (DATE '2013-07-01', DATE '2014-07-01')
  UPDATE Emp SET Edept = 4 WHERE Eno = 12345;
```

Support of Transaction Time. The TRANSACTIONTIME clause defines a time period as transaction time (see Example 9). The transaction time-variant column must be of the TIMESTAMP WITH TIME ZONE type.

Example 9

```
CREATE MULTISET TABLE T_Emp( ENo INTEGER NOT NULL, EDept INT NOT NULL,
 T_Emp_period PERIOD(TIMESTAMP(6) WITH TIME ZONE) NOT NULL
                AS TRANSACTIONTIME)    PRIMARY INDEX (ENo);
```

Teradata also supports temporal qualifiers for transaction time. All qualifiers described earlier can be used for transaction time (with TRANSACTION keyword). The syntax of INSERT and UPDATE statements in Teradata is identical to the syntax of the same statements in IBM DB2. Teradata supports temporal extensions for SELECT, semantically similar to those extensions defined in IBM DB2:

a) CURRENT TRANSACTIONTIME

b) TRANSACTIONTIME AS OF TIMESTAMP

The first option selects only the current tuples, which fulfill the specified condition. Therefore, this option corresponds semantically to the FOR SYSTEM_TIME AS OF CURRENT_DATE clause in DB2. The semantics of the second option above is identical to the semantics of the DB2's FOR SYSTEM_TIME AS OF clause (see Example 10).

Example 10

```
TRANSACTIONTIME AS OF TIMESTAMP '2010-01-01 23:59:59'
SELECT Eno, EDept FROM T_Emp;
```

Note that Teradata does not support the SEQUENCED TRANSACTIONTIME clause. This clause would semantically correspond to the DB2's FOR SYSTEM_TIME FROM … TO … clause. SEQUENCED TRANSACTIONTIME can be implemented using the NONSEQUENCED TRANSACTIONTIME clause and the OVERLAPS operator [12]. Teradata supports bitemporal tables, too.

3.2 Teradata: Temporal Key Constraints and Coalescing

Teradata supports three qualifiers in relation to temporal primary key constraint:

a) CURRENT VALIDTIME PRIMARY KEY
b) SEQUENCED VALIDTIME PRIMARY KEY
c) NONSEQUENCED VALIDTIME PRIMARY KEY

The first constraint ensures that the value for the constrained column in a tuple is unique for all instances of time from current time through the future. The second constraint ensures that the value for the constrained column in a tuple is unique for all instances of time, including past, current, and future. The semantics of this constraint is identical to the semantics of the DB2's WITH OVERLAPS clause. The third constraint treats a time-variant column as a non-temporal column. Teradata does not support referential constraints on tables with valid time [10].
Teradata does not support actually coalescing of data. The only way to coalesce data is using the P_NORMALIZE function, but it works only for the output. The implementation of coalescing is under way and is based upon the paper [16].

3.3 Teradata: PERIOD Data Type and Implicit Timestamps

Teradata is the only DBMS which supports the PERIOD data type. The system supports temporal operators, such as CONTAINS, OVERLAPS and MEETS [11].

Teradata supports implicit timestamps. This means that values of temporal attributes will not be displayed with queries, such as the following one:
"SELECT * FROM table_name". The only way how values of temporal columns can be displayed is naming them explicitly in the projection of a query (see Example 14).

4 Oracle

Oracle supports temporal data since Version 12c. The characteristic of Oracle's support for temporal data is that there are two independent components: valid time is based upon the component called "Temporal Validity", while "Flashback Data Archive" supports transaction time.

4.1 Oracle: Time Dimensions

Support of Valid Time. The PERIOD clause in the CREATE TABLE statement is used to specify valid time intervals (see Example 11). Whether time-variant attributes are implicitly or explicitly defined depends on the PERIOD clause [5].

Example 11

```
CREATE TABLE Emp(ENo INTEGER, EStart DATE,EEnd DATE, EDept INT,
                 PERIOD FOR EPeriod (EStart, EEnd));
CREATE TABLE Emp_1(ENo INTEGER,  EDept INTEGER);
ALTER TABLE Emp_1 ADD PERIOD FOR valid_time;
```

The first statement in example above specifies explicitly the names of the two in the PERIOD clause. The second statement creates a table with implicitly defined time-variant attributes. The names of these attributes, **valid_time_start** and **valid_time_end,** are derived from the name of the PERIOD clause.

Support of Transaction Time. The creation of a table with transaction time requires that an archive is created first [6].

Example 12

```
CREATE TABLE TEmp(Eno INT PRIMARY KEY NOT NULL,Edept INT)
   FLASHBACK ARCHIVE dusan;
```

The insertion of tuples in a table with transaction time is identical to the same activity with IBM DB2. The same is true for the UPDATE statement (see Example 2).

Concerning the SELECT statement. Oracle supports additionally two different forms of the TIMESTAMP option to select current as well as old versions of tuples. To specify a time granule, the AS OF TIMESTAMP clause is used. The second query shows how to retrieve a time interval.

Example 13

```
SELECT * FROM T_Emp AS OF TIMESTAMP CURRENT_TIMESTAMP;
SELECT * FROM T_Emp AS OF TIMESTAMP TO_TIMESTAMP
        ('12-05-2014 11:20', 'dd-mm-yyyy hh24:mi');
SELECT eno ,versions_startscn,versions_endscn FROM T_emp
VERSIONS BETWEEN TIMESTAMP TO_TIMESTAMP ('12-05-2014 11:20', 'dd-mm-yyyy
hh24:mi') AND TO_TIMESTAMP('12-05-2014 11:30','dd-mm-yyyy hh24:mi');
```

A bitemporal table in Oracle is formed through union of a valid time table and a corresponding transaction time table.

4.2 Oracle: Temporal Constraints and Coalescing

Oracle does not support temporal key constraints. The user has to define time-variant columns for valid as well as transaction time. The system does not support any form of coalescing.

4.3 Oracle: Implicit vs. Explicit Timestamps and PERIOD Type

Oracle supports implicit as well as explicit timestamps. To specify explicit timestamps, the temporal columns have to be defined and the PERIOD clause must contain their names. If the PERIOD clause does not contain the specification of

temporal columns their names are derived from the name of this clause. (The PERIOD data type is not supported by Oracle.)

Example 14

```
SELECT * FROM Emp_1;
SELECT e.*, valid_time_start, valid_time_end FROM Emp_1 e;
```

The queries above display different results. The first one displays only values of time-invariant columns, while the second one displays values of all columns.

5 Microsoft SQL Server

Microsoft will support temporal data with SQL Server 2016. The characteristic of Microsoft's support is that there are just a few concepts which the system supports. For this reason, the structure of this section will be different than the structure of the other sections. (The detailed discussion of the future support of temporal data for SQL Server can be found in [8].)

From all concepts listed in the introductory part of this paper, SQL Server 2016 supports only transaction time. (Microsoft refers to the tables that implement transaction time as "temporal tables".)

Example 15

```
CREATE TABLE dept_temp(dept_no CHAR(4) NOT NULL PRIMARY KEY CLUSTERED,
 dept_name CHAR(25) NOT NULL,  location CHAR(30) NULL,
s_date DATETIME2 GENERATED ALWAYS AS ROW START NOT NULL,
e_date   DATETIME2 GENERATED ALWAYS AS ROW END NOT NULL,
   PERIOD FOR SYSTEM_TIME (start_date, end_date))
WITH (SYSTEM_VERSIONING= ON(HISTORY_TABLE = dbo.Hist));
```

Microsoft's implementation of transaction time corresponds to specification of the SQL:2011 standard. The WITH SYSTEM_VERSIONING option is used to enable the creation of the corresponding history table.

The only temporal extensions are in relation to the SELECT statement. These are:

- AS OF <date_time>
- FROM <start_date_time> TO <end_date_time>
- BETWEEN <start_date_time> AND <end_date_time>
- CONTAINED IN (<start_date_time> , <end_date_time>)

The first three clauses correspond to the clauses specified in the SQL standard, while the last one returns a result with the values of all old versions that were opened and closed within the specified time range defined by the two parameters in CONTAINED. (The syntax of UPDATE and DELETE has not been extended with any temporal clauses.)

6 Summary

The most important attitude of temporal extensions in DB2 is that they are implemented according to the specification in the SQL:2011 standard. The only significant difference is that IBM DB2 uses two tables to store transaction time data, one for current tuples and the other for old versions of them. In contrast to IBM DB2, the temporal model of Teradata corresponds to the TSQL2 model. Concerning implicit and explicit timestamping, Teradata supports only the first one. As a direct consequence of this fact, the basic data object in Teradata is not a relation, and the temporal model supported by this database system is certainly not relational. Oracle's current implementation of temporal data seems rudimentary, because many temporal concepts are not implemented.

From our point of view, the two most important temporal concepts are the support of the PERIOD data type and coalescing. Teradata has already implemented the first concept and will implement the second one in the future. IBM DB2, and its underlying temporal model specified in the SQL:2011 standard lack these concepts. We can hope that the implementation of these concepts will happen soon.

References

[1] Allen,J.-Maintaining knowledge about temporal intervals,in CACM, 1983.
[2] Böhlen, M.,Snodgrass,R.-Coalescing in Temporal Databases, VLDB, 1996
[3] ISO/IEC 9075-2:Information technology–DB languages–Part 2, 2011.
[4] Nicola, M.; Sommerlandt, M. - Managing time in DB2 with temporal consistency, www.ibm.com/developerworks/data/library/techarticle/dm-1207/index.html, 2012.
[5] Multitemporal Features in Oracle 12c, www.salvis.com/blog/2014/01/04/multi-temporal-database-features-in-oracle-12c/
[6] Oracle Flashback Data Archive, http://www.oracle-dba-online.com
[7] Petković, D. – Modern Temporal Data Models: Strengths and Weaknesses, BDAS 2015, Springer, Communication in Computer Science, Vol. 521.
[8] Petković, D.-SQL Server 2016, Beginner's Guide, McGraw-Hill, 2016 (to appear)
[9] Saracco, C., Nicola, M., Gandhi, L. - A matter of time: Temporal data management in DB2, www.ibm.com/developerworks/data/library/techarticle, 2012.
[10] Sannik, G.; Daniels, F. - Enabling the Temporal Data Warehouse, http://www.teradata.com/white-papers/Enabling-the-Temporal-Data-Warehouse.
[11] Snodgrass -Developing Time-Oriented Applications in SQL, Morgan Kaufman
[12] Snodgrass, R. - A Case Study of Temporal Data, http://www.teradata.com/white-papers/A-Case-Study-of-Temporal-Data-eb6237/?type=WP
[13] Snodgrass, R. - The TSQL2 Temporal Query Language, Springer Verlag, 1995.
[14]Teradata: SQL Functions, http://tunweb.teradata.ws/tunstudent/TeradataUserManuals/SQL_Reference__Functions_Operators_Expressions_Predicates.pdf.
[15] Wijsen, J. – Temporal Integrity Constraints, www.informatique.umons.ac.be/jef
[16] Kateb, M. Ghazal, A.- An Efficient SQL rewrite approach for temporal coalescing in Teradata, DEXA 2012, LNCS, Vol 7447, pp.375-383.

Governance of Higher Education Institutions in Brazil: an Exploratory Study Based on Supply and Demand Conditions

Sílvia Regina Machado de CAMPOS[1],
NOVA IMS, Universidade Nova de Lisboa, Lisboa, Portugal.
Roberto, HENRIQUES[2],
NOVA IMS, Universidade Nova de Lisboa, Lisboa, Portugal.
Mitsuru Higuchi YANAZE[3],
Universidade de São Paulo, São Paulo, Brazil.

Abstract: This article aims to assess the context of Private Brazilian Higher Education Institutions comparing their supply and demand conditions. It adopts an inductive and exploratory methodological approach through the longitudinal analysis of data provided by the Census of Higher Education, between the years of 2008 and 2013, and the Demographic Census of 2010, in order to map its scenario. Its contribution shall enable higher education institutions (HEI) to identify new target groups as potential entrants, enhance the discussion of forms and mechanisms of governance models and deliver strategic information.

Keywords: higher education institutions; university governance; supply and demand; strategic information.

1. Introduction

The educational system of a country is, as a rule, consistent with the governmental system of that country. Normally the future welfare and the national purpose and public policies are dependent upon the universities and other kinds of higher education institutions (HEIs) [1].

However, in the last decades, around the globe, higher education (HE) has been subject to profound changes [2]. The pressures for higher education grew up, and the profit-making educational establishments expanded, creating a fierce competition and an imbalance marketing condition, which hampered the higher education institution's flexibility and responsiveness and had threatened their financial and economic sustainability [3].

As some previous research has shown, "*amid demands for universities 'to do more with less', national education policy makers are designing and embracing new models of governance and frequently transforming HE institutions, the role of the state, as well as the socio-economic role and function of HE"*[2].

The higher education institutions are exposed to marketplace pressures in a similar way to other businesses [3]. Mainly as private providers, they depend on adequate enrollment growth, quality, cost-effectiveness and equitable access to a remarkable extent. Add to this, a more "evaluative" role adopted by the state, which puts pressure on HEIs outputs [4].

This new scenery has modified, as in many different countries, the forms and mechanisms of management and governance[3].

Many authors have been approaching the higher education changes from various perspectives

1 PhD Student in Information Management at NOVA IMS, Universidade Nova de Lisboa, Lisboa, Portugal. E-mail: silvia.rmc@hotmail.com.
2 PhD in Information Management. Professor at NOVA IMS, Universidade Nova de Lisboa, Lisboa, (Portugal). E-mail: roberto@novaims.unl.pt.
3 PhD in Marketing and Communication. Professor at Universidade de São Paulo, São Paulo, (Brazil). E-mail: mitsuruyanaze@uol.com.br.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_3

including supply and demand [5-29] and management and governance [1-4, 30-36] around the world to comprehend its context. Their discussion contributes to this research as the higher education institutions in Brazil will not be free to this environmental flux and will need to adapt themselves, considering its nuances and peculiarities. Also, the HEIs will need to align their management practices to a prominent market-oriented form of governance.

This article proposes to analyze and to compare the data from two Brazilian surveys like *Censo da Educação Superior*[4], an annual survey, conducted by the National Institute of Educational Studies Anísio Teixeira (INEP), an autarchy linked to the Ministry of Education, from the period of 2008 to 2013; and the Demographic Census (2010), a statistical study, conducted typically in ten years. It intends to compare some variables, specially: the total number of HEIs, places offered, candidates, entrants, students enrolled and undergraduate students and the percentage of young people (aged 18 to 24) proportionally to the total resident population.

It adopts an inductive process as a research strategy and an exploratory and longitudinal methodological approach. It uses descriptive statistics analysis of dynamics in the time series datasets that have been summarized at the *Panel Dataset* and graphically presented.

The remainder is organized as follows. The next section presents the Literature Review on supply and demand conditions of the private higher education institutions in Brazil in the last decades. Discussions and practical implications are provided in section three. The final section points out some recommendations for future research.

2. Supply and Demand for Higher Education Institutions

The terms supply and demand come from the Offer and Demand Law, used to identify the relationship between the demand for a product and the amount that it is offered and, also, to describe the consumer's behavior in the purchase of goods and/or services at certain times, in function of its amount and price [5].

It provides that, in periods when the supply of a particular product far exceeds demand, its price tends to fall. When demand begins to outstrip supply, the trend is the increase in price. The stabilization of the relationship between supply and demand would, in the first instance, lead to a stabilization of the price and a situation of "balance."

Competition could disrupt these relationships, causing price changes. Other factors, besides prices, participate in the conditions of variation between supply and demand. The value of a product can be a positive or negative incentive for consumers to buy goods or services they need, but not the only one. Thus, other factors have been identified as participants in the variation between supply and demand, such as consumer wants and needs; purchasing power; availability of services; and offering capacity of institutions [5].

One can also add to this discussion, dimensions related to the offering, for example, of products and/or services focused on generating knowledge, involving not only discussion of their economic value, but also its relationship and impact on its social value [31].

Over the past decades, numerous authors have studied the relationship between supply and demand in higher education institutions in an attempt to identify the demand of students entering and quantify it appropriately (*e.g.* [9, 10, 24, 25]).

2.1. Historical Context of Higher Education Institutions in Brazil

Until the 60s, the Higher Education in Brazil was marked by a limited supply. There were a significant number of "surplus" students for places offered which translated into "candidates who obtained the average rate in college entrance exams, but could not enroll in higher-level schools because the number of approved extrapolated the number of places available" [37]. There was, therefore, a point of "bottleneck". This condition was due to a significant number of students who concluded high school due to promotion policies to higher levels and financing of studies [37].

At the end of the 60s, this situation begins to revert to the idea of "expanding with restraint",

[4] The Census of Higher Education

supported by an incipient funding policy to public and religious institutions to partially fill this existing demand [37-39].

In the 70s the first expansion of higher education occurred, led by the private sector, to increase the number of educational institutions, courses, places and enrolled students [40].

The late 80s and early 90s were marked by periods of growth interspersed with stagnation due to the economic crisis experienced by the country, evidenced by high rates of inflation and unemployment [38].

From the end of the 90s, a significant increase in a number of places occurred broadening people's access to higher education. From 1994, private higher education institutions were encouraged to increase the number of places offered and, after 2002, also the number of places provided by public higher education institutions increased. This is the so-called democratization period [38] or universalization of higher education [32, 41].

With the Brazilian expansion policy of higher education in the two recent decades, higher education institutions face a bigger competitiveness in search of students, resources, quality and price, in addition to offering other modalities, such as technologists training courses or those offered in online mode, reflecting directly in their forms of governance.

2.2. The Supply and Demand Conditions in Brazil

It can be observed from data provided by the Census of Higher Education, the increase in the number of higher educational institutions, throughout the 1980-2013 period, from 882 (eight hundred and eighty-two) IES in 1980 to 2391 (two thousand, three hundred and ninety-one) in 2013, representing a growth of 271% in number of higher education institutions. If we consider the period under study, this percentage is around 106% between 2008 and 2013.

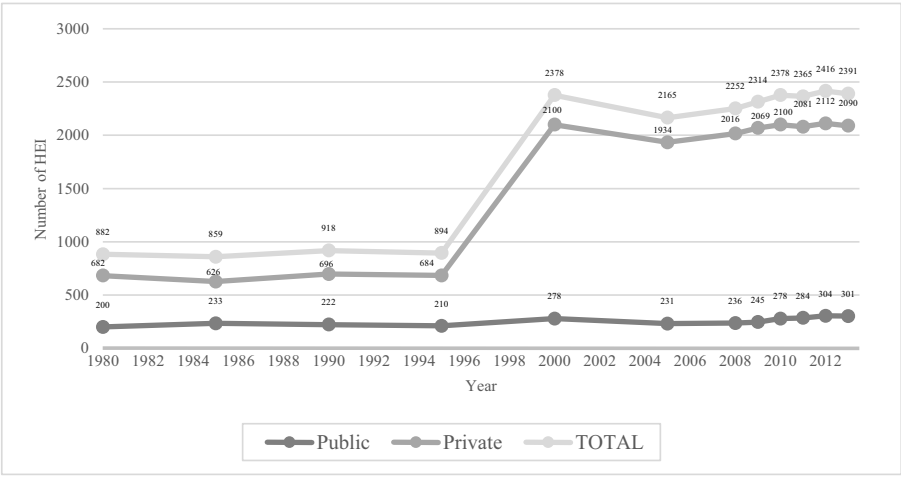


Fig. 1. Higher Education Institutions-1980-2013, Brazil. Source: MEC/INEP.

In 2013, private HEIs accounted for about 87.41% of all universities in Brazil, while public higher education institutions accounted for some 12.59% of the total. Note that from 2012 to 2013 there was a decrease in the number of HEIs of the two categories in the order of 1.03%. There is a predominance of the number of private higher education institutions on the public.

Although the change in the total number of higher education institutions, between the years 2008 and 2013, has minor modifications (increases or decreases), their distribution throughout the country and the degree of participation of the five regions in the market proved to be quite different. In a longitudinal analysis, there has been a change in the selectivity of the regions to meet

potential demands. Earlier, the Southeast region was the most "attractive", due to its high market share. From the data analyzed, the focus of the last two years is in the South, Northeast, and Midwest what corroborates with the literature when it mentions the process of expansion of higher education and its internalization to other regions of the country [34, 39].

On the one hand, there was no significant change in the total number of higher education institutions in Brazil over the period studied, as explained (around 1.03%). On the other, the number of undergraduate courses offered and the consequent number of vacancies has grown substantially over the same period, reaching about 24.56% and 14 89% respectively. This means an increase of 6,072 courses and 444 578 vacancies during this time.

Concerning the evolution of the number of vacancies, candidates, places, enrolled and undergraduate, data from the period show the imbalance between supply conditions, represented by the number of places offered; and demand, "translated" by the number of candidates, places, enrollments,and undergraduates.

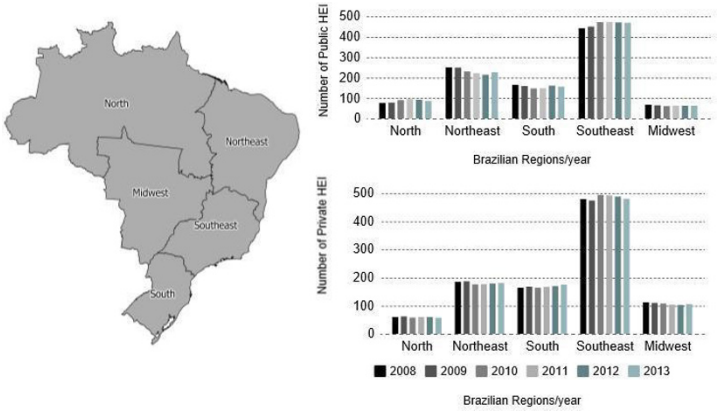


Fig. 2. Public and private number of HEI in Brazil - 2008-2013. Source: MEC/ INEP.

The number of places offered, which has been growing since 2008, is superior to the number of candidates' places, which sets up a market instability condition with supply greater than demand. In the data analyzed (Table 1), while in 2008 this condition was already present, the number of vacancies expanded in subsequent years by higher education institutions. In contrast, it is observed that the number of candidates, places, and enrolled increases, but in very different proportions. Except the number of undergraduate students does not follow the same proportion of students enrolled.

Table 1. Number of places, candidates, entrants, enrolled and undergraduate - 2008 a2013

	2013	**2012**	**2011**	**2010**	**2009**	**2008**
Places offered	3.429.715	3.324.407	3.228.671	3.120.192	3.164.679	2.985.137
Candidates	11.945.079	10.927.775	9.166.587	6.698.902	6.223.430	5.534.689
Entrants	1.951.696	1.970.392	1.686.854	1.590.212	1.511.388	1.505.819
Enrolled	6.152.405	5.923.838	5.746.762	5.449.120	5.115.896	5.080.056
Undergraduate	800.318	826.928	829.286	865.161	876.091	829.938

Source: MEC/ INEP.

When it comes to the number of undergraduate courses offered, there is an increase in the number of courses offered, contrary to what happened with the number of higher education institutions

(HEIs). This indicates that HEIs are providing a larger list of options (wider range of courses) since there is no change in the absolute number of HEIs. Although the number of undergraduate courses increased, its distribution among the regions of Brazil is also quite distinct.

Table 2. Number of Courses 2008-2013

Year	Courses
2008	24.719
2009	27.827
2010	28.577
2011	29.376
2012	30.718
2013	30.791

Source: MEC/ INEP.

The offering of courses is predominantly concentrated in the Southeast, followed by the South, Northeast, Midwest and North regions, respectively. Small variations are observed over the period, as well as a trend change in the scenario, and a supply shift to other regions, such as Northeast, South, and Midwest. The market remains in unstable condition with supply greater than demand; and the increased offering courses and places by the higher education institutions.

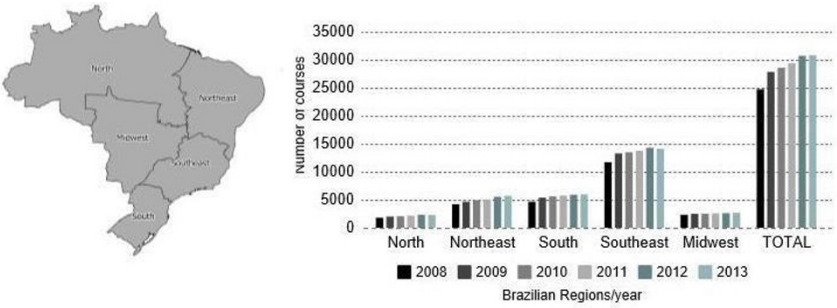


Fig. 3. Number of Undergraduate Courses in Brazil - 2008-2013. Source: MEC/ INEP.

From the demand perspective, the expansion of higher education occurred, predominantly, with the number of vacancies (unfilled places) followed by the substantial increase in the number of educational institutions [42]. Despite the growing demand for higher education in Brazil be related to the expansion of the completion of basic education rate, this demand was only partially met, given the predominantly private character of the offered places [42], which requires financial means to match fees charged. Part of the supply of places in private higher education institutions has been accompanied by an increase in the proportion of unfilled places.

Another reason that contributes to the considerable number of vacant or unfilled places on the higher education institutions is due to the priority and the rapid expansion of the network of universities, not followed by corresponding growth in the lower levels of education, mainly high school, blocking the advance to higher education [43]. Just a few entered the beginning of schooling and many stranded midway, due to high failure rates and evasion in this level of education, reflecting in the potential demand for higher education [42, 44].

Other factors influence the demand, for example, the large portion of the population that do not have access to higher education in the age group considered "ideal," as well as livelihood opportunities and the needs of the labor market [6]. Therefore, there is a contingent of people over 24 years to be attended, called "late entry" population [42].

2.3. The Demographic Perspective

From the demographic point of view, it is assumed that this market instability is getting worse, since the evolution of the size of the Brazilian youth, over these last decades, especially the one in the range of 18 and 24, representing the incoming quota for higher education, is not presented in ascending order. Over and, according to the outlook, this young cohort grew until 2008, when it reached its peak and, from there, according to the Department of Strategic Affairs (SAE) [45] of the Presidency of Brazil (2013), declined (Fig. 4).

According to its estimates[45], the youth has expanded sharply in 20 years (1983 to 2002) and will remain stagnant for another 20 (2003-2022), and then, in the twenty years following, twitching in rhythm with which expanded (the size of the youth will contract by 12.5 million between 2023 and 2042), as shown in Figure 5.

Associated with this condition is the fact that Brazil lives a moment of transition in which there is an increase in life expectancy and lower birth rates, reflecting thus reducing the average number of children per woman. As a result, in addition to reducing the number of children, there is a slowing of population growth, with a significant impact on youth contingent [46, 49, 50].

It is true that the population of young people will continue to exist, but with a smaller number of people, which will reflect in a fiercer competition for that audience. Added to this context the variable employment, given the need for subsistence or joining the large contingent of the population in the labor market, which prevents the continuation of studies [6].

It follows on from the above, that the expansion of higher education policy has given signs of exhaustion, with idleness on the number of vacancies offered; plus, although market saturation in various professions, by bad debts and the inability to commit significant part of the income from the monthly payment[6, 43, 46].

Brazil had in 2010 a resident population of 190,755,799 people (Census 2010). Of these, 3,367,172 between the ages of 18 years hypothetically entitled to enter higher education. However, this entire contingent did not arrive at higher education, since the data provided by the Census of Higher Education show that the number of entrants was 1,590,212 and 5,449,120 were registered; being less than the number of places offered 3,120,192 in 2010.

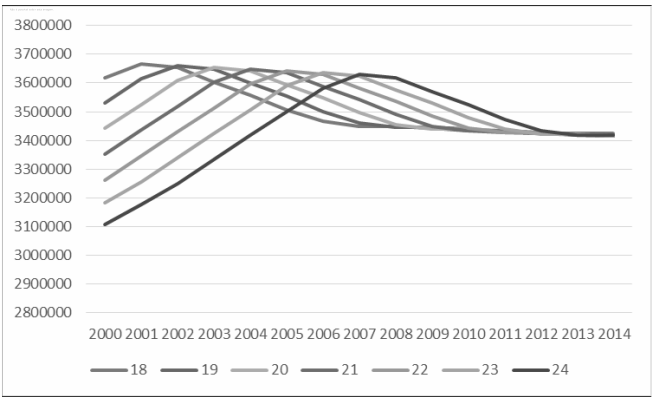


Fig. 4. Evolution of young people aged between 18 and 24 years old. Source: IBGE.

Theoretically, the number of young people old enough to enter higher education (18 years) is 3,367,172 to 3,120,192 places offered. However, as evidenced by the data of the Census of Higher Education, in practice, the number of entrants was 1,590,212, which represents only 47% of all young people in the age range considered ideal for pursuing it. Even smaller is the number of undergraduate students. It forecasts that the number of youth will suffer a drastic reduction from 2020, confirming that this "potential demand" will be reduced further.

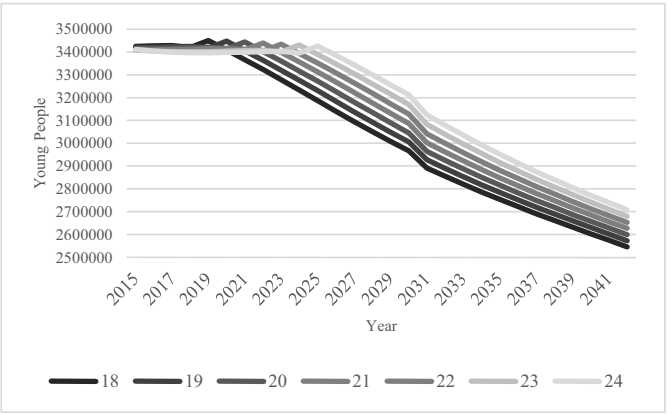


Fig. 5. Projection of young people aged between 18 and 24 years old, 2015-2042. Source: IBGE.

This instability of supply and demand conditions directly affects sustainability and governance of Private HEIs. That is the reason they need consistent demand estimation models as well studies involving educational distribution, especially in a country like Brazil, of vast territorial dimensions [47], associated with the review and proposal of public policies conducive to its actual scenario.

Table 3. Total percentage of young people aged 18 to 24 in the total population

Total number of places offered	Total percentage of young people aged 18 to 24 in the total population		
3.120.192	18 years old	1,77%	3.367.172
	19 years old	1,71%	3.265.826
	20 years old	1,78%	3.389.729
	21 years old	1,79%	3.421.736
	22 years old	1,84%	3.510.497
	23 years old	1,79%	3.420.254
	24 years old	1,84%	3.502.976
	Total resident population		190.755.799

Sources: IBGE (Demographic Census, 2010). MEC/INEP.

2.4. Governance and Management

Governance and Management have different implications. The ISO 38502:2014 [35] – which provides guidance on the nature and mechanisms of governance and management together with the relationships between them, in the context of Information Technology (IT) within an organization – define them as: "*governance* – the system of directing and controlling"; and "*management* –exercise of control and supervision within the authority and accountability established by governance".

Despite the fact that these definitions are related to the Information Technology (IT) environment, it could also be transposed to the Higher Education Sector, as they did not differ in concept to what other authors [2, 3, 33] propose, as stated below.

2.4.1. Governance and Management in Higher Education Institutions

As the Private Higher Education Institutions have been faced to the presented scenery, this will require them new forms and mechanisms of management and governance to grant its

sustainability to long term. So, it is necessary to distinguish between both terms and their implications.

Concerning the Higher Education, *Governance* focuses on the rules and mechanisms by which various stakeholders influence decisions, how they are held accountable, and to whom. It englobes organizational and managerial structures, state regulation, inter-institutional competition and the policies that arrive from this agenda [33]. It refers to "the formal and informal exercise of authority under laws, policies, and rules that articulate the rights and responsibilities of various actors, including the rules by which they interact*"* [3].

Governance encompasses "*the framework in which an institution pursues its goals, objectives and policies in a coherent and coordinated manner*"[3]. In other words, it is the analysis of how higher education is governed, including a legislative framework, the characteristics of the institutions and how they relate to the whole system, as well as less formal structures and relationships, which steer and influence behavior.

Dobbins, Knill and Vögtle [2] proposed three ideal-type models of governance for higher education institutions, which comprises patterns of control, coordination, and the autonomy allocation among State, professoriate and university management. They are the state-centered model, "where the state directly coordinates all or most aspects of higher education". The university as a self-governing community of scholars, also called the Humboldt model, or Republic of Science or Ivory Towers, "based on a state-university partnership, governed by principles of corporatism and collective agreements." Moreover, the market-oriented model, "which contend that universities function more effectively when operating as economic enterprises within and for regional or global markets". The latter defines its policy to increase quality and variety of services offered, strengthening students' choice.

In the market-oriented model, HEIs are seen as a commodity, investment, and strategic resource and may offer governments an array of instruments to enhance competition such as regulations on subsidies and instruments affecting pricing structure and enrollment [2].

Management, on the other hand, refers to the implementation of a set of objectives pursued by a higher education institution based on established rules. It answers the question: 'How are the rules applied' and is concerned with the efficiency, effectiveness and quality of services provided for internal and external stakeholders [3].

Management is part of the governance process and a final stage of a more complex activity because it refers to the process of implementation of the decisions, the day-to-day activities to ensure the achievement of the strategies and goals [3].

3. Discussion

Whereas the aim of this paper was to evaluate the context of Brazilian Higher Education Institutions in order to provide subsidies to generate strategic information, it concludes that offer conditions are diverse, and that demand is increasingly limited for the population considered ideal for undergraduate courses.

As in Brazil, the Higher Education is mainly provided by the private sector (Fig. 1), the HEIs compete for students and financial resources, increasing its quality and variety of services offered, competitive forces are guided by adaptation to new constraints and opportunities.

From 2008 to 2013, the number of Higher Education Institutions varied slightly. If considered the 2008 year as a reference, the total number has increased from 2.252 to 2.391 (Table 1 from *ANNEXE 1 – Panel Dataset*).

The number of courses increased (Table 2 from *ANNEXE 1 – Panel Dataset*) during 2008-2013, but not reflected in the number of the enrolled students (Table 6 from *ANNEXE 1 – Panel Dataset*) when compared to the demographic, young population data. If, in the 60s, there were many students concurring to a place in the HEIs [37], nowadays, the situation inverted. There is a high number of vacant or unfilled places for each potential student. As an example, from 2008 to 2013, the number of places offered for undergraduate courses almost duplicate, from 1.715.994 to 3.429.715 (Table 3

from *ANNEXE 1 – Panel Dataset*). Also the number of candidates improved from 5.534.689 to 11.945.079 (Table 4 from *ANNEXE 1 – Panel Dataset*), but, as already said, was not converted in enrolled students as the same candidate can enroll for more than one selective process in different HEIs.

For the same period, the number of entrants has grown up from 1.505.819 to 3.429.715 (Table 5 from *ANNEXE 1 – Panel Dataset*).

There was an internalization of education in the period studied, but most of the places offered, enrolled students and candidates were concentrated in the Southeast, Northeast and South regions. The number of undergraduate students is lowermost if compared to the enrolled students (Table 7 from *ANNEXE 1 – Panel Dataset*), calling the attention to the fact that despite all the efforts of the expansion and internalization of the HEIs, it has little effect in practice, since the undergraduate do not occur effectively.

Besides that, the information generated from the analysis of microdata of the Census of Higher Education, associated with the Demographic Census data (2010), points to a drastic reduction in the population of young people aged 18-24 years, which is going to be scarce in a short period. Today Brazil has the largest number of young people in its history [45]. However, as studies indicate [42], from 2025 this figure will be reduced drastically.

Both conditions – reduced number of enrolled and undergraduate students added to the reduction of the youth population considered ideal for undergraduate courses – will impact in the private higher education institutions' sustainability conditions. Nowadays, the HEIs already have more places offered than the number of enrolled students.

On the one hand, this map of the scenery calls attention to the practical implications of this study like the necessity to retain the enrolled students, avoiding evasion and promoting permanence in the HEIs as a way of improving the number of enrolled and undergraduate students. Besides that, the countries' education level has a great impact on its development. So, it would be of great interest and relevance improving the number of undergraduate people. As a result, the HEIs will need to enhance the discussion of forms and mechanisms of governance models as the above conditions, plus the fierce competitiveness, impact on their future maintenance.

By the other hand, at the same time, they will need to identify new target groups as potential entrants, as they are faced with the falling birth rate and the increasing of aging population. Concerning this subject, based on the literature review and in the data analyzed, this study punctuates potential target entrants, despite the one considered ideal for undergraduate courses which are the so-called "*late entry*" population [42]; the *stranded midway younger students* [43], and the "*academic second-training professional*" already undergraduate which would like to embrace a new profession. The HEIs will need yet to estimate correctly these groups and to evaluate its impact on their offer conditions' and proper ways of implementation.

Complementary, price concurrence varies in a high range in the country, depending on knowledge area, country regions, HEIs price and discount policies and government subsidies. Important to state that Public Education for undergraduate courses is free of charge. Even though, the number of unfilled places continues for the vast majority of undergraduate courses.

As a gap, it points the 2014's year Census of Higher Education disclosure of results that has not occurred till this moment. Also, the period between the data collection and its availability incurs in a lack of time which could impact the decision-making process of the HEIs. So, it is highly recommended that HEIs be attentive to the data, as they point tendencies; but also monitor their economic, political, educational and technological environment.

4. Future Research

Further study will be required to evaluate the impacts of the new potential target groups of entrants in the HEIs and to enhance the discussion about its forms and mechanisms of governance, especially in a country like Brazil, where education moved from a privilege to a right or a necessity for successful life and employment. This research continues in order to be updated with the Census of Higher Education new data.

References

1. Selden, W.K.: The Governance of Higher Education. Science 149, 711 (1965)
2. Dobbins, M., Knill, C., Vögtle, E.: An analytical framework for the cross-country comparison of higher education governance. Higher Education 62, 665-683 (2011)
3. Cucui, I., Robescu, V.-O., Stegaroiu, I., Petrescu, M.: Knowledge Management and Impact on Governance of Romanian Universities. Proceedings of the European Conference on Knowledge Management 315-322 (2010)
4. Carnoy, M., Dossani, R.: Goals and governance of higher education in India. Higher Education 65, 595-612 (2013)
5. Miranda, M.B.: A lei da oferta e da procura e os preços dos produtos e serviços. Revista Virtual Direito Brasil 6, (2012)
6. Neri, M.: Educação profissional: as razões da demanda. Conjuntura Social
(2011)
7. Buss, C., Parker, J., Rivenburg, J.: Cost, quality and enrollment demand at liberal arts colleges. Economics of Education Review 23, 57-65 (2004)
8. Callahan, R.B.: Private College Enrollment in the Midwest: An Exploration of Significant Growth within a 10-Year Period. (2014)
9. Canton, E., de Jong, F.: The demand for higher education in The Netherlands, 1950–1999. Economics of Education Review 24, 651-663 (2005)
10. Duchesne, I., Nonneman, W.: The Demand for Higher Education in Belgium. Economics of Education Review 17, 211-218 (1998)
11. Eight, G.o.: Future demand for Higher Education in Australia. (2010)
12. Glewwe, P., Jacoby, H.G.: Economic growth and the demand for education: is there a wealth effect? Journal of Development Economics 74, 33-51 (2004)
13. Gölpek, F.: Price of higher education and individual demand. Procedia - Social and Behavioral Sciences 41, 349-356 (2012)
14. Guimbert, S., Miwa, K., Thanh Nguyen, D.: Back to school in Afghanistan: Determinants of school enrollment. International Journal of Educational Development 28, 419-434 (2008)
15. Hübner, M.: Do tuition fees affect enrollment behavior? Evidence from a 'natural experiment' in Germany. Economics of Education Review 31, 949-960 (2012)
16. King, J.: The Demand for Higher Education in Puerto Rico. (1993)
17. Menon, M.E.: The demand for higher education in Cyprus: an educational policy perspective. Higher Education Policy 10, 31-39 (1997)
18. Mueller, R.E., Rockerbie, D.: Determining demand for university education in Ontario by type of student. Economics of Education Review 24, 469-483 (2005)
19. Noorbakhsh, A., David, C.: The demand for higher education: Pennsylvania's nonresident tuituion experience. Economics of Education Review 21, 277-286 (2002)
20. Radner, R., Miller, L.S.: Demand and Supply in U.S. Higher Education: A progress report. (1970)
21. Saiti, A., Prokopiadou, G.: The demand for higher education in Greece. Journal of Further & Higher Education 32, 285-296 (2008)
22. Tansel, A., Bircan, F.: Demand for education in Turkey: A tobit analysis of private tutoring expenditures. Economics of Education Review 25, 303-313 (2006)
23. Tierney, M.L.: The Impact of Institutional Net Price on Student Demand for Public and Private Higher Education.
24. Toutkoushian, R.K.: Changes in the demand for public land-grant Universities: the use of Panel Datasets. Research in Higher Education 42, 679-707 (2001)
25. Vieira, C.V., Isabel: Determinants and projections of demand for higher education in Portugal. CEFAGE-UE (2011-2015)
26. Wetzel, J., O'Toole, D.a., Peterson, S.: An analysis of student enrollment demand. Economics of Education Review 17, 47-54 (1998)
27. Wilkins, S.: Higher Education in the United Arab Emirates: An Analysis of the Outcomes of Significant Increases in Supply and Competition. Journal of Higher Education Policy and Management 32, 389-400 (2010)
28. Zhang, L.: Nonresident Enrollment Demand in Public Higher Education: An Analysis at National, State, and Institutional Levels. The Review of Higher Education 31, 1-25 (2007)
29. Žiga Čepar, Š.B.: Higher Education Demand Factors and the Demand for Tourism Education in Slovenia. Organizacija Volume 43, (2010)
30. Beuren, I.M., Teixeira, S.A.: Evaluation of management control systems in a higher education institution with the performance management and control. 2014 11, 24 (2014)
31. Kim, Y.J., Lee, C.-I.: Social values and economic dynamics. Journal of Economic Dynamics and Control 53, 69-84 (2015)

32. Lima, P.G.: Universalização da Educação Superior no Brasil: contrapontos e possibilidades. Educar em Revista n.51, p. 243-264 (2014)
33. Magalhães, A., Veiga, A., Ribeiro, F., Sousa, S., Santiago, R.: Creating a common grammar for European higher education governance. Higher Education 65, 95-112 (2013)
34. Silva, E.P.d.Q., Paulo César Ribeiro & Araújo, Elvira Aparecida Simões: Educação e desenvolvimento. Latina American Journal of Business Management - LAJBM v. 4, p. 42-57 (2013)
35. Commission, T.I.O.f.S.T.I.E.: Corporate governance of information technology.
36. Gulati, R., Nickerson, J.A.: Interorganizational Trust, Governance Choice, and Exchange Performance. Organization Science 19, 688-708 (2008)
37. Braghini, K.M.Z.: A história dos estudantes "excedentes" nos anos 1960: a superlotação das universidades e um "torvelinho de situações improvisadas". Educar em Revista n. 51, p. 123-144 (2014)
38. Martins, C.B.: A Reforma Universitária de 1968 e a abertura para o Ensino Superior Privado no Brasil Educ. Soc. 30, 15-35 (2009)
39. Tavares, M.d.G.M., Meneguel, S.M., Peixoto, A.L.V.A., Prado, A.d.P., Griboski, C.M., Robl, F., Barreyro, G.B., Fernandes, I.R., Rothen, J.C., Sousa, J.V.d., Bortolin, L., Oliveira, M.A.A.d., Seiffert, O.L.M.B., Abensur, P.L.D., Cavachia, R.C.: A relação expansão-avaliação da educação superior no período pós-LDB/1996. Revista Eletrônica de Educação 8, 92-105 (2014)
40. Sampaio, H.: versidade e Diferenciação no Ensino Superior no Brasil: conceitos para discussão RBCS 29 (2014)
41. Gomes, A.M.M., Karine Numes de: Educação Superior no Brasil Contemporâneo: transição para um sistema de massa Educ. Soc. 33, 171-190 (2012)
42. Corbucci, P.R.: Evolução do Acesso de Jovens à Educação Superior no Brasil (2014)
43. Castro, C.: Educação no Brasil: Atrasos, Conquistas e Desafios. (2006)
44. Barioni, M.C.N., Razente, H., Marcelino, A.M.R., Traina, A.J.M., Traina, C.: Open issues for partitioning clustering methods: an overview. Wiley Interdisciplinary Reviews-Data Mining and Knowledge Discovery 4, 161-177 (2014)
45. Estratégicos, G.F.P.d.R.S.d.A.: Juventude levada em conta: demografia. (2013)
46. Queiroz, F.C.B.P.Q., Jamerson Viegas; Vasconcelos, Natalia Veloso Caldas; Furukava,Marciano; Hékis, Hélio Roberto & Pereira, Flávia Aparecida Barbosa: Transformações no ensino superior brasileiro: análise das Instituições Privadas de Ensino Superior no compasso com as políticas de Estado. Ensaio: aval. pol. públ. Educ. v. 21, p. 349-370 (2013)
47. Dickson, M., Harmon, C.: Economic returns to education: What We Know, What We Don't Know, and Where We Are Going—Some brief pointers. Economics of Education Review 30, 1118-1122 (2011)
48. Instituto Brasileiro de Geografia e Estatística. Comitê de Estatísticas Sociais. Censo da Educação Superior. Retrieved from: <http://censo2010.ibge.gov.br/> Access14 jun 2014. (2010).
49. Instituto Brasileiro de Geografia e Estatística. Contas Regionais do Brasil. Série 1995-2012. Retrieved from: <http://www.ibge.gov.br/home/estatistica/economia/contasregionais/2012/default.shtm>. Access 01 abril 2015. (2010)
50. Instituto Nacional de Estudos e Pesquisas Educacionais Anísio Teixeira. Censo da Educação Superior. <Retrieved from: <http://portal.inep.gov.br/basica-levantamentos-microdados>. Access nov 09 2014

ANNEXE 1 Panel Dataset, 2008-2013, Brazil

Table 1 - Number of Higher Education Institutions, 2008-2013, Brazil													
	North		Northeast		South		Southeast		Midwest		BRAZIL		
	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	Public	Private	TOTAL
2008	18	121	59	373	39	331	104	965	16	226	236	2.016	**2.252**
2009	19	128	61	387	39	347	110	980	16	227	245	2069	**2.314**
2010	25	121	64	369	41	345	131	1038	17	227	278	2100	**2.378**
2011	27	125	63	369	42	347	134	1.023	18	217	284	2081	**2.365**
2012	28	126	65	379	49	360	143	1.030	19	217	304	2112	**2.416**
2013	26	120	68	378	47	366	141	1.004	19	222	301	2090	**2.391**
Table 2 - Number of Undergraduate Courses, 2008-2013, Brazil													
2008	946	856	2.187	2.028	1.235	3.423	1.616	10.093	788	1.547	6.772	17.947	**24.719**
2009	1.041	963	2.288	2.367	1.582	3.804	2.424	10.854	893	1.611	8228	19599	**27.827**
2010	1.148	918	2.496	2.398	1.642	3.964	2.587	10.894	948	1.582	8821	19756	**28.577**
2011	1.221	970	2.550	2.522	1.874	3.879	2.737	11.029	986	1.608	9368	20008	**29.376**
2012	1.337	1.000	2.911	2.633	2.291	3.623	2.862	11.441	993	1.627	10394	20324	**30.718**
2013	1.293	1.006	2.889	2.818	2.295	3.685	2.845	11.275	1.022	1.663	10344	20447	**30.791**
Table 3 - Number of Places Offered, 2008-2013, Brazil													
2008	29.185	127.397	100.014	328.740	61.339	328.685	117.215	328.685	36.285	258.449	344.038	1.371.956	**1.715.994**
2009	33.919	135.400	117.260	354.929	73.868	360.114	128.289	1.659.846	40.546	260.508	393.882	2.770.797	**3.164.679**
2010	37.866	119.679	128.415	372.356	78.356	359.773	150.649	1.543.319	50.051	279.728	445.337	2.674.855	**3.120.192**
2011	43.628	129.236	140.828	383.875	86.047	360.310	164.781	1.611.482	49.659	258.825	484943	2743728	**3.228.671**
2012	50.498	136.799	160.965	399.328	103.837	362.966	171.822	1.634.829	52.526	250.837	539648	2784759	**3.324.407**
2013	46.134	139.453	147.281	432.511	102.498	395.689	177.679	1.678.988	52.341	257.141	525933	2903782	**3.429.715**
Table 4 - Number of Candidates, 2008-2013, Brazil													
2008	263.967	188.275	613.817	437.274	364.788	370.554	954.106	1.818.774	256.983	266.151	2.453.661	3.081.028	**5.534.689**
2009	252.405	216.669	804.648	632.738	367.632	383.239	931.454	2.065.646	232.958	336.041	2589097	3634333	**6.223.430**
2010	272.296	203.914	1.132.222	487.156	482.318	387.186	1.194.311	1.870.832	283.696	384.971	3364843	3334059	**6.698.902**

2011	405.242	323.094	1.683.793	628.397	716.773	428.989	1.908.545	2.238.711	423.783	409.260	5138136	4028451	**9.166.587**
2012	572.238	288.111	2.374.894	726.025	891.006	430.282	2.224.498	2.494.056	514.847	411.818	6577483	4350292	**10.927.775**
2013	747.723	307.877	2.288.628	783.392	979.760	485.215	2.681.688	2.645.320	534.847	490.629	7232646	4712433	**11.945.079**

Table 5 - Number of Entrants, 2008-2013, Brazil

2008	27.427	63.960	91.756	165.883	55.619	178.326	99.541	688.728	32.970	101.609	307.313	1.198.506	**1.505.819**
2009	33.117	63.550	101.761	159.664	67.029	149.738	116.168	673.595	36.256	110.510	354331	1157057	**1.511.388**
2010	38.986	58.970	121.333	178.617	69.406	161.711	138.168	669.136	40.669	113.216	408562	1181650	**1.590.212**
2011	37.484	73.529	120.757	195.674	76.104	176.284	150.252	697.724	42.000	117.046	426597	1260257	**1.686.854**
2012	42.851	84.292	126.848	236.738	90.031	190.773	156.455	848.601	45.912	147.891	462097	1508295	**1.970.392**
2013	40.498	85.098	127.660	249.482	86.306	190.756	159.864	807.746	42.878	161.408	457206	1494490	**1.951.696**

Table 6 - Number of Enrolled Students, 2008-2013, Brazil

2008	136.519	186.671	383.539	529.154	237.384	649.798	394.903	2.117.657	121.620	322.811	1.273.965	3.806.091	**5.080.056**
2009	128.689	185.270	409.393	556.109	246.882	619.054	441.800	2.074.912	124.404	329.383	1351168	3764728	**5.115.896**
2010	152.469	199.889	438.090	614.071	242.367	650.763	493.881	2.162.350	134.889	360.351	1461696	3987424	**5.449.120**
2011	168.327	217.390	471.209	667.749	277.696	651.750	533.355	2.222.280	144.804	392.202	1595391	4151371	**5.746.762**
2012	180.017	224.710	499.721	713.798	328.001	613.737	558.899	2.257.187	149.114	398.654	1715752	4208086	**5.923.838**
2013	185.753	237.812	511.825	775.727	335.968	626.716	590.242	2.312.847	154.186	421.329	1777974	4374431	**6.152.405**

Table 7 - Number of Undergraduate Students, 2008-2013, Brazil

2008	19.242	23.114	48.140	68.480	36.367	97.057	64.081	370.071	19.928	53.838	187.758	612.560	**800.318**
2009	18.241	25.351	50.242	80.587	39.152	97.185	61.427	386.384	18.742	49.617	187804	639124	**826.928**
2010	16.287	28.392	48.172	85.662	33.145	99.660	62.988	384.381	17.815	52.784	178407	650879	**829.286**
2011	18.393	36.413	53.799	94.342	34.525	100.832	68.263	377.352	19.686	61.556	194666	670495	**865.161**
2012	17.418	33.964	53.259	95.541	42.224	93.431	71.125	385.158	18.368	65.603	202394	673697	**876.091**
2013	17.453	35.904	53.457	95.913	43.226	87.933	73.321	345.192	18.804	58.735	206261	623677	**829.938**

Source: MEC/INEP; Census of Higher Education - 2008-2013.

The role of information, experience and participation in building brand equity on social media

Bih-Huang Jin[1], Yung-Ming Li[2]

[1] Department of Business Administraiton, Tunghai University, Taiwan
bihuang.jin@gmail.com
[2] Institute of information Management, National Chio Tung University, Taiwan
yml@mail.nctu.edu.tw

Abstract. Social media has changed the interactive mode between business and customer, which are important factors contributing to marketing 3.0. This study is to understand how to use social media as a marketing tool to build brand for social media users, considering the influence of friends. This study used online questionnaires to collect data, and to verify the impact of these factors on brand trust, brand loyalty and brand equity. The study found the information, experience, and participation could influence brand equity through brand trust and brand loyalty.

Keywords: Brand equity, social media, information, experience, participation

1 Introduction

In recent years, social media has been raised much popularity and became an important channel of information transmission. Social media can connect with each other easily all over the world. People no longer just a recipient of information, but also the creator of information, which let the information recipient are not only a customer, but also a producer (Kotler, Kartajaya, & Setiawan, 2010).

For marketing, social media is a fast spreading tool with low cost, which can interact directly with targeted users. Especially for the small brand, social media offers very low cost to enter, to promote on social media is very easy and cheap, compare to the use of television commercial, magazine, and so on. Besides, it can act as an information filter for users to follow the information they are interested in. Consumers have no longer just a lonely individual in a passive position, but link up with each other to provide the practical advices in an initiative position (Kotler et al., 2010). The new form of marketing called marketing 3.0 appeared recently. It focus on communicate to people and collaborate with people. Social media can do both easily.

No matter it is online or offline, marketers face the challenges of how to continually stick customers. Without geographic limitation, Internet can connect with users across the world. Many research indicated that the cost for attracting new customers is much more than to retaining current ones. When people started building brands from real life to Internet, the strategies would change, because on the Internet, only the websites could be used as the transmission channel to connect to customers.

Previous studies found many factors to consider when building brands online. However, due to the restriction of websites, the impact of friends, which is the major

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_4

characteristic of social media, did not exist in the online environment in the past. Social media build the network via the friendship. This study applied the factors of brand building in the past to social media, and confirms whether these factors are still effective on social media. Besides, the influence of friends on social media is also considered. In this way, the research questions of this study could be identified as: Whether the factors which have impact on brands in the E-commerce environments are still effective on social commerce? Furthermore, compare the difference between two different types of social media platforms.

This paper is organized as follows: Section 2 discusses theoretical background. We present research model in Section 3. In Section 4, we proposed the research framework and conclude the analysis of this study.

2 Theoretical Background

The Internet has created a new environment for marketing by providing much more functions and tools than the physical world. And social media also makes the distance more closely with customers (Palmer & Griffith, 1998). This study observed some factors of building brand in the past that happened on social media. All the data about products, service, events, or ideas of business that have been arranged to present for customers can be viewed as information. Information is regarded as an important prerequisite to trust. Effective information can lead to improve awareness and brand perception. And Bakos (1997) and Kania (2001) also addressed that the main reason for people using Internet is to search and collect information.

It is important to show the right information to the customers. According to Janiszewski (2002), irrelevant information can make customers become less certain about the product's ability. Xu and Koronios (2004) argued that there are four dimensions to measure quality of information: accuracy, timelines, completeness, and consistency. On the social media, there are some restrictions for showing information. Business can decide the content of information, but cannot totally decide the format of display. But social media give a special function that other media can't replace. That is reposting any message to friends. Users can see many messages on social media that are shared by friends but the original message was posted by vendors, even if users do not follow the brand on social media. The following hypotheses were tested:

H1a. Quality of information is positively related to brand trust.

H1b Quality of information is positively related to brand loyalty.

Experience, a mix of excitement, touch, and adventures, has been defined as displaying a relatively high degree of familiarity with a certain subject area (Braunsberger & Munch, 1998). Customers usually expect vendors give them not only the information, but also good and positive experience. The more satisfied the customers feel, the more durable are the relationship. Relationship depends on customers' experience that plays an important role in building long-term successful brand. Experience makes customer deeper impressions and be more memorable, that can give customer trust the brand. Kania (2001) suggested that experience, which

provides games, chat, and other events, let customers enjoys various meaningful experiences and can increase brand trust.

Experience that is enjoyed through brand page is perceived to have high brand trust. Ha (2004)indicated that good online experience significantly influence brand trust. Experienced customers can help to generate positive WOM, brand trust, and finally, brand loyalty. Brand that give customers pleasant experiences will have higher brand loyalty (Jin, 2009) This leads to the following hypotheses:

H2a. Perceived experience is positively related to brand trust.

H2b Perceived experience is positively related to brand loyalty.

Social media offer the function that can help consumers connect to vendors or other consumers very quickly. When one consumer posts a question, not only vendor but also all consumers can see it. All the consumers can give suggestions to the original poster; also can know how vendors deal with the questions. It is fast, public and multi-way.

Participation is one of the most important factors for developing the virtual communities. It can ensure the survival of community in the long term. Members can share information related to the mutual interest. Participations can help share knowledge, spread idea, and provide some support to other members. Hagel and Armstrong (1997) indicated that sharing information is the basic and necessary for participation. Ridings (2002) addressed that perceived responsiveness is the key point to participation. In other words, if someone posts a message but no one gives some response, motivation to participation will decrease.

To build a brand page on social media, just like to develop a brand community, participation of users is important that related to the survival of brand page. Arrange above words, this study defines participation as sharing information or knowledge on brand page on social media. Not only has that but also given some response to other members' message. The influence of participation to brand trust had been rarely mentioned before, but Casaló (2007) proposed that the participation have a positive and significant effect on brand trust. According to the previous study, participation in a brand community may encourage consumer loyalty to the brand (Algesheimer, Dholakia, & Herrmann, 2005; Benyoussef, Hoffmann, Roehrich, & Valette-Florece, 2006). Thus:

H3a. Perceived participation is positively related to brand trust.

H3b Perceived participation is positively related to brand loyalty.

In recent years, brand has become powerful weapon in marketing to differentiate among competitors and to maintain customers. Branding is the process of building brand. A good brand can help business to establish the sustainable competitive advantage (Aaker, 1991; De Chernatony, 2001; K.L. Keller & Lewi, 2008). De and MeDonald(1992) said a successful brand is dependent on customer perception; perception is influenced by the added-value characteristics of the product; the added value characteristics need to be sustainable.

Branding is an important tool in building customer familiarity and confidence (Rowley, 2004). Page and Lepkowske (2002) indicated that successful brand can offer additional value. Some previous researches have recognized that brand is a kind of active relationship with customers (Page & Lepkowska-White, 2002). Ellonen (2010)

indicated that there are two types of online interactions for developing the relationship between brand and customer: visiting the brand website and participating to the virtual community of brand.

Trust is a critical factor in the online environment (Ha, 2004). Brand trust is important for customers to increase brand loyalty on the Web (Ha, 2004). The main goal of brand trust is to maintain the sustainable competitive advantage between competitors and gain the business performance.Past research also addressed that brand trust lead to brand loyalty because trust creates exchange relationships that are highly value (Morgan & Hunt, 1994).

There are some researches about brand trust. Ha (2004) studied brand trust that be influenced by six factors: security, privacy, brand name, word-of-mouth, experience, and information. And Ha (2004) found that brand trust is built by the interrelationship between factors, not one or two factors. Ha (2004) indicated that brand trust is extremely important in increasing brand loyalty on the Web. It is an underlying dimension of brand loyalty. The related hypothesis is:

H4. Brand trust is positively related to the brand loyalty.

Research presented that although brand trust did not directly influence brand equity, but this factor strongly influence brand loyalty, which is the most important factor to create brand equity (Rios & Riquelme, 2008). Thus, trust is important in a computer-mediated environment (Rios & Riquelme, 2008). The related hypothesis is:

H5. Brand trust is positively related to the brand equity.

According to previous studies, loyalty contains behavioral and attitudinal measures (Jang, Ko, & Koh, 2007; Kevin Lane Keller, 1993; Rios & Riquelme, 2008). The behavioral brand loyalty refers to revisit and repurchase; and the attitudinal brand loyalty mention to the active word-of-mouth to the brand (Clarke, 2001; Oliver, 1999). Thus can be seen as the favorable attitude about brand and in addition repurchases the product of the brand. In our research, brand loyalty refers to a customers' intention to revisit the brand page, or to continuously follow the page now and in the future.

Brand loyalty can be the fundamental of brand equity. Aaker (1991)indicated that brand loyalty is the major component of brand equity and at the heart of brand equity; as well brand loyalty can measure the customers' attachment of brand. Also, Rios, and Riquelme (2008) indicated that brand loyalty is the most important factor for brand equity online because it directly influences the brand equity and play the mediating role in creating brand equity. To make short of the matter, loyalty can be as the foundation of brand equity Clarke (2001). Thus the final hypothesis of this study is:

H6. Brand loyalty is positively related to the brand equity.

Brand equity provides competitive advantage, efficiency and effectiveness of marketing programs, brand extensions (Yoo & Donthu, 2001). Rios, and Riquelme (2008) indicated that 4 antecedents of brand equity for online companies, they were awareness, value, trust, and loyalty. Jin (2009)presented 5 dimensions that useful for measuring website brand value, namely brand loyalty, perceived quality, brand relationship, brand experience, and brand attraction.

From many past studies, there are many factors which affect brand equity. According to the observation, when the research consider the online environment, brand trust and brand loyalty are indispensable antecedent factors for brand equity.

However overmuch factors may cause overlapping, that mean lack of distinct causal relationship. Therefore, this study use brand trust and brand loyalty as the antecedent of brand equity.

3 Research Model

3.1 Research Model

The above points verified the influence of brand trust and brand loyalty in the previous researches. However, they only considered the direct connection from vendors to consumers. But the most important is that they did not consider the indirect connection from vendors to consumers by friends. This research considers the relationship between people.

According to the above part, six hypotheses which were explored to examine the relationship between behavior of social media and brand equity via brand trust and brand loyalty to the following table.

Table 3.1. Hypotheses of proposed framework

Hypotheses	*Content*
H1a	Perceived information is positively related to brand trust.
H1b	Perceived information is positively related to brand loyalty.
H2a	Perceived experience is positively related to brand trust.
H2b	Perceived experience is positively related to brand loyalty.
H3a	Perceived participation is positively related to brand trust.
H3b	Perceived participation is positively related to brand loyalty.
H4a	The higher the brand trust, the higher the brand loyalty.
H4b	The higher the brand trust, the higher the brand equity.

The integrated model was developed and showed in Figure 2.1.

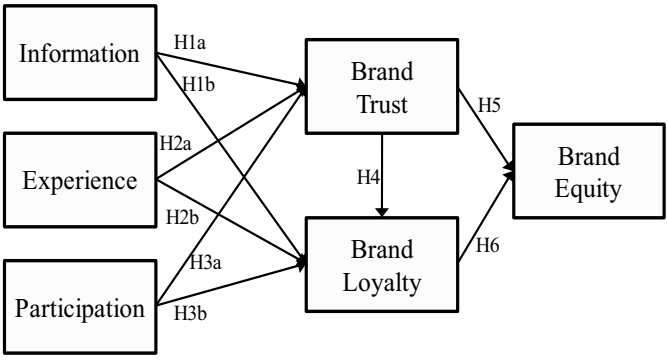


Fig 3.1 Conceptual framework

4 Conclusion

The purpose of this study is to understand how to effectively use social media as a marketing tool to build brand for social media user, consider the influence of friends' behavior. We expect the empirical results from the survey indicate that the information, experience, and participation could influence brand equity through brand trust and brand loyalty. The results provide suggestions for practitioners to develop strategies building brands on social media.

References

Aaker, D. A. (1991). *Managing brand equity*: Free Press New York.

Algesheimer, R., Dholakia, U. M., & Herrmann, A. (2005). The social influence of brand community: Evidence from European car clubs. *Journal of marketing*, 19-34.

Bakos, J. Y. (1997). Reducing buyer search costs: Implications for electronic marketplaces. *Management science*, 1676-1692.

Benyoussef, H., Hoffmann, J., Roehrich, G., & Valette-Florece, P. (2006). *The relational antecedents of loyalty: the case of proprietary software users vs. Libre software users*.

Braunsberger, K., & Munch, J. M. (1998). Source expertise versus experience effects in hospital advertising. *Journal of Services Marketing, 12*(1), 23-38.

Casaló, L., Flavián, C., & Guinalíu, M. (2007). The impact of participation in virtual brand communities on consumer trust and loyalty: The case of free software. *Online Information Review, 31*(6), 775-792.

Clarke, K. (2001). What price on loyalty when a brand switch is just a click away? *Qualitative Market Research: An International Journal, 4*(3), 160-168.

De Chernatony, L. (2001). Succeeding with brands on the Internet. *The Journal of Brand Management, 8*(3), 186-195.

De, C. L., & McDonald, M. (1992). Creating Powerful Brands: Butterworth-Heinemann, Oxford.

Ellonen, H.-K., Tarkiainen, A., & Kuivalainen, O. (2010). The effect of website usage and virtual community participation on brand relationships. *International Journal of Internet Marketing and Advertising, 6*(1), 85-105.

Ha, H.-Y. (2004). Factors influencing consumer perceptions of brand trust online. *Journal of product & brand management, 13*(5), 329-342.

Hagel, J., & Armstrong, A. (1997). *Net gain: expanding markets through virtual communities*: Harvard Business Press.

Jang, H., Ko, I., & Koh, J. (2007). *The influence of online brand community characteristics on community commitment and brand loyalty.* Paper presented at the 40th Annual Hawaii International Conference on System Sciences.

Jin, L. (2009). Dimensions and determinants of website brand equity: From the perspective of website contents. *Frontiers of Business Research in China, 3*(4), 514-542.

Kania, D. (2001). *Branding. com: On-Line Branding for Marketing Success*: McGraw-Hill/Contemporary.

Keller, K. L. (1993). Conceptualizing, measuring, and managing customer-based brand equity. *The Journal of Marketing, 57*(1), 1-22.

Keller, K. L., & Lewi, G. (2008). *Strategic brand management: building, measuring and managing*: New Jersey: Pearson Prentice Hall.

Kotler, P., Kartajaya, H., & Setiawan, I. (2010). *Marketing 3.0: From Products to Customers to the Human Spirit*: Wiley.

Meyvis, T., & Janiszewski, C. (2002). Consumers,Äô beliefs about product benefits: The effect of obviously irrelevant product information. *Journal of Consumer Research, 28*(4), 618-635.

Morgan, R. M., & Hunt, S. D. (1994). The commitment-trust theory of relationship marketing. *The Journal of Marketing*, 20-38.

Oliver, R. L. (1999). Whence consumer loyalty? *Journal of marketing, 63*(Fundamental Issue and Directions for Marketing), 33-44.

Page, C., & Lepkowska-White, E. (2002). Web equity: a framework for building consumer value in online companies. *Journal of Consumer Marketing, 19*(3), 231-248.

Palmer, J. W., & Griffith, D. A. (1998). An emerging model of Web site design for marketing. *Commun. ACM, 41*(3), 44-51. doi: http://doi.acm.org/10.1145/272287.272296

Ridings, C. M., Gefen, D., & Arinze, B. (2002). Some antecedents and effects of trust in virtual communities. *The Journal of Strategic Information Systems, 11*(3-4), 271-295.

Rios, R. E., & Riquelme, H. E. (2008). Brand equity for online companies. *Marketing Intelligence & Planning, 26*(7), 719-742.

Rowley, J. (2004). Online branding. *Online Information Review, 28*(2), 131-138.

Xu, H., & Koronios, A. (2004). Understanding information quality in E-Business. *Journal of Computer Information Systems, 45*(2), 73-82.

Yoo, B., & Donthu, N. (2001). Developing and validating a multidimensional consumer-based brand equity scale. *Journal of Business Research, 52*(1), 1-14.

Using Social Media for Business Process Improvement: a Systematic Review

Ademir Macedo Nascimento[1,2] and Denis Silva da Silveira[2]
[1]University of Pernambuco, Recife, Pernambuco, Brazil {ademir.nascimento@upe.br}
[2]Federal University of Pernambuco, Recife, Pernambuco, Brazil {dsilveira@ufpe.br}

Abstract. Social media have become an increasingly frequent research topic in management studies, whether in marketing for product promotion, in public relations for customer relationships, or even as a hiring tool in the area of human resources. However, the vast majority of studies are concerned with analyzing how information may be disclosed in social media, with few management studies dealing with the employment of User-Generated Content (UGC) in these media. In this study, we sought to make a systematic review of studies that addressed this issue with the purpose of using UGC for the improvement of organizational processes. As a result of this systematic review, we noted the paucity of studies related to this, although we found some interesting results for public organizations and those that generate content.

Keywords: Social Media; User-Generated Content; Improved Business Processes; Systematic Review.

1 Introduction

Internet access has become easier in recent years due to improvements in the infrastructure of telecommunications. The Internet, previously used only for military purposes, grew in its technical capabilities and its penetration into different territories once it was released to the general public [1].

As this developed and spread, innumerable applications, such as blogs, sharing platforms and social media, were developed [2]. Thus, according to Kaufman [3], the development of social media is perhaps one of the greatest events in recent years, as it represents a new way of organization of contemporary society. Fialho and Lütz [4] emphasize that these kinds of networks are becoming increasingly widespread and play a highly important role among the options for communication and information on the Internet.

Meanwhile, Cross and Thomas [5] and Kirkpatrick [6] report that users are creating new ways to use social media, affecting both personal relationships as well as relationships with businesses and governments. This is the case of social media that has gained an important place over the years, as, for example, Facebook®,

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_5

LinkedIn®, and Twitter ®, which permit organizations to have their pages and applications related to them.

Following the growth of popularity of social media, many studies were mounted on its potential for disseminating information, whether information of public interest, advertisements or even rumors. However, apparently very little has been researched about the information generated by users of the social media for the improvement of processes within organizations.

This article fits in at this point. Indeed, starting from a synopsis of the few references to articles, exploiting the theme of user-generated content in social media, a systematic literature review was conducted, aiming to point out the research opportunities in this regard, more specifically, how organizations have been using content generated in the social media for feedback that can produce improvement in their processes.

In a systematic review, according to Kitchenham and Charters [7], the first step is to formulate a research question. Following this recommendation, the issue guiding this study is: how can social media contribute to the improvement of business processes, according to research published in international journals from 1975 to 2012.

To this end, in addition to this introductory section, this paper is organized into five sections. The second section explains what a systematic review of the literature is. The third deals with the procedures adopted in this study. The fourth and fifth present quantitative and qualitative analysis of the articles selected. Finally, the sixth presents final remarks on the study.

2 Systematic Review

According to Kitchenham and Charters [7], a systematic review is a mean of identifying, evaluating and interpreting the available research relevant to a research question, a topic or a phenomenon of interest. According to this author, conducting a systematic review allegedly presents an impartial assessment on a research topic, as it uses a methodology of rigorous review, reliable and able to be repeated by other interested researchers.

There are several ways to conduct a literature survey, ranging from the traditional bibliographical review, known as the narrative review or a discursive review, including mechanisms used by researchers in the fields of health, social sciences and education to describe the state of the art on a topic, as is the case of a systematic literature review. In the area of organizational studies, a more robust methodology for the systematic review allows researchers to approach the problem that interests them, seeing its evolution over time and pointing out research opportunities [8].

According to Sousa and Ribeiro [9], a systematic review of literature is a rigorous research strategy, serving to identify and evaluate research on a specific topic, with more reliable results in exploratory studies. This strategy, according to these authors, establishes a formal process for conducting the investigation, giving greater credibility to the ongoing study.

While it is possible to do a literature review unsystematically, i.e. through a narrative/discursive review, systematization is preferable, since the use of a reproducible methodology prevents unnecessary duplication of effort, can be quickly updated, and defines what further studies are needed on the topic, as can be seen in Table 1. On the other hand, the systematic review presents some disadvantages compared to the narrative/discursive review, namely [10]:

- The large amount of time it requires;
- The great amount of intellectual work in analyzing and cataloging publications it requires and;
- Its limitation in only being able to point to studies and the fact that it usually requires the involvement of more than one researcher.

Table 1. Differences between narrative and systematic reviews.

Items	Narrative / discursive review	Systematic review
Issue	Broad	Specific
Source	Often not specified, potentially biased	Selection based on criteria applied uniformly
Selection	Variable	Thorough and reproducible assessment
Evaluation	Variable	Thorough and reproducible
Synthesis	Qualitative	Quantitative

To Dyba and Dingsoyr [11], if a review of the literature of any type is not conducted reliably, the study results will have little scientific value as personal interests can guide them, or even a repetition of other works, as the problem under study may have been resolved elsewhere. Thus, systematic literature can be understood as a summary of the state of the art in the literature.

Kitchenham and Charters [7] portray related that a systematic review of the literature follows three phases: planning of the review, execution and analysis, and dissemination of the results. In the first stage above, the research question is formulated, the search strategy of the study is determined, and the inclusion and exclusion criteria are set. In the implementation phase, data collection is carried out. In the analysis phase, a synthesis and an interpretation of the data is made.

In advanced research, where novelty and originality on the subject under study are required, the literature review plays a crucial role. It is important to conduct it in a systematic and rigorous manner, thus contributing to the development of a solid knowledge base, identifying areas where there are opportunities for further research [8].

However, due to a large amount of material available, the process of finding and identifying these studies becomes complex and exhaustive. Kitchenham and Charters [7] adds further that there are specific reasons that help a review to be systematic, namely:

- Consolidation of evidence and results obtained in previous studies on the topic of interest;

- Identification of gaps in theory and recent research as a basis for the improvement of research;
- Provision of background and theoretical models to position properly new topics and research opportunities, or even refute or validate hypotheses, or create new hypotheses on a particular research topic.

Thus, systematic review helps the researcher to make decisions about a study given a huge volume of content, allowing information to be visualized that would not be apparent in individual studies [12, 7]. The following section describes the procedures adopted in this study.

3 Systematic Review Procedures

The procedures for carrying out the systematic review were started with the creation of a protocol that enabled the identification of studies addressing the issue of the use of social media by organizations. Subsequently, a template for cataloging the work was created to refine further the studies that would compose the final catalog.

The Academic Search Premier® from Ebsco® was chosen to create the database in order to cover a very wide area of academic fields with indexed content from more than 8,500 journals from 1975 to the present. This database is designed specifically for academic institutions and is recommended for multidisciplinary research studies such as ours. It allows articles from other fields of study to be searched, thus enabling a comprehensive systematic review of the academic community [13]. It is worth mentioning that Academic Search Premier® searches articles from Emerald®, the Sage®, Blackwell® and Science Direct®, thus demonstrating its scope and potential for a systematic review.

This study adopted 1975-2012 as the search period to have a broad understanding of how the issue was being addressed by 2012, 15 years after the first social media had been launched. The strings adopted were words in English since this is the primary language for research, and the selected studies from academic journals were those that exhibited the complete work.

We decided to limit the study to items that addressed the use of social media for improving processes in organizations, provided they were related to the use of information obtained from social media, that is, to content generated by users. Thus, articles were excluded that dealt with the social media for personal use only, research that focused on the behavior of users or studies that saw social media just as dissemination mechanisms for the publication and spread of organizational information. Were also excluded articles focused exclusively to the use of social media for crisis management in public relations and articles that addressed technical and computational aspects.

The strings selected, which can be seen in Table 2, were related to two central points of the research question. The words chosen were fine-tuned to the CAPES® Periodicals repository in order to exclude or include similar terms, as in the case of the composition of the words "*social media*", which was also found as "*social network site*", "*social networking site*" and "*online social network*". Thus, we used the

boolean operator "*" to guarantee the inclusion of some terms could also be found with suffixes, for example in their plural forms.

Table 2. Search strings.

"*social network* site**" AND process*	"*social media**" AND *process**	"*online social network**" AND *process**
"*social network* site**" AND *manag**	"*social media**" AND *manag**	"*online social network**" AND *manag**
"*social network* site**" AND *compan**	"*social media**" AND *compan**	"*online social network**" AND *compan**
"*social network* site**" AND *organization**	"*social media**" AND *organization**	"*online social network**" AND *organization**

The research protocol defined the work selection process in three stages. In each step, the texts would be evaluated for adherence to the concept "*use of social media to improve business processes*", having also decided that whenever it was not clear enough whether the article was out of scope, the text would be kept for re-evaluation in the next step.

In the first stage, all selected items, starting with research conducted with search strings (Table 2) had their titles, keywords and abstracts read to check whether the selected articles were related to the research. After this first stage, 169 articles were selected from 1,100. Continuing the process, in the second stage, after reading the introduction and conclusion of the 169 texts, only 24 articles were selected. Finally, in the third step, all 24 selected articles were read completely. Figure 1 shows the filtering process of article selection.

After the selection, there was a quantitative analysis of 24 articles to identify the evolution and concentration of works by journals, periods and authors. Later, there was a qualitative analysis aimed at observing how the academic community had addressed the topic.

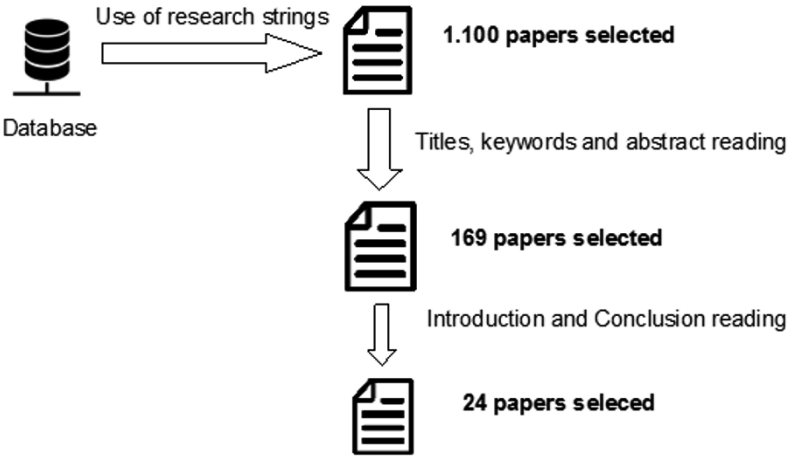


Fig. 1. Process of Article Selection.

4 Quantitative Analysis

The survey, which selected articles published between 1975 and 2012, initially found 1,100 articles from scientific peer-evaluated journals. Of these, as already mentioned, only 169 (15.36%) were selected after the first filtering and 24 (14.2% articles from the previous stage and 2.18% of all items indicated by the database) after the second step.

After the third refinement, which maintained 24 of the articles, data from articles were quantitatively analyzed. Twenty-one journals in the areas of communication, politics, computer science, health, and marketing were represented, but with a predominance of periodicals from the computing area. In addition, 55 different authors from various countries such as Singapore, Belgium, Netherlands, Greece, Portugal and France were represented. However, it is noteworthy that most of the articles were from the United Kingdom and the United States. Table 3 shows the two authors and the three journals with the most occurrences among those selected, with two events each.

Table 3. Journals and Authors mentioned most.

Journals	Authors
Communications of the ACM Media, Culture & Society Social Marketing and Health Communication	Brad L. Neiger Rosemary Thackeray

Following this, the articles were also separated by their occurrences over the years. However, it is noteworthy that only in 2007 did the first publication on the topic appear and after the next year, the topic began to take off, as can be seen in Figure 2.

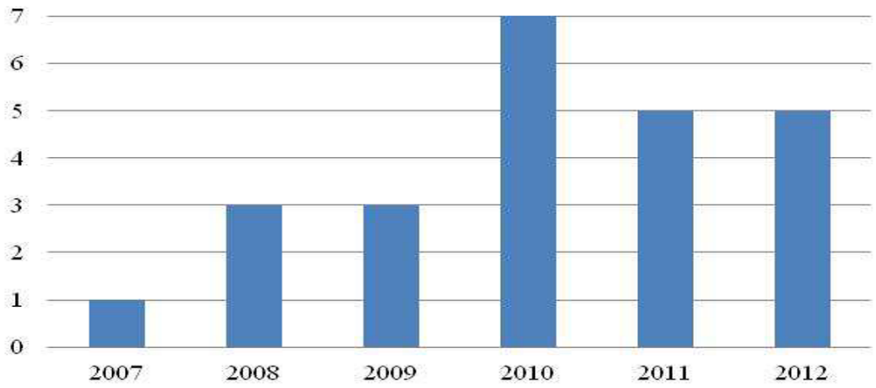


Fig. 2. Numbers of articles, by year.

When analyzing the references to the 24 selected articles, 746 distinct citations were found, with some cited more than once, highlighting the study by O'Reilly [2] was by 25% of the articles cited, as shown in Table 4.

Table 4. Most cited references among the selected articles.

Title	References
Twitter Adoption and Use in Mass Convergence and Emergency Events	HUGHES; PALEN, 2009
Twitter Power: Tweets as Electronic Word of Mouth	JANSEN; ZHANG; SOBEL; CHOWDURY, 2009
Users of the World, Unite! The Challenges and Opportunities of Social Media	KAPLAN; HAENLEIN, 2009
A Few Chirps About Twitter	KRISHNAMURTHY; GILL; ARLITT, 2008
Social Network Sites: Definition, History, and Scholarship	BOYD; ELLISON, 2007
How Businesses are Using Web 2.0	BUGHIN; MANYIKA, 2007
Why we Twitter: understanding Microblogging Usage and Communities	JAVA; SONG; FININ; TSENG, 2007
Understanding Web 2.0.	MURUGESAN, 2007
Introducing Web 2.0: Social networking and social bookmarking for health librarians.	BARSKY; PURDON, 2006
Enterprise 2.0: The dawn of emergent Collaboration	MCAFEE, 2006
Social bookmarking tools (II): a case study—connote	LUND; HAMMOND; FLACK; HANNAY, 2005
What is Web 2.0? Design Patterns and Business Models for the Next Generation of Software	O'REILLY, 2005
'The Challenge of Changing Audiences'	LIVINGSTONE, 2004
The Wisdom of Crowds	SUROWIECKI, 2004
Smart Mobs: the Next Social Revolution	RHEINGOLD, 2002
Communities of practice social learning Systems	WENGER, 2000

Later we looked for the keywords most frequently cited by the authors in the articles, which resulted in the following expressions: "*social media*", "*social network site*" and "*blog*". However, many of the articles did not have keywords provided by the authors. Thus to get a similar notion of keywords that would address all of the selected articles, a table was generated with the words most frequently found in the texts of the twenty-four articles, as can be seen in Table 5.

Table 5. Key Word Frequency in Selected Articles.

Word	Number	Word	Number
Social	1336	*Participate*	695
Web	1014	*Media*	680
Use	980	*New*	636
User	913	*Network*	622
Blog	832	*Technology*	554
Inform	740	*Content*	477

5 Qualitative Analysis

When starting the research on the topic, we noticed that there were many articles dealing with social media in some way since 1,100 articles were found in the first

phase of the search. There were, however, few articles with the approach that is of interest to this study.

Among the items observed in the first phase of the search, there was a lack of studies addressing the topic of user-generated content in social media to improve processes of organizations. It is also worth noting that many of the items returned at this stage of the search dealt with technical issues of virtual social networks such as folksonomy.

When applying the first filter, it was realized that social media were used in actual business processes in 169 articles. Nevertheless, most of these articles focussed on the publication of information be it advertisements, scientific research, government action or everyday personal.

When the third selection filter was applied, resulting in only 24 articles, we could observe that although social media were still the subject of a number of scientific studies related to management and processes, only after 2007 was it possible to identify studies dealing with these as a mechanism enabling a search for improvement in business practice [14].

Of these 24 studies were selected, a chronological overview shows how the first studies dealt with the issue and how the approaches evolved over time.

In the first study on the timeline, it is noted that Boulous [14] focussed on how social media can be used to produce knowledge, to influence the collective intelligence of an organization and to build social capital. At this point, it is interesting to notice that although the areas of computing, information science and communication are those with more studies on social media, it was in the field of healthcare that social media for process improvement was initially observed in this study.

In the following year, 2008, is possible to see the first articles dealing with the use of social media to improve processes in the business area [15, 16, 17]. Huberman [15] reports that social media plays a central role in the generation, dissemination and validation of ideas. This also occurs in studies of Thackeray *et al*. [16] and Warr [17] in which is highlighted where they note the ability to directly engage consumers in the creative process since this when the consumer acquires the power to create, organize and share information. In this respect, Warr [17] cites the IdeaStorm®, platform created by Dell®, where consumers can submit product ideas and suggestions from for existing product enhancements.

Already in 2009, this discussion was taken up by [18, 19, 20] that demonstrate how social media can change the consumer relationship to producer, and how even non-professional users can bring relevant information relevant for organizations through social media, which makes the user-generated content begins to have high value for organizations.

Andriole [21] continues to address this issue, but other aspects begin to emerge in 2010, with the highlight a feature of use for public administration in the United States, reporting noting the application of social media to better the process of engagement of citizens and, consequently, the government processes. Twitter® was highlighted as notable for this purpose due to its great adherence to the political studies [22, 23]. Already Rebillard and Touboul [24] as well as Brennan, Monroy-Hernandez and Resnick [25] highlight the importance of this type of use in the areas of content creation and journalism, highlighting the amount of content created by users. Besides

that, Stafford *et al*. [26] and Piotrowski [27] demonstrate how content collected in social media has helped the field of research that requires information from over a large area, making it less costly the research process less expensive, although it can be as rich as the traditional process of data collection.

In 2011, there are three reports associated with public organizations [28, 29]. Here it is noteworthy worthy of note that while in the selected studies, for 2010 the use of social media by public organizations were was focused only in the United States [22, 23], from this year 2011 on, note up studies related to also related to European contexts. Also in 2011, we can see a new approach in which [30] depict how social media can better the e-learning process.

Finally, in 2012, we found studies focused on the integration of the generated content in the social media to improve business processes, especially marketing. In these studies, it is noted that such tools only are seen as output channels, makes given businesses ignore ignoring all communication that occurs between users, and therefore not failing to seize the opportunities to improve its processes [31, 32, 33].

On the other hand, in 2012, [34, 35] emphasized again the importance of using the media to improve the processes of public organizations. But with the prominence alert that the social media do not work as well for creating interest among citizens about politics, but rather to stimulate and organize those who already have any concerns about specific topics. A summary of the main issues observed over the years can be seen in Table 6.

Table 6. Major Topics observed during the period of the study.

Year	Themes observed
2007	Social media for process improvement in healthcare;
2008	Social media for generation, validation and dissemination of business ideas;
2009	Social media for generation, validation and dissemination of business ideas;
2010	Citizens engagement for improvement of the processes of public organizations; Engagement readers for process improvement in content creation of journalism organizations;
2011	Citizens engagement for improvement of the processes of public organizations; Engagement of students and teachers to improve the e-learning process;
2012	Citizens engagement for improvement of the processes of public organizations; Social media to improve business processes in organizations.

6 Conclusion

The purpose of this article was to see how studies on social media had been viewed as mechanisms to improve business processes in organizations.

From the initial research, we noted that the theme of social media associated to processes and management has been widely studied, given they were returned of 1,100 articles at the beginning. Most of these studies, however, were concerned only with information dissemination given the vast potential for sharing.

It was observed, that the studies focused on obtaining information from social media were few and far, without any research group specifically focused on this them or any region where that stood out.

In the articles studied, we noted that among the objectives of the purposes, that stand what stood out are those for improvement of business processes focused on innovation, improving content creation processes for journalism and process improvement in government institutions.

As whether as a creative consumer, either or as information provider, that is, or as engaged citizens, users of social media can create or change content in a way that is useful and profitable for organizations, and these are the scenarios that research studies in this theme had paid attention to.

In this sense, we can see a gap to improve such studies, particularly through more detailed research in organizations, in order to understand the dynamics carried out on the subject.

It is concluded that application of the detailed criteria, 1076 jobs works that were initially selected for by the search words had to be discarded as they join were outside the context of this study, with only leaving only 24 studies from 1975 to 2012. The few studies that focus on organizations do with user-generated content is shown as a potential research agenda that can address the following approaches:

- Comparative studies on how citizen participation can help improve processes in government institutions;
- Research on the impact of consumer participation in social media when it comes to developing new products and services;
- Analysis of the dynamics of social media users as information providers to journalism organizations;
- Impact assessment of user-generated content in social media in contexts not observed in this systematic review, as, for example, in non-governmental organizations;
- Research on how the user-generated content can help companies improve everyday processes, not directly related to innovation.

References

1. Wachter, R. M.; Gupta, J. N. D.; Quaddus, M. A. It takes a village: virtual communities in support of education. International Journal of Information Management, v. 20, p. 473–489 (2000).

2. O'Reilly T. What is Web 2.0: Design Patterns and Business Models for the Next Generation of Software. (2005).
3. Kaufman, D. Processo de tomada de decisão no ciberespaço, o papel das redes sociais no jogo das escolhas individuais. São Paulo: PUC–SP (2010).
4. Fialho, C. B.; Lütz, C. B. Análise da Intenção de Continuidade de Uso de um Sistema Voluntário: em Cena o Fenômeno Twitter®. In: III Encontro de Administração da Informação, 3, Porto Alegre. Porto Alegre: Anpad (2011).
5. Cross, R.; Thomas, R. J. Redes sociais: como os empresários e executivos de vanguarda as utilizam para obtenção de resultados. São Paulo: Editora Gente, (2009).
6. Kirkpatrick, D. O efeito Facebook®: os bastidores da empresa que conecta o mundo. Rio de janeiro: Intrínseca (2012).
7. Kitchenham, B.; Charters, S. Guidelines for performing systematic literature reviews in software engineering, Technical Report EBSE-2007-01, School of Computer Science and Mathematics, Keele University (2007).
8. Botelho, L. L. R.; Cunha, C. C. de A.; Macedo, M. O método da revisão integrativa nos estudos organizacionais. Revista Eletrônica Gestão e Sociedade. V5, n11 (2011).
9. Sousa, M. R.; Ribeiro, A. L. P. Systematic Review and Meta-Analysis of Diagnostic and Prognostic Studies: A Tutorial, Arquivo Brasileiro de Cardiologia, v. 92, n.3, pp. 241-251 (2009).
10. Atallah, A. N.; Castro, A. A. Revisão sistemática da literatura e metanálise: a melhor forma de evidência para tomada de decisão em saúde e a maneira mais rápida de atualização terapêutica. Diagnóstico & Tratamento. v.2, n.2 (1997).
11. Dyba, T.; Dingsoyr, T. Empirical studies of agile software development: A systematic review, Information and Software Technology, n. 50, p. 833-859 (2008).
12. Biolchini, J.; Mian, P. G.; Natali, A. C.; Travassos, G. H.; Systematic Review in Software Engineering: Relevance and Utility, Relatório Técnico, PESC - COPPE/UFRJ (2005).
13. Ebsco. Academic Search Premier. http://support.ebsco.com/help/?int=ehost&lang=en&feature_id=Databases&TOC_ID=Always&SI=0&BU=0&GU=1&PS=0&ver=live&dbs=aphjnh,aph.
14. Boulous, M. N. K.; The emerging Web 2.0 social software: an enabling suite of sociable technologies in health and health care education. Health Information and Libraries Journal, 24, pp. 2-23 (2007).
15. Huberman, B. A. Crowdsourcing and Attention. W e b t e c h n o l o g i e s (2008).
16. Thackeray, R.; Neiger, B. L.; Hanson, C. L.; MckenzieE, J. F. Enhancing Promotional Strategies Within Social Marketing Programs: Use of Web 2.0 Social Media. Social Marketing and Health Communication, 9,4, (2008).
17. Warr, W. A. Social software: fun and games, or business tools? Journal of Information Science, 34, 4 (2008).
18. Djick, J. V. Users like you? Theorizing agency in user-generated content. Media, Culture & Society, 31,1 (2009).
19. Grinelli, C. K. From Consumer to Prosumer to Produser: Who Keeps Shifting My Paradigm? (We Do!). Public Culture, 21,3 (2009).
20. Wilson, J. Social networking: the business case. Engineering & Technology (2009).
21. Andriole, S. J. Business Impact of Web 2.0 Technologies. Communications of the ACM. 53, 12 (2010).
22. Golbeck, J., Grimes, J. M., Rogers, A. Twitter Use by the U.S. Congress. Journal of the american society for information science e technology. 61,8 (2010).
23. Mandarano, L.; Meenar, M.; Steins. C. Building Social Capital in the Digital Age of Civic Engagement. Journal of Planning Literature, 25,2 (2010).
24. Rebillard, F. Touboul, A. Promises unfulfilled? 'Journalism 2.0', user participation and editorial policy on newspaper websites. Media, Culture & Society, 32,2 (2010).

25. Brennan, K. Monroy-Hernandez, A. Resnick, M. Making projects, making friends: Online community as catalyst for interactive media creation. New directions for youth development. 128 (2010).
26. Stafford, R.; Hart, A. G.; Collins, L.; Kirkhpe C.; L. Williams, R. L.; Rees, S. G.; Lloyd, J. R.; Goodenough, A. E. Eu-Social Science: The Role of Internet Social Networks in the Collection of Bee Biodiversity Data, PLoS ONE, 5, 12 (2010).
27. Piotrowski, C. Facebook: A Bibliographic Analysis of the PsycINFO Database. Journal of Instructional Psychology, 39,1 (2010).
28. Auer, M. R. The Policy Sciences of Social Media. Policy Studies Journal. 39, 4 (2011).
29. Colombo, C.; Kunstely, M.; Molinari, F.; Todorovski, L. Journal of Balkan and Near Eastern Studies. 13,1 (2011).
30. Rodrigues, J. J. P. C.; Sabino, F. M. R.; Zhou, L. Enhancing e-learning experience with online social networks. IET Commun. 5, 8 (2010).
31. Araujo, T.; Neijens, P. Friend me: which factors influence top global brands participation in social network sites. Internet Research (2012)
32. Sreenivasan, N. D.; Lee, C. S.; Goh, D. H. Tweeting the friendly skies: Investigating information exchange among Twitter users about airlines. Program: electronic library and information systems, (2012)
33. Thackeray, R. Neiger, B. L. Keller, H. Integrating Social Media and Social Marketing: A Four-Step Process. Social Marketing and Health Communication, 13, 2 (2012).
34. Vesnic-Alujevic, L. Political participation and web 2.0 in Europe: A case study of Facebook. Public Relations Review. 38 (2012).
35. Bridgesa, F. Appela, L. Grossklagsb, J. Young adults' online participation behaviors: An exploratory study of web 2.0 use for political engageme. Information Polity. 17 (2012).

A Knowledge Management Approach for Software Engineering Projects Development

Paulo Carreteiro[1], José Braga de Vasconcelos[1], Alexandre Barão[1], Álvaro Rocha[2]

[1] Knowledge Management and Software Engineering Research Group
Universidade Atlântica
Fábrica da Pólvora de Barcarena, 2730-036 Barcarena, Portugal
{pcarreteiro, jose.braga.vasconcelos, abarao}@uatlantica.pt

[2] Department of Informatics Engineering
Universidade de Coimbra
Pólo II - Pinhal de Marrocos, 3030-290 Coimbra, Portugal
amrocha@dei.uc.pt

Abstract. Aiming to emphasize the effect of knowledge management practices during software development projects, this research paper presents a first approach to cope with knowledge management and engineering practices across software development projects. The main goal is to define a roadmap for representative software development life cycle tasks during a typical software project development. The research introduces an ongoing architectural case study using software maintenance tasks as a means to enhance the knowledge flows within the organization. Software maintainers validate, correct and update knowledge from previous phases of software development life cycle through the application of back flushing technique at the software data warehouse. Further research developments will present a detailed guidance model for both research areas: knowledge management for software engineering combining insights across corporate software projects as a means of evaluating the effects on people and organization, technology, workflows and processes.

Keywords: Software Engineering; Knowledge Management; Knowledge Life Cycle; Software Maintenance; Software Development Life Cycle; KM Processes.

1 Introduction

In an organization individuals create documents, deal with software legacy applications, emails and many other tools where their everyday work is documented. Additionally, there's an informal or formal exchange of ideas with their peers to clarify doubts or discuss certain topics. All of these are contents for the three levels of refinement to knowledge, which are: data; information; and knowledge [1], [2].
Organizational knowledge resides in individuals or in a group, it can be explicit or tacit, regarding if it is documented or in the minds of individuals and having as scope the way it is applied, who accesses it and what activities it supports. Explicit knowledge can easily be shared, accessed and used. On the other hand, tacit

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_6

knowledge cannot, and it is acquired along the years by individuals, leaving the organization at the end of the day.
Knowledge Management (KM) aims at the individuals, their knowledge and the flows between them. Knowledge life cycle, defines the phases of organizational knowledge [2]. These phases are: (1) *Creation*, the origin of the cycle, occurs by informal or formal exchange of ideas and information either from internal or external sources; (2) *Capturing***,** follows creation, it is the moment when it becomes explicit/documented; and (3) *Transforming* knowledge, which means organizing, mapping and converting it into an interpreted form. After it has been documented and organized, it can be *deployed*, meaning it can be accessed. Accessibility does not mean it reaches individuals, therefore *sharing* is when knowledge is used. The last phase is the goal of KM, which is the *usage*, allowing individuals to create more knowledge and therefore closing the cycle.

Although every project is unique and each model for software development has its specific methodology, all of them bare in common a complex set of tasks to achieve the final goal. According to the SWEBOK[1], *Software Engineering* (SE) is "the application of a systematic, disciplined, quantifiable approach to the development, operation, and maintenance of software". The aim of SE is the improvement organization productivity and quality by applying technologies and project management practices in activities related to the software development. Individuals that work in software development projects, also known as "knowledge workers" [1] must be able to interpret the sponsor's needs and transform them into coded language, thus SE is a discipline where one has to master both social and technical skills [4].

There are several models like cascade, agile, v-model, spiral, etc. for the *Software Development Life Cycle* (SDLC), these are approaches that determine the tasks and deliverables for software creation. In general, they are composed by six phases, allowing knowledge workers to specify and change software requirements into the final product or deliverable [5]. *Requirements specification* and *Analysis,* to interpret and explicit the client's needs; *design,* to transform requirements (business knowledge) into a plan (technical knowledge); *coding,* where the plan is implemented; *testing,* a proof of concept that the software meets the requirements; software *deployment,* when it is shared and implemented and finally *maintenance,* to support the software usage. Sponsors, who have the business know-how, interact with the knowledge workers to whom they transfer the aforesaid business knowledge, so that they can design models to transfer it into technical knowledge, meaning models that describe the software [6]. Combining distinct approaches, such as KM and SE, the key challenge of our research is to answer the following question: "What kind of KM framework is needed to help Software Maintenance knowledge workers?". In section 2, we present an overview of KM for SE, identifying the challenges organizations face to apply knowledge management practices. With the aim of answering our research question, in section 3, the MIMIR Framework is presented, namely: (A) The MIMIR Model Overview; and (B) The MIMIR Methodology.

[1] Software Engineering Body Of Knowledge

Finally, in section 4, we present our preliminary conclusion regarding our research's key challenge.

2 Knowledge Management for Software Engineering

Dependency on technology grows each day, increasing the costs for developing software, making it a larger piece of the "companies cake" called budget as well as boosting the amount and diversity of information that organizations must deal with [2], [7]. The ability to become leaner without losing efficiency and quality are challenges that these knowledge intensive companies must overcome and the trigger for a KM approach to the SDLC. Some of the challenges that organizations must deal with are presented next, as well as a KM approach regarding the SDLC phases. Knowledge is not a recipe, it is a set of procedures for dealing with a concrete situation, a routine. Knowledge should allow organizations to cope with different situations, anticipate implications and assess its effects [3].

2.1 Organizational Challenges

There is a significant amount of documents and artifacts produced during the phases of the SDLC, recording knowledge gathered along each sprint or project. Dealing with their usage is a challenge for the organizations. How to access it, along with ways to research what is really needed in a particular context, makes all this documentation unusable and difficult to share. Moreover these knowledge so dispersed that makes it hard to update [2], [7]. While some knowledge is recorded, some still remains in the individuals' mind [7], meaning that at the end of the day knowledge leaves the organization. Heuristics that individuals attain over several years cannot be transmitted within months to others and when they leave the company a knowledge gap is create, sometimes with complex and serious consequences for the organization. To manage knowledge and it is flows is of the utmost relevance. However, KM is not a product that the company can acquire, KM must be implemented in time [6] and involves processes, technology but above all individuals and organizations to enable a sharing culture, where the first ones must participate and the second ones must encourage, KM = People + Process + Technology [8].

2.2 KM/SE Approach

The SDLC is a knowledge-intensive environment where KM processes fit like a glove. It can function as a complement to support individuals during the SDLC phases to enhance productivity and quality [7]. The map we present in fig. 1 evidences the proximity between the Knowledge Life Cycle processes and SDLC activities. SDLC activities transform tacit knowledge into explicit [9], and when properly documented, they are organizational knowledge reification activities.

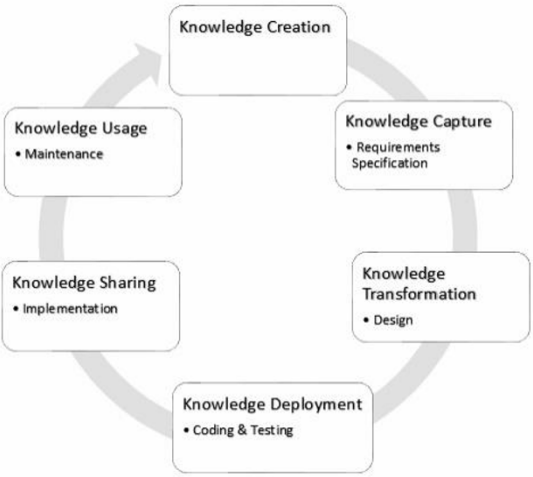


Fig. 1. Mapping KLC processes versus SDLC activities.

Knowledge in software development projects is diverse and growing in proportions. Organizations have problems identifying the contents, location and the best way to make use of it [2]. An important step towards a knowledge management project is the characterization of the knowledge assets. The domain knowledge includes business processes, decision-making, entrepreneurial, declarative and procedural knowledge, heuristics and informal knowledge [10]. For this paper, the activities of SDLC were segmented in three major process areas derived from fig. 1, regarding their outputs combined with their needs. They are Requirements Definition (RD), Software Development (SD) and Software Maintenance (SM), as seen in fig. 2. With this it is possible to identify all the documents created during the SDLC and determine within each one the more significant information.

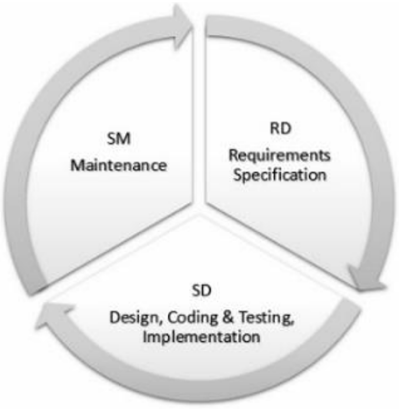


Fig. 2. SDLC segmentation accordingly to their outputs and needs

Our main focus is the SM area, since in general KM processes have been less explored [2], [4], [5], [7], [10], [11]. It turns out that the documents produced in

previous phases of SDLC are rarely used to aid in solving maintenance problems. Maintainers end up mainly resorting to read the legacy software code or to an informal exchange of ideas with their peers; 40% to 60% of the effort made in SM is spent understanding the software that is being maintained [12]. SM deals with real problems and its activity can be used to evaluate knowledge documented in the previous phases.

2.3 Research Methodology

Methodology is the study of methods, the set of techniques and processes used for research and development of a scientific work. Due to the nature of this research, of the various existing methodologies, the choice fell on the Design Science Research (DSR).
This is fundamentally a methodology for problem solving in order to create innovations that define the ideas, practices, technical capabilities or products that can be made more effective and efficient through analysis, design, implementation, management and the use of information technologies [16].

As well as the SDLC activities, which are widely discussed in this paper, so the DSR has its cycle of research, making it for this reason a methodology course used in conducting research related to information systems. There are seven guidelines in DSR aimed to assist researchers, reviewers, editors and readers to understand the requirements, namely: Design as an Artifact, Problem Relevance, Design Evaluation, Research Contributions, Research Rigor, Design as a Search Process and Communication of Research [16].

Design as an artifact aims at problem solving and problem knowledge, their understanding and resolution are solved with the creation and implementation of an artifact, hence our model overview in fig.3 and fig. 4. For an activity that is intended to be efficient and objective, as is the case of SM, it is a subject of *relevant importance* to the organization that up 60% of the time spent in maintenance is trying to understand the software itself. DSR is inherently iterative [16] therefore our *Design as Search Process* is based on literature revision, for reference to our work and with which we have a comparison table on section 3.3, but also provided from personal experience on a large software development organization.

DSR is essentially a search process to discover an effective solution to a problem [16], future work will continue to be developed for this research using the guidelines and the research life cycle from DSR.

3 MIMIR Framework

SM is a demanding and complex activity. Software maintainers need to master programming languages, the system architecture, understand data models, have

procedural knowledge, software updates and their impacts and often this is done for several applications. Experienced individuals are chosen for these tasks, seniority and heuristics makes them the manager's top choice, thus highlighting that these are tasks that require a high level of organizational knowledge, sensibility and experience, due to their criticality and urgency. The MIMIR Model presented next, named after the Norse mythology god who guards the "Well of the Highest Wisdom", is an approach to a framework mapping information based on documents created in the SDLC phases to retrieve from them the utmost relevant knowledge for SM.

3.1 MIMIR Model Overview

This model was driven by the fact that maintainers deal with problems, therefore accessing relevant knowledge to aid them in the research is extremely important. Additionally, they can validate, correct or update the accessed knowledge, for which back flushing is applied, a technique used to correct data in the origin during the Extract, Transform and Load (ETL) process in Data Warehousing.

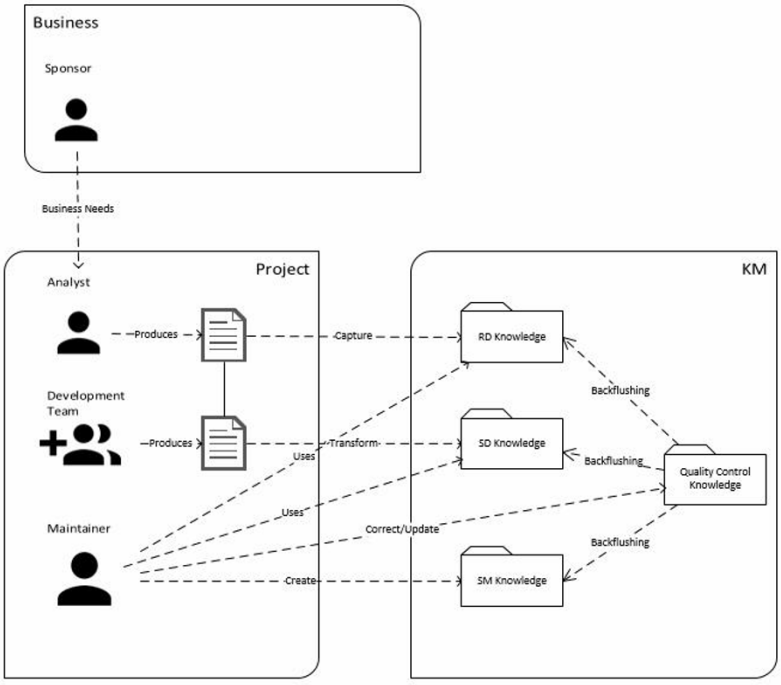


Fig. 3. MIMIR Model Overview

MIMIR Model performs a preliminary approach to the SDLC phases in organizations based in three segmentation areas as shown in fig. 2. Thus, as shown in fig. 3, several roles were defined as Unified Modeling Language (UML) stereotypes for participants, namely: *Sponsor*, *Analyst*, *Development Team* and *Maintainer*. Sponsor role is to define the needs for project and validator for the requirements quality, they can be

external or internal to the organization. Analyst is the expert for the model, providing the requirements elicitation, application analysis and main source of knowledge in the project area. Development Team involves the individuals that participate in the project mainly in the coding phase. In smaller projects the Analyst can participate in the development team. Maintainer is the individual that provides support for the usage of the system, if the analyst has exclusive business knowledge he does not play the maintainer role, on other hand, if he is an Application Analyst he will surely be a Maintainer. *RD Knowledge* will retain all significant information regarding requirements elicitation. *SD Knowledge* will gather information from development phases of the project like technical plans or software design specification. *SM Knowledge* gathers maintainers' most frequently problem solutions, batch processing sequences, or application navigational sequences. *Quality Control Knowledge* is where the corrections and updates to previous knowledge remain until approval from experts like analysts to initiate the back flushing process.

3.2 MIMIR Requirements Capture Model

MIMIR is centered in the extraction of knowledge created in documents produced by the knowledge workers throughout the SDLC phases using the CMMI-DEV[2] model base. In this paper, in fig. 4 we only present the main concepts of the *RD Knowledge Base* feed in the requirements phase.

The elicitation of *Sponsor* needs from the *Analyst* will first produce the *Business Requirements Specifications* (BRS) document, a high-level business needs document and kick-off for the SDLC phases. The project ID goals and scope are important information that the *MIMIR-Extractor* module will acquire from the document. These will permit to create the project in the *MIMIR RD Database* as well as the first tags will be added to help in the search queries and the knowledge flow for the individuals, specially maintainers.

Also produced by the *Analyst* is the *Project Requirements Specifications* (PRS), in which the requisites for the development team will be described, each one with a specific ID, type and description and all referring to a functional area of the application or system. This information will be added to the RD Database project created previously. The requirement description will provide important knowledge in a natural language, easy and quick to interpret by the individuals specially *Maintainers*. Using the requirement ID as a key, MIMIR will map these descriptions to the list of artifacts that are affected in the project, registered later in the *SD Knowledge Database*.

The *Project Requirements Specifications Check-List* (PRS-CK) will close the requirements phase and consolidate the RD Database information from this document, and *MIMIR-Extractor* will retrieve information regarding the *Analyst* involved in the requirements elicitation, for previous expertise referral. The last step of the

[2] Capability Maturity Model Integration for Development – A model that provides guidance for improving organization's capability to develop quality products and services that meet the needs of customers and end users.

requirements phase is determined by requirements acceptance from the *Sponsor,* which will provide the trigger for the *Requirements Close and Dissemination* module (*MIMIR-RCD*) to make the knowledge from the *MIMIR RD Database* visible and distribute it to individuals in the *Development Team*.

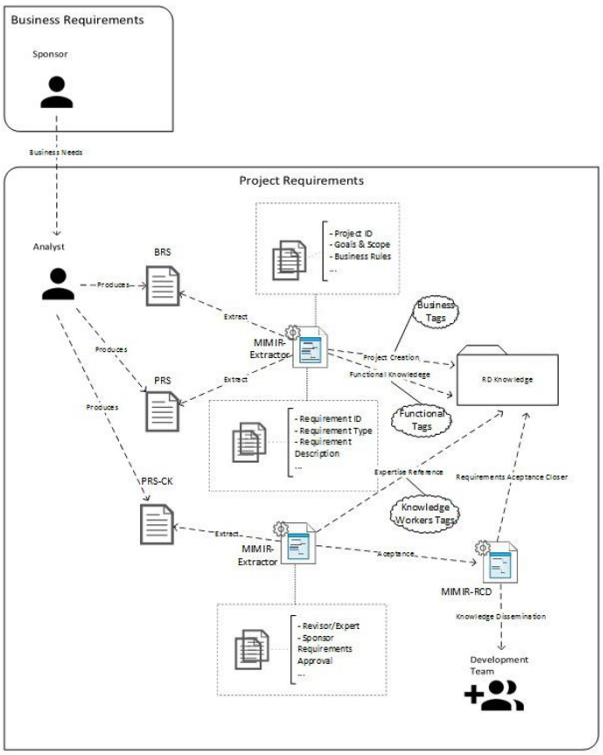


Fig. 4. MIMIR Requirements Capture Model

3.3 A Comparison with Related Work

We review other authors researches in KM for SE and especially through the SM approach as means of reference and guidance to our work, in which we have resumed in fig. 5 each one regarding their focus in the KM, SDLC and Quality dimensions.

For the P1 [13] the main focus is essentially on knowledge capture in the software requirements phase, enhancing the corporate memory as the main area of intervention, and it has left out the SM phase and the related problems. P2 [14] and P3 [15] have the main focus on the SM phase and its problems for the SDLC dimension, and for the KM dimension emphasize the knowledge share and the reuse of lessons learned. The previous phases of SDLC were left aside.

P4 [12] is the most in-depth research paper in this area, however, has no focus on quality control and knowledge correction. Although the primary focus is the SM

phase, it does not neglect the previous phases in the SDLC framework. Knowledge sharing has a minor attention and knowledge capture has a mild focus.
P4 is definitely a reference and guidance for the future of our research work because it has a well-defined ontology based on the maintenance problems to support other dimensions. On the other hand, P4 has reached the perception that the application of KM in SM phase promotes the creation of knowledge management culture (and approach) within the organization.

Dimensions / Projects		P1	P2	P3	P4	MIMIR
Knowledge Management	Knowledge Capture	●●●	❍	❍	●●	●●
	Knowledge Sharing	●	●●●	●●●	●	●●
	Knowledge Usage	●	●●●	●●●	●●●	●●●
Quality	Knowledge Quality Control & Correction	❍	❍	❍	❍	●●●
Software Development Life Cycle	Requirements Definitions	●●●	❍	❍	●●	●●●
	Software Development	●	❍	❍	●●	●●●
	Software Maintenance	❍	●●●	●●●	●●●	●●●

Legend:
❍ No Focus
● Little Focus
●● Mild Focus
●●● Large Focus

Fig. 5. Analogous Projects Review

4 Conclusion

Software development projects are knowledge-intensive and SDLC activities are the reification of the organizational knowledge. A lot of knowledge is documented but a lot still remains in the individuals' mind, therefore creating a potential (organisational) knowledge gap.
How to use documented knowledge and how to document the one that is not, are challenges for the organizations. SDLC proximity to KM can work as a facilitator to implement a KM project. However KM approaches to SE are mainly connected to the early phases of SDLC and especially in the requirements specification, leaving the software maintenance activities to a second plan. Up to 60% of the time spent in maintenance activities is re-acquiring knowledge and this is the main driver for our KM approach to SDLC, along with the fact that accessing knowledge maintainers can became validators for information created previously.
MIMIR approach applies documents provided from previous software engineering phases to capture knowledge from each software project and has a particular concern to use the maintainers as a means to validate and adjust the knowledge gradually inferred. The result is a KM software project charter combining a set of knowledge acquisition tasks across the SDLC framework.
As future work, regarding our research question, our aim is to present a detailed MIMIR model, methodology and tool, based on software development organization,

combining insights across corporate software projects as a means of evaluating effects on people and organization, technology, workflows and processes.

Acknowledgements

We acknowledge the financial support of the Iberian Association for Information Systems and Technologies (AISTI), which permitted the registration in the WorldCIST'16 (4th World Conference on Information Systems and Technologies), held at Recife, Brazil, 22 - 24 March 2016, and consequently this publication.

References

1. Davenport, T. H. (2010). Process Management for Knowledge Work. Handbook on Business Process Management 1. Springer
2. Rus, I., & Lindvall, M. (2002). Knowledge Management in Software Engineering. IEEE Software
3. Cascão, F. (2014). Gestão de Competências, do conhecimento e do talento. Lisboa: Edições Sílabo, Lda
4. Alawneh, A. A., Hattab, E., & Al-Ahmad, W. (2008). An Extended Knowledge Management Framework during the Software Development Life Cycle. International Technology Management Review
5. Bourque, P., & Fairley, R. E. (2014). SWEBOK v3.0 - Guide to the Software Engineering Body of Knowledge. New Jersey: IEEE Computer Society.
6. Camacho, J. J., Sanches-Torres, J. M., & Galvis-Lista, E. (2013). Understanding the Process of Knowledge Transfer in Software Engineering: A Systematic Literature Review
7. Natali, A. C., & Falbo, R. d. (2005). Knowledge Management in Software Engineering Environments. Vitoria
8. Leistner, F. (2010). Mastering Organizational Knowledge Flow. New Jersey: John Wiley & Sons, Inc
9. Aurum, A., & Ward, J. (2004). Knowledge Management in Software Engineering - Describing the Process. 2004 Australian Software Engineering Conference
10. Vasconcelos, J. B., Kimble, C., Miranda, H., & Henriques, V. (2009). A Knowledge-Engine Architecture for a Competence Management Information System
11. Isotani, S., Dermeval, D., Bittencourt, I., & Barbosa, E. (2015). Ontology Driven Software Engineering A Review of Challenges and Opportunities. IEEE Latin America Transactions
12. Anquetil, N., Oliveira, K. M., Sousa, K. D., & Dias, M. G. (2007). Software maintenance seen as a knowledge management issue. Information and Software Technology
13. Andrade, J., Ares, J., Garcia, R., Rodriguez, S., & Suarez, S. (2006). A Reference Model for Knowledge Management in Software Engineering.
14. Rodriguez, O. M., Vizcaino, A., Martinez, A. I., Piattini, M., & Favela, J. (s.d.). Applying Agents to Knowledge Management in Software Maintenance Organizations.
15. Talib, A. M., Abdullah, R., Atan, R., & Murad, M. A. (April de 2010). MASK-SM: Multi-Agent System Based Knowledge Management System to Support Knowledge Sharing of Software Maintenance Knowledge Environment. Computer and Information Science.
16. Hevner, A. R., Ram, S., March, S. T., & Park, J. (March de 2004). Design Science in Information Systems Research. MisQuartely, pp. 75-105.

Our SIHE: e-collaboration in academic management

Joel Alves de Lima Júnior[1], Marcelo Mendonça Teixeira[1], Jorge S. Correia-Neto[1], Guilherme Vilar[1], Marcelo Brito Carneiro Leão[1]
[1] Federal Rural University of Pernambuco, Departament of Statistics and Informatics, Rua Manuel de Medeiros, s/n – Dois Irmãos, 52171-900, Recife-PE, Brazil
jr.alves18, marcelo.ufrpe.br, jorgecorreianeto, guilherme.vilar{@gmail.com}, vreitor@reitoria.ufrpe.br

Abstract. New interfaces brought facility of access to communication by the increase of storage capacity of news and by the processing speed of information in real time. In this sense, the present paper reports a mobile platform for the monitoring of structural problems in academic institutions, which at the same time works as a technological resource to support teachers. From theory to practice, we demonstrate this prototype developed for a state institution of higher education, from here after addressed as SIHE. Was used a qualitative study design of a descriptive, empirical nature, supported by the Development Methodology of a Prototype. This study took place between February 2014 and February 2015.

Keywords: Mobile Platform, IHC, Digital Citizenship, Online Campus.

1 Introduction

Our new lifestyles are permeated by a global culture that enhances our ways of socializing in the world, often through digital technologies - and particularly mobile technologies [6]. In other words, we are experiencing a cultural virtualization of human reality, mediated by information and communication technologies (ICTs) that are regulated by its own codes, symbols, and social relationships. Furthermore, these technologies offer real-time communication and interaction means, as well as instant access to information, which we do not simply repeat, but rather produce, reproduce, collaborate, and distribute [8]. With the fast advances in means of communication – which we now call "net media" – innovation becomes a resource for the development of group communication, propelled by a contemporary mobility movement (seen in tablets, smartphones, and portable computers, among others, which are important aspects of our new reality). This movement is reflected in the intense connectivity of generation Y [9]. In these times of change that we have experienced since the middle of the 20th century, the internet has revolutionized the way in which individuals exchange information, relate to each other, learn, collaborate, work, and study, immersed in a web of hyperlinks and hypermedia of the online universe - the "fluid

[1] Please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames. This determines the structure of the names in the running heads and the author index.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_7

languages of the mobile era", in the words of Santaella [1]. Following this trend, new technological platforms have been evolving as a way to meet market demands and provide satisfaction to their users; users who are migrating from desktop platforms to mobile platforms because the latter are more versatile, faster, and more objective, aimed at providing the comfort and the practicality of carrying one's equipment in their own pockets [7]. In the ICT context, a new opportunity emerges to address issues found at the heart of academic institutions, supporting a kind of academic management that is efficient and that benefits the learning and teaching processes. Therefore, we would like to present a mobile platform for the monitoring of structural problems in academic institutions, which at the same time works as a technological resource to support teachers. From theory to practice, we demonstrate this prototype developed for a state institution of higher education, from here after addressed as SIHE.

2 Mobility and Digital Citizenship

Technologies, equipment, and the languages that circulate through them allow for a new cultural logic, as well as a more personalized, individualized consumption of messages – as opposed to mass consumption [1]. These processes that constitute media culture; "this culture constitutes of a new period of passage, of transition, functioning as a bridge between mass culture and cyber-culture" (ibidem, p. 125). Nicolau [3] reminds us that it is the conceptions corroborated by Henry Jenkins, from his idea of a "culture of convergence" fixated on the influx of content through multiple cooperating media supports, associated to the migratory behavior of the target audiences of the traditional communication means, who are capable of chasing the information they need almost anywhere. We live in a consumerist society; we legitimate a culture of convergence for common sense, incessantly seeking individuality, autonomy, social recognition, nationality, sexuality, and social interaction, all of which were previously limited by the depersonalization and single dimensionality of traditional means of communication media offer is mobility" [4, p.163]. At the reach of the fingertips of homo communicants is a new world of information that comes from places that are far away and, per tradition, closed – like large archives that allow you to be in different places without physically moving [5].

In this way, the multidimensionality of communication merges with the ubiquity of the individual (ibidem). The contemporaneous view of Bento Silva is reflected in the contemporary society, what we call the mobile culture [2]. Since the emergence of mass culture, moving from one cultural cycle to another has happened so much faster that the expression of the mobile culture is today placing its previous, most recent expression – the cyber-culture – on a second plane (ibidem). Even though the mobile culture results from the digital revolution and, therefore, is located in the same paradigm as cyber-culture, unlike cyber-culture, the mobile culture mixes "cyber" with the physical space, in a new, interstitial space. These "cultures" can help promote sociocultural transformations that are necessary to change our present reality, as they constitute a global common culture that produces, distributes, receives, redistributes, and appropriates contents which are generated through our collective interactions. Therefore, once immersed in the mass culture, media culture,

convergence culture, mobile culture, and cyber-culture, human beings need to learn to discern and criticize the information received from the new and older communication means, therefore avoiding sociocultural manipulation. In a more broad perspective, discussed by McQuail [10], the public is pushed to be more conscious and selective regarding communication enterprises related to the production of mass media, given that at the same time that they represent freedom of speech, they also alienate the masses for their own benefit, complements Tomei [14].

When considering of citizen's participation through the mobile interface, we must understand that the process of digital inclusion is not present in Brazil [6]. The share of the population with access to the internet and those that use it exclusively for the purposes of entertainment and communication reflects the lack of knowledge and conscience to make their rights respected. This is why Mike Rible, cited in Teixeira e Lima Júnior [7], defends that in order to be productive as citizens we must have a compromise to equality in digital access. That is, the equal participation of all citizens is of crucial importance in the process of investigating, suggesting, and evaluating the issues found in academic institutions, from infrastructure to the educational environment of the classrooms. The virtual universe has allowed citizens to directly participate in a flexible, effective communication interaction with the public power, which is akin to digital citizenship, as demonstrated in Figure 1 [ibidem]:

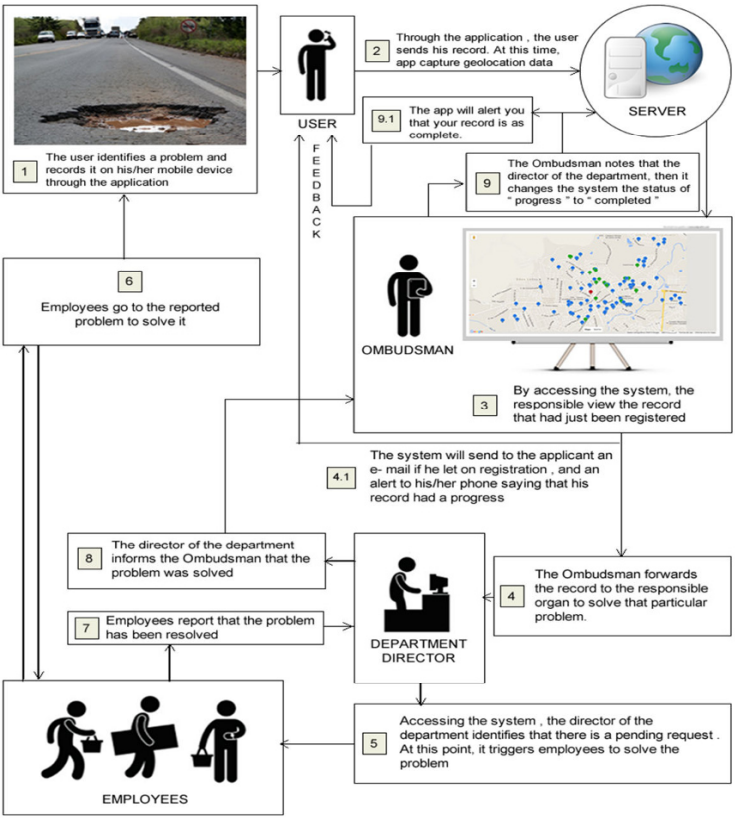


Figure 1. Digital citizenship model.

Society and political figures normally have to address several issues in the public arena, from potholes to the lack of street lights, crumbling streets that lack street signals, visible trash and open sewers, accessibility, and many others. Similar issues are faced in academic institutions, which gave rise to the present development project.

3 Methodology

As Waslawick describes, computer science research frequently contemplates the creation of a new system, algorithm, or model, in which novelty is fundamental [12]. From this standpoint, the present study aims to develop a prototype for a collaborative system that involves the students and management professionals of one specific SIHE seeking faster, more effective solutions for the issues detected in the institution's infrastructure.

Following Waslawick's propositions [12], the present study has an applied nature, as it seeks to solve real problems. Regarding its objectives, this study is descriptive because it describes the characteristics of the object being studied. The approach we followed is qualitative, given the dynamic relationship between the object of study and the researcher, as well as its inductive character [11].

The software Our SIHE is a mobile platform (application) that addresses the process of the academic management of issues identified by the academic community, within the campus and surrounding areas, therefore becoming an important resource for decision-making by the ombudsman and the higher management officials. The prototype's contribution transverse both the conception and availability of the software and the submission of public interest information (including accessibility resources), delivering here a concrete proposal for its implementation in other social contexts beyond academia.

The present study is justified because, generally speaking, in terms of SIHE management, most Brazilian states observe: a) lack of follow-up tools to solve problems and provide feedback to society; b) information systems that are fragmented and not standardized; c) difficulty in diagnosing issues; d) absence of plans of action to address the present issues, among others. Therefore, we asked the following questions from five managers at the SIHE that we studied, in its main campus:

1. Currently, is it possible to identify infrastructure and service issues in this institution, in a continuous manner, through the academic community?
2. When an issue is identified, is it possible to inform the time-frame for its solution to the claimant, in an informative manner?
3. Do you have a guiding map of the present issues by sector, center, or department, highlighting priority areas for administrative action?
4. When did the academic management professionals learned about the current issues?
5. What measure was adopted to address the issue?
6. Was the issue addressed and solved?
7. Did the issue cause stagnation in any areas? Why? For how long?
8. Since the solution was implemented, has anyone checked to see if the problem was effectively corrected?

9. Has the user received feedback on the solution adopted?
10. What was the solution adopted for a recurring problem? Are there a best practices guideline for problem-solving?

All the responses (students and professors of Federal Rural University of Pernambuco), converged to the need for a system that standardizes solutions for these (and other) questions in an effective manner and in short time period. Usually, these demands are received or forwarded through an institutional ombudsman. In direct relation to the process of teaching and learning, the lack of books in the library, lack of didactic materials (white-board markers, board erasers, projector, etc.), the lack of a teacher for a specific field of knowledge, assigning teachers to areas that are not their expertise, are just some of the most common problems faced by academic institutions. It arises, then, a technological model for monitoring the problems previously mentioned. Yet, how would the process work, from the moment a problem is identified to the final response to the claimant?

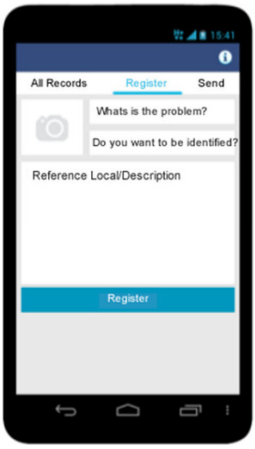


Figure 2. Submitting the claim for the issue.

As shown on figure 2, the user must submit the issue through his or her smartphone or tablet, and will then receive immediate feedback on the claim.

After the data is sent, the user sees a screen with all the claims made from his or her mobile equipment, followed by information on the chosen category, a summary of the issue, and the status of each of the claims (akin to notifications). Claims go through three different statuses: New, In Progress, and Concluded. These statuses express the current stage of each claim and are visually represented using colors, as described in Table 1. How will these claims help with problem solving? Claims reported by the academic community get analyzed and, from there, it is possible to visualize the situation in several different areas of the campus and to identify the problems that have made the lives of the community hard. The map used to visualize these problems from a “macro” perspective is Google Maps (described below).

Table 1. Font sizes of headings. Table captions should always be positioned *above* the tables.

Status	Color	Description
New	Red	This status indicates that the claim was submitted and no action has yet been taken regarding this claim.
In Progress	Blue	This status indicates that the claim has been identified by the manager and that studies/analyses are being conducted along with other involved organs to solve or contain the issue.
Completed	**Green**	This status informs the user that the claim has been successfully solved.

Using these data, management professionals can make decisions to contain or solve issues in a fast, effective manner, using the application's data to identify the location of these problems.

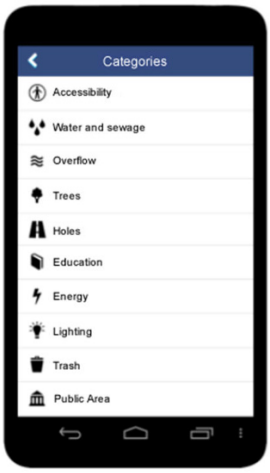


Figure 3. Classifying the issue

The system allows for using categories that facilitate the selection of related issues. This classification will allow management professionals to generate statistics on the main issues, allowing them to develop plans of action that address a specific set of problems in a location.

Working offline – the system works even when not connected to the internet. It will be possible to register every problem that is identified, and once connected, the application will transmit all previously filed claims.

In the act of submitting a claim, the application captures the exact latitude and longitude of the issue using the GPS capabilities of the mobile equipment, registering and storing the location using the database of the equipment. One of the biggest problems for using this kind of application is access to a reliable internet network, given that in Brazil the cellphone networks with 3G capability have not yet achieved

the expected connectivity and that 4G is still undergoing implementation. Therefore, considering this barrier, the proposed system will register claims offline (activating only the GPS), allowing the user to take advantage of the application without necessarily being connected to the web, and making it possible to submit claims in areas that do not yet possess an internet signal (such as rural areas).

How does the claim process work? As soon as the user connects to the internet using wifi, 3G, or 4G, the application will identify connectivity, will inform the user that claims were made while offline, and that these claims need to be submitted. In order for these claims to be validated, the user must submit them to the server. The application will then display to the user a screen with the number of claims that were made and a button that reads "Submit Claims." When this button is pressed, the application will send the data that was entered offline to the server, as shown on figure 4.

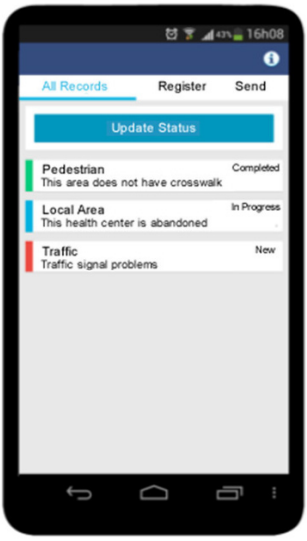


Figure 4. Following the claims.

Monitoring the status of the issues' solutions can be done through the same equipment that submitted the claim. The user will easily follow the evolution of the issue and its solution through a color-coded system that refreshes automatically, allowing the user to quickly verify what is new, what is in progress, and what has been concluded. From these data, the ombudsman or the academic higher management (provost, dean, etc.) will take action to contain/solve the problem in a fast and effective manner, using the application's data to support and recognize the location of the issue. In practice, the tools shown on figures 5 and 6 will be made available.

In figures 5 through 6, the management professional determines the priorities to be addressed in each area, sector, department, and teaching center; priorities can also be determined using the urgency of the claims. It is possible to visualize the data

submitted by students, teachers, technicians, managers, and all other members of the local academic community, as well as to generate statistical graphs and the status of each registered claim. After the issues are solved by the responsible parties, the management professional will be in charge of modifying the status of the claim to "concluded". This way, he or she can relay in a simple and objective manner which procedures were necessary to solve the issue.

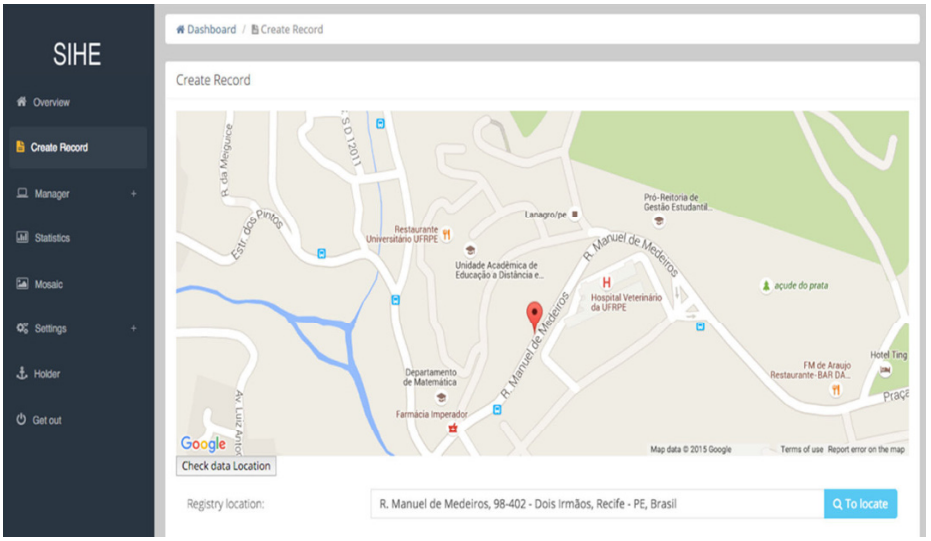


Figure 5. Map of geolocated claims.

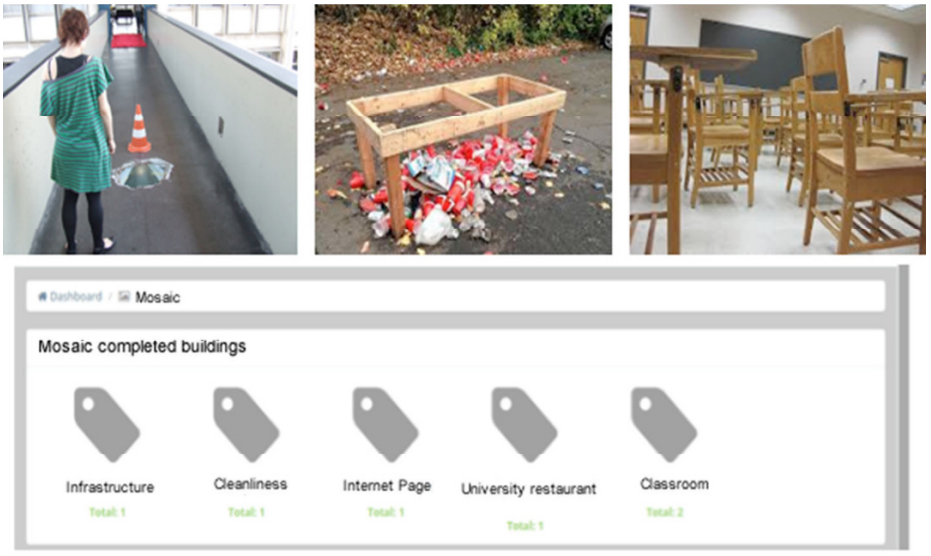


Figure 6. Categories of issues.

Finally, through the capabilities of "e-mail" and "alerts" from the mobile equipment's, the claimant will receive several notifications on the progress of his or her claim, which department is responsible for addressing it, what is the protocol for the solution, and other information in regards to his or her claim. Feedback to the academic community is an essential part of this process because offering information represents a guarantee of compromise and social responsibility on the part of the public administration toward the community.

The feedback process is of main importance to society and to the communicative process; with the Web 2.0, several mechanisms have adapted to these new models of communication, which intervene by modifying the passive-receptive state into an active-communicating state, establish a dual-direction communication system [13], [15]. The feedback mechanism is considered an important aspect of the informational system, and it is bilateral because it happens in both directions; that is, in addition to sending out the original message, the information returns to the sender decoded by the receiver, so that the former can know the result of his or her original message [8].

From the interviews made with the five academic management professionals that oversaw the development of the prototype here presented, we identified the following achievements that came from the implementation of this system:

a) Increased easiness in identifying and locating issues reported by the academic community through the efficient use of the management system;
b) The possibility of promoting integrated actions to solve issues in all locations (departments, academic units, teaching centers, etc.);
c) Complete registry of all the issues existent in the teaching institution, not only in regards to infrastructure, but making it possible to strategically follow actions on the part of the management professionals and their team;
d) Increased involvement and participation in the academic community through using the mobile application, relating it to problems of interest to the community;
e) Finally, the feedback of actions in the public arena not only to the user that submitted the claim, but also to society, allowing the management professionals to be recognized for their capacity to solve problems.

4 Conclusion

The emergence of new means of socializing in the contemporary world opened space for new directions in technological advances, changing and creating unexpected relationships between people, information, and communication technologies. Following this premise, the software Our SIHE offers a more effective avenue for communication between the academic community and the academic management professionals, beyond a simple system of digital ombudsman. Through scientific research and the development of this prototype, we observed the submission of claims involving different kinds of issues. These issues were identified within an institution of higher education and could be managed through mobile technology platforms. The platforms aided to the process of identification of such issues, reduced their resolution time by directing them to the specific departments responsible for solving them, and

minimized the financial cost that would result from hiring third-party materials and staff.

In summary, the proposed application – a first of its kind in Latin America and heavily praised during the 3rd Forum of Ombudsman of Higher Education Institutions in Pernambuco (which took place in July and August of 2014) – recognizes the importance of public opinion. In addition, the community feels represented and satisfied because its demands are heard and, when not immediately solved, they are offered an explanation on what prevented its resolution as well as a time estimate for future solutions. That is, the application improved communication, consolidated popular participation, satisfied public opinion, supported the decision-making of management professionals, reduced the time and expenses of addressing issues, and directly contributed to the quality of education.

References

1. Santaella, L. 2007. Linguagens líquidas na era da mobilidade. São Paulo: Paulus.
2. Santaella, L. 2008. O impacto das novas mídias sobre a cultura. In Villares, F. (org.) (2008). Novas mídias digitais (audiovisual, games e música) – Impactos políticos, econômicos e sociais, p.17-54. Rio de Janeiro: E-papers.
3. Nicolau, M. 2010. A busca por uma web semântica cognitiva. In Revista Temática, ano 7, nº 7, p. 1-15.
4. Silva, B. 1998. Educação e comunicação. Braga: Centro de Estudos em Educação e Psicologia da Universidade do Minho.
5. Soares, T. Os meios de comunic@ção social na Internet: contributos para à análise sociológica dos cibermedi@. Disponível em: http://www.bocc.ubi.pt/pag/soares-tania-meios-comunicacao-social-internet.pdf. Acesso em 03 de Novembro de 2014.
6. Teixeira, M. M. 2013. Da educação a distância às plataformas de aprendizagem: sistemas alternativos de educação mediada. Munique: Grin Verlag.
7. Teixeira, M. M. e Lima Júnior, J. A. 2013. Cidadania digital: uma proposta de dispositivo móvel para o monitoramento das cidades. Revista Temática, ano IX, n. 12, p. 1-22.
8. Silva, M. Sala de aula interativa. Rio de Janeiro: Quartet, 2. ed., 2001. 220 p.
9. Tapscott, D. Grown up digital: how the net generation is changing the world. New York: McGraw Hill, 2009.
10. McQuail, D. Media performance: mass communication and the public interest. London: Sage Publ. 1992.
11. Flick, U. An Introduction to qualitative research. Thousand Oaks: Sage. 2006.
12. Wazlawick, R. S. Metodologia de pesquisa para Ciência da Computação. Rio de Janeiro: Elsevier, 2008.
13. Massey, B. L. & Levy, M. R. Interactivity, online journalism, and english-language web newspapers in Asia. Journalism & Mass Communication Quarterly, v. 76, n. 1, p. 138-151. 1999.
14. Tomei, L. 2011. Online courses ans ICT in education: emerging practices and applications. New york: IGI Global.
15. Teixeira, M. & Ferreira, A. 2014. Communication model of virtual universe. Munich: Grin Verlag.

Model Accreditation for Learning in Engineering Based on Knowledge Management and Software Engineering

Víctor Hugo Medina García[1], Germán Andrés Méndez Giraldo[1], José Fernando López Quintero[2]

[1] District University "Francisco José de Caldas", Faculty of Engineering, Bogotá, Colombia
[2] CUN University Faculty Enginnering, Bogotá D.C., Colombia
vmedina@udistrital.edu.co gmendez@udistrital.edu.co
jose_lopezq@cun.edu.co

Abstract. This article presents a model to register and to accredit higher education institutions in engineering based on the new advances that they have carried out using the CMMI model (Capability Maturity Model Integration - Software Development) and the knowledge management. The proposed model looks to improve the capacity of engineers and engineering students, as well as the processes in engineering institutions. What is pursued with this feedback is the multilevel refinement of engineering programs as an instrument that assures the mobility of programs to regions that are still deficient in accreditation systems.

Keywords: Accreditation, engineering, CMMI, maturity, capacity, knowledge management.

1 Introduction

Today is known that higher education institutions are in the effort to produce a global engineering; this is partly due for the need to create an International Registration for Engineers, need that has increased dramatically with the socio-economic and culture changes. The importance of international recognition of engineering degrees is possible thanks to the accreditation process. In many countries and in all regions of the world, efforts are made to adopt a system of accreditation for engineering programs, but these efforts have met with excessive costs and prohibitive time to adopt them as in the case of the systems ABET (Accreditation Board for Engineering and Technology) it is a recognized organization in the EEUU, which accredits engineering programs, technology, computing and applied science institutes of higher education and universities or CEAB (Canadian Engineering Accreditation Board) which are essentially equivalent but accredits undergraduate engineering programs in Canada [1].

At the last International Conference LACCEI (Latin American and Caribbean Consortium of Engineering Institutions), which are founding members among other universities, the FAU (the Florida Atlantic University) and the "Francisco José de Caldas" District University of Bogotá, Colombia, it was proposed to develop an

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_8

institutional accreditation model based on assessment levels, depending on the capabilities of institutions, also in the future it can become a methodology to facilitate and to obtain accreditation, first of all to partner institutions of the LACCEI and secondly to facilitate accreditation processes of other higher education institutions, especially in Latin America and the Caribbean.

It was then proposed the development of an accreditation model from that proposed in the Capability Maturity Model Integrated and used in software engineering and by making adjustments to it, could be applied to accreditation processes. Improvement processes based on models, as its name says implies the use of an emulator to address the processes to improve the organization, independent of its nature and it aims to increase the work processes capacity. Must understand the process capability is an inherent possibility of a process to produce planned results.

2 Base Model

The concept to support the development of this research is based on the international recognition of related and successful models that have facilitated the guideline approach for a new proposal in the process of audit, validation and consolidation in Latin America. Hence, the CMMI model is considered as a fundamental basis for this research.

2.1 The CMMI Model

In 1986, the SEI (Software Engineering Institute) of Carnegie Mellon University with the Mitre Corporation began to develop a multilevel model based on process models of process improvement, this was called Capability Maturity Model or CMM [2], which was based on the early work of the Quality Management Deming [3], Crosby [4], and Juran [5]. The model measures the ability of an organization process, which is more than the ability of the process of obtaining planned results. As process capability increases, the result becomes predictable and measurable and most causes of declining quality and productivity are controlled or eliminated.

The original model was the Model CMM - *Capability Maturity Model for Software* (SW-CMM) used to highlight the software development capabilities of an organization to deliver applications on time, within budgeted costs and meeting the customer expectations and requirements. Their proven success led to the CMM-based models to improve engineering processes, which in 1998 were quickly adopted by the U.S. government and the SEI to get the project of a Maturity Model Integrated Capacity (CMMI) in a single structure designed to improve multi-disciplinary processes of an organization.

In 2002, CMMI Version 1.1 was released, then followed by the August 2006 version 1.2 and finally just released the November 1, 2010 version 1.3. The objective of the CMMI project is to improve the usability of maturity models by integrating several different models in one framework. His success and enthusiasm have quickly set to be considered as a potential good approach for process improvement in engineering education.

Now a brief description of the CMMI and purposes based on that model to ensure the quality of engineering and technology programs, which as mentioned has been called CMMEE - Capability Maturity Model Education Engineering, which was first proposed by the LACCEI in 2004 [6].

In the CMMI model there are two representations: *staged and continuous,* which are not equivalents and each organization may choose which one that suit and adapt better to their own characteristics and priorities for improvement. If there is an equivalent, which tells that a maturity level is like having a set of areas of process establishing a certain Level of Capacity.

- *Model staggered* or centered on the maturity of the organization is a model for software (CMM-SW) which provides 5 levels of maturity to classify organizations in terms of which areas achieve their goals and processes, managed with engineering principles. This vision will define the organization staged in a whole giving level of maturity of 1 to 5 as shown in the figure below:

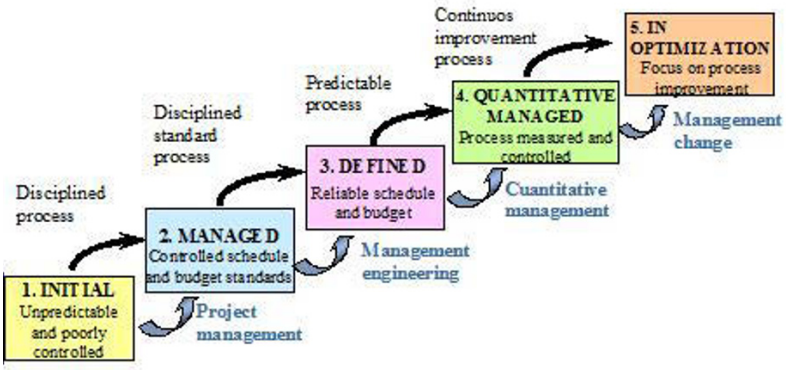


Fig. 1: The five levels of Capability Model Maturity Integrated. Source: Adapted Medina [7].

The Fig. 1 shows the progression of levels. Each level provides the basis to reach the next level; it is counterproductive jumping from one level to another without a sufficient degree of maturity. An organization can adopt a specific improvement process at any time, however it is understood that a process will fail without proper basis. Following the structure of CMMI tends to produce an improved stability in the process whenever the required conditions have been successfully institutionalized.

- *The continuous model* is a model for Systems Engineering (SE-CMM) that provides 6 possible levels of capacity for the 22 process areas involved in systems engineering. It does not group the processes into 5 sections to define the maturity level of the organization, but directly analyze the capacity of each process separately. The continuous vision of an organization will show the capability level representation from each of the areas of process model.

  The 6 levels defined in CMMI to measure the ability of processes in the continuous model are:

  0- Incomplete: The process is not performed, or not achieved its objectives.

  1- Executed: The process is executed and achieved its goal.

2- Managed: In addition to running, the process is planned, reviewed and evaluated to verify if it accomplish the requirements.
3- Defined: In addition of being a managed process according to the policy of processes that exist at the organization, it is aligned with the company policies.
4- Quantitatively Managed: Besides being a defined process is monitored using quantitative techniques.
5- Optimization: Besides being a quantitatively managed process of systematically reviewing and adjust or change to suit your business objectives. Continuous improvement.

The objective of using this model is to facilitate continuous improvement and to gather required documentation to obtain higher levels of accreditation for engineering programs from national and regional accrediting organizations. The documentation required for ABET accreditation has been located at each level of the maturity process and then it guides to facilitate the evaluation process.

Organizations can not be certified under the CMMI. By contrast, an organization is assessed (e.g., using an evaluation method as SCAMPI - Standard CMMI Appraisal Method for Process Improvement)) and receives a score of 1-5 level by following the maturity levels (although it starts with level 2). If the organization wants, it can take process areas rather than maturity levels therefore can get the capacity levels in each process, obtaining the "Profile of capacity" of the organization.

The SCAMPI - Standard CMMI Appraisal Method for Process Improvement is the official method SEI to provide benchmarks of rating systems in relation to the CMMI models. SCAMPI is used to identify strengths and weaknesses of processes, risks revealing development/acquisition and determining levels of ability and maturity. It is used either as part of a process or program improvement, or for the qualification of potential suppliers. The method defines the evaluation process consisting of preparation, the field activities, remarks, findings and assessments, reporting and monitoring activities [8].

The development of the CMMI SEI has announced that from version 1.3 will be combined into a single document the continuous and staged versions and the SCAMPI assessment model will also change. The current is valid until 2010. The next expiration incorporates as if it were not, but certification assessment [9].

3 Proposed Model for Accreditation

Based on the experiences and success of the CMMI model applied to software development, the following model is proposed to support the accreditation process, particularly those programs and institutions in the field of engineering:

3.1 CMMEE Model

The model is summarized in the following Fig. 2:

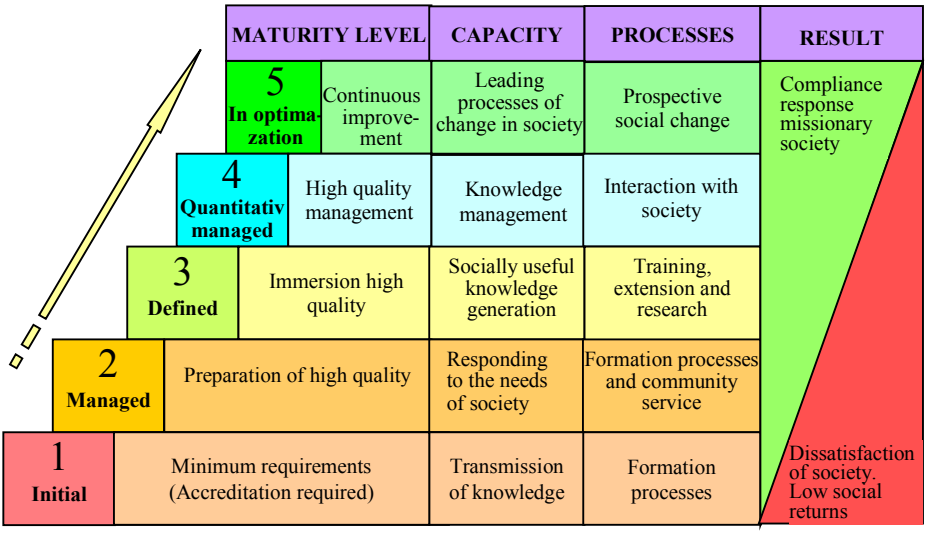


Fig. 2. Model accreditation for learning in engineering based on knowledge management and CMMI. Source: Authors

The purpose of the accreditation proposed model of this type, called Maturity Model for Learning Ability in Engineering (CMMEE), is a model based on the Capability Model Maturity Integrated (CMMI), aims to facilitate the *certification process* through continuous improvement of engineering institutions that are part of LACCEI and will lead to a system of mutual recognition and eventually transferred to a Professional Registration process for the region. Then briefly explaining each one of the maturity levels, the ability to record every level and incorporate new processes of the university community who are impacted on the dynamics that proceeds from certification:

Level 1 - Initial, starts with the minimum requirements to be met by an academic program (Institution) to provide training services. This level determines the ability to meet the minimum to do in the program and it is basically the transmission of knowledge and providing the basic training process. At this level can be included cycles 1 and 2 of training, i.e. technicians and technologists and those emerging programs of Level 3 or professional training.

Level 2 - Managed, this involves an academic program (institution) that meet the minimum quality standards and is determined on the pursuit of higher quality standards and that is visible in the administration. To determine this, it is necessary to listen and engage in dialogue with users/ beneficiaries to respond what society demands. At this level in addition to covering the factor of training, the program absorbs the field of extension, i.e. to meet other players and services at the University.

Level 3 - Defined, here the program (institution) to be located at this level not only acts in accordance with the formation and extension process, but their level of maturity and quality allows to make generation and appropriation of new knowledge

through research processes. In the case of programs and / or engineering institutions, this new knowledge must be applied by providing a value to the society.

Level 4 - Quantitatively managed, at this level, the program (Institution) has generally achieved its mission and at this stage is now concerned to the management process to raise significant quality standards. And to do it, must evolve in a systematic process based on data management, scope development to achieve knowledge management, enabling better interaction with multiple stakeholders.

Level 5 - In optimization, to achieve this level the program (Institution) has fully completed the mission for which it was created and now its framework is based on achieving a goal called teleological vision and that is none other than continuous improvement. To make better the training process, the community service, research, management and leads him to be a leader in its field of discipline.

To the extent that progress in the maturity model levels, achieved *greater compliance* of what society demands from educational institutions, or in a comprehensive way, from the faculties or in a particular case from the programs or careers. This means that at least society demands adequate and relevant training then graduates can fulfill their task in professional performances, but of course, society demands better welfare standards through the social appropriation of knowledge that originates from research, through the community expectations considering they are calling for the extension that makes the university.

3.2 Relation of proccess areas in two models

As mentioned, the possibility that the proposed accreditation model is based on the guidelines of CMMI, focus on the relationships that exist between one and other, to contrast this a work with the 22 areas involved in the software projects development process was executed and compared with what is generated in the accreditation process, see Table 1. It is denoted that in this area of process the level of capacity that is counted in the organization. To illustrate the isomorphism between an accreditation system and the CMM are these areas of development and accreditation systems.

Table 1. Comparison of CMMI at Software Engineering Process and Accreditation. Source: Authors

Maturity Level	SOFTWARE ENGINEERING PROCESS		ACCREDITATION PROCESS	
	PROCESS AREA	**RESPONSIBLE**	**PROCESS AREA**	**RESPONSIBLE**
2	Project monitoring and control	Project Manager	Follow the accreditation program	Program direction
2	Project planning	Project Manager	Accreditation program	Program direction
2	Supplier management	Project Manager	Facilities management	Program direction
2	Requirements management	Engineering	Content management	Teachers
2	Configuration management	Support Staff	System management documentary evidence	Support Staff
2	Measurement and analysis	Support Staff	Assurance and feedback	Support Staff

2	Quality assurance process and product	Support Staff	Ensuring student training	Support Staff
3	Organizational process definition	Process Manager	Curriculum Design	Accreditation Team
3	Organizational process focus	Process Manager	Curriculum Design	Accreditation Team
3	Organizational Training	Process Manager	Professional Development	Accreditation Team
3	Risk management	Project Manager	Retention management and student abandon	Program direction
3	Product integration	Engineering	Student cognitive skills	Teachers
3	Requirements Deployments	Engineering	Mapping of competenci and training objectives	Teachers
3	Technical solution	Engineering	Effectiveness of teachin learning process	Teachers
3	Validation	Engineering	Evaluation system peer- friend	Teachers
3	Verification	Engineering	Evaluation system accrediting agency	Teachers
3	Decision analysis and resolution of difficulties	Support Staff	Self-assessment peer- friends	Support Staff
3	Integrated project management	Project Manager	n/a	n/a
4	Organizational performance process	Process Manager	Peer Comparison	Accreditation Team
4	Quantitative Project Management	Project Manager	Assurance and improvement plan	Program direction
5	Organizational innovation and deployment	Process Manager	Curriculum innovation	Accreditation Team
5	Causal analysis and resolution of difficulties	Support Staff	Continuous review and refinement of program	Support Staff

3.3 Description of the stages in CMMEE Model

For the development of this model it is assumed that there is an initial state in which it is guaranteed that the institution can provide some quality engineering programs, it means that the user can meet a set of quality attributes to guarantee at least a service offered with a minimum of education standards. After, the features and quality variables that must be met at each level of accreditation will be given.

The objective of using this model is to facilitate continuous improvement and gather required documentation to obtain higher levels of accreditation of engineering programs from national and regional accrediting organizations. The documentation required for ABET accreditation has been located at each level of process maturity, then guides to facilitate the evaluation process. Table 2 lists the states at each stage of maturity.

Table 2. Steps in the Accreditation Model based on Capability Maturity. Source: Authors

Level	DESCRIPTION	POTENTIALITY
1	**Initiated**	- It is capable of providing higher education courses but not to ensure quality - There is uncontrolled variability and graduate courses - Have the skills to be developed but have not come across the curriculum - It's time to start developing a certification process

2	**Managed**	- It is planned standardized training process according to the educational objectives - Variability has been defined and defines a control system - Have defined the accreditation process is to take - It has the infrastructure to support management accreditation
3	**Defined**	- It has entered the educational process aimed at meeting the training object. - Measure the variability of the educational process - There is evidence of the strengths and weaknesses of the academic program - There is a team responsible for the accreditation process
4	**Quantitatively managed**	- It has entered the educational process aimed at meeting the training object. - Measures the educational process variability and creates mechanisms for its standardization
5	**Optimization**	- There are mechanisms for review and updating improvements - Have an organizational culture willing to permanent change

The Engineering program should first make a diagnosis of its actual condition to determine at which level is at and how is going to continue on this path of maturity towards accreditation in a state of permanent optimization or improvement

3.4 Actions to be taken in the CMMEE model

Then in Table 3 presents the implementation of measures to move from one level to its immediate successor, that is to say how is the maturity of the accreditation process.

Table 3. Actions to be taken in the Model Accreditation based on Capability Maturity. Authors

Start Level	Arrival Level	Conditions to be met
Initial	**Managed**	- Institutional Mission - Mission Department / Faculty - Quest Program - The requirements of society, employers, communities - The educational objectives - Monitoring system courses - System selection of teachers - Model curriculum changes follow a - A curriculum according to the educational objectives - System selection process stakeholders: Teachers, students and support staff - Responsible for the process
Managed	**Defined**	- The syllabus of subjects for educational purposes - Define the competencies per course - Define performance criteria - Define the educational tools used and to ensure achievement of educational objectives - Process training to teachers and support staff to improve their perfor. - Have a system for monitoring the quality of courses - Flexible curriculum
Defined	**Quantita-tively managed**	- Extracurricular activities that promote the skills and educational goal - Strategies and systems for collection and measurement tests - Process performance evaluation of teachers and support staff - Plans of correction

Quantitatively managed	**Optimization**	- There are mechanisms for review and update continuous improvement - Processes are performed for comparison or benchmarking - Have an organizational culture ready to permanent change

From all of this, it is expected that institutions apply the Model Accreditation Self-designed for this purpose, this model is a set of questions that are being processed in accordance to the responses that are entering and it allows that the program define the state that is within the Capability Maturity Model proposed in Table 1.

Once implemented the model described above and assisted with the developed application, it is time to continue with the model and move permanently to each of the stages and it should be analyzed together as proposed in Table 1 and Table 2.

4 Prototype

A prototype was implemented to support the accreditation *process simulation* (Fig. 3), which through a series of surveys of different quality factors (Figure 4) such as: Institutional, Educational, Academic, Infrastructure, Graduates and Welfare, allows a valuation percentage that reflects the different levels of the proposed model (Fig. 5).

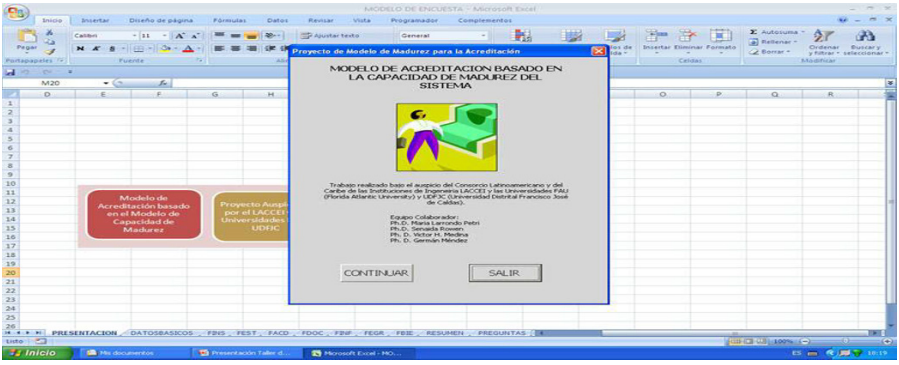


Fig. 3. Accreditation prototype model (process simulation menu). Source:Authors

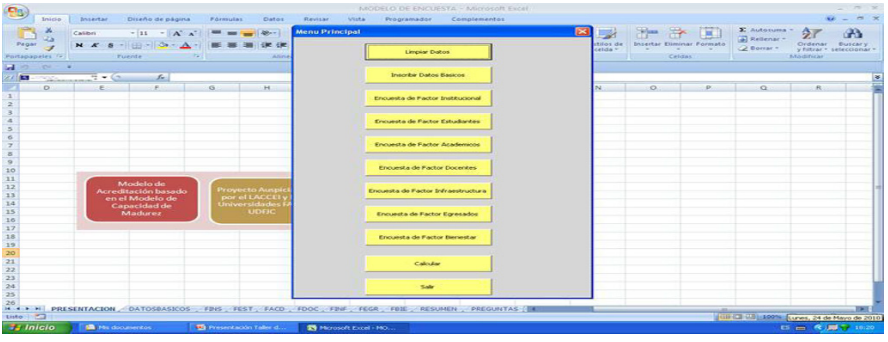


Fig. 4. Accreditation prototype model (surveys). Source: Authors.

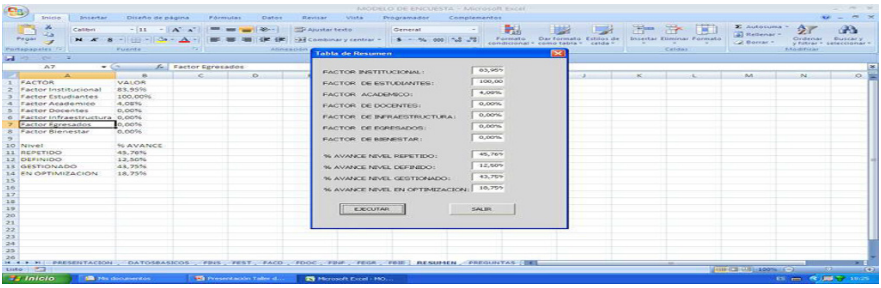


Fig. 5. Accreditation prototype model (valuation percentage). Source: Authors.

5 Conclusions

The field of high quality accreditation is an issue that is in growing confrontation with the different systems of accreditation of *the university*, which could lead to re-evaluate, differentiate, and efficiently improve these models, we can conclude that:

- The CMMI model provides a basis for defining the scalability of the process of improving the higher education institutions, but it requires strategic redefinition since its origin is for software projects.
- Any organizational process is likely to mature over time and requires a mechanism that lets view your progress.
- This is a first approximation of the accreditation process to be carried out by higher education institutions and it is based on the CMMI course but that requires more maturation.

References

1. ABET/ESPOL Proyecto. http://www.abet.espol.edu.ec/ abet.html [date of consultation: January 25 2010]. (2010).
2. Carnegie Mellon University, Software Enginering Institute. (Principal Contributors and Editors: M. C. Paulk, B. Curtis, M.B. Chrissis), A History of the Capability Maturity Model for Software, Reading, MA: Addison-Wesley. (2009)
3. Deming, W. E. "Out of Crisis". Cambridge, MA: MIT Center for Advancement Engineering. (1982).
4. Crosby, P. B. "Quality is Free". New York: McGraw-Hill. (1979).
5. Juran, J. M. "Juran on Planning for Quality". New York: MacMillan. (1988).
6. Larrondo Petrie, Maria M. "A Model for Assessment and Incremental Improvement of Engineering and Technology Education in the Americas," in *Proceedings of the 2nd LACCEI*, Miami Florida. (2004).
7. Medina, V., Pérez, N., & Torres, J. La Investigación en Ingeniería: Ciencia y Tecnología de la Información y del Conocimiento (p. 360). Bogotá: Universidad Distrital. (2011).)
8. Wikipedia. *CMMI* [on line]. [date of consultation: January 11 2009]. Available in <http://es.wikipedia.org/w/index.php?title =CMMI&oldid=22261922>. (2009).
9. Navegapolis. http://www.navegapolis.net/index.php?option =com_content&task=view&id= 330& Itemid=84 [date of consultation: January 15 2009]. (2008).

An Approach to Relevancy Detection: contributions to the automatic detection of relevance in social networks

Alvaro Figueira, Miguel Sandim and Paula Fortuna
CRACS / INESC TEC and University of Porto,
Rua do Campo Alegre, 1021/1055,
4169-007 Porto, Portugal
arf@dcc.fc.up.pt, miguel.sandim@fe.up.pt, paula.fortuna@fe.up.pt

Abstract. In this paper we analyze the information propagated through three social networks. Previous research has shown that most of the messages posted on Twitter are truthful, but the service is also used to spread misinformation and false rumors. In this paper we focus on the search for automatic methods for assessing the relevance of a given set of posts. We first retrieved from social networks, posts related to trending topics. Then, we categorize them as being news or as being conversational messages, and assessed their credibility. From the gained insights we used features to automatically assess whether a post is news or chat, and to level its credibility. Based on these two experiments we built an automatic classifier. The results from assessing our classifier, which categorizes posts as being relevant or not, lead to a high balanced accuracy, with the potential to be further enhanced.

Keywords: Automatic, Relevance Detection, Social Networks.

1 Introduction

Social Networks have an inherent capacity to spread information at a much higher pace than traditional media. They allow users to post and exchange messages almost instantaneously all over the world. This constitutes an ideal environment for the dissemination of news and of important information directly from their sources, or from the location of the events.

We have seen many cases of emergency situations [1] where some users disseminate information either by providing personal observations, or by sharing received messages from external sources, in their posts. From this pool of information, users generally combine and synthesize what they read, and then elaborate to produce their own interpretations, in a continuous cycle.

While this process can gather, filter, and propagate information very rapidly, it is not able to separate relevant information from simple false rumors. In 2010 we observed that immediately after a reported earthquake, many posts in Twitter did spread rumors which contributed to an increase of insecurity in the population [2]. Interestingly, we also observed that the spread of this information which turned out to be false was much more questioned than information which ended up being true.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_9

Nevertheless, we also know that information disseminated from official and reputable sources is often considered more valuable, more shared/propagated, and generically understood as having a positive degree of relevance.

1.1 Research Focus and Outline of the Methodology

This introduction serves to focus our research which is to understand the spread of news information and its credibility over social media networks. In this paper we consider as "news" the information that is relevant to a large audience, as opposed to information which may be important, but only to a reduced set of people. We also use "credibility" in the sense of believability.

Our approach is based on a supervised learning methodology. We first identified a set of four relevant discussion topics. Then, each post on the topic was labeled by humans according to whether it corresponds to newsworthy information or to an informal conversation. After the data set is created, each item of the former class is assessed on its level of credibility by human judgement.

Our objective is to determine if we can automatically distinguish news from informal chat and, in the former case, to assess the level of credibility of content posted in social networks.

In the following section we focus on related work, namely why social networks are important sources for news and the way credibility relates with them. In a second stage, we extract some relevant features from each labeled topic and use them to build an automatic classifier that attempts to automatically determine if a social network message corresponds to newsworthy information. As a second step we try to, also, automatically assess its level of credibility (section 4). The base and rational of our automatic classifiers is described in section 5. Finally, in section 6 we present our conclusions and point out directions for future work.

2 Related Work

The literature regarding automatic assessment of newsworthy information has been increasing in the last couple of years and, regarding information credibility, it is even more extensive. Therefore, in this section our coverage is by no means complete nor extensive. Instead, we try to provide an outline of the research that is most closely related to the one used in this paper.

2.1 Social Networks as News Media

While most messages on social networks are conversational, people also use them to share relevant information and to report news [3,4,5]. Indeed, according to a 2010 study on the Twitter social network, the majority of trending topics can even be considered "headline news" [6]. For example, Twitter spreads news stories from

traditional media like in the case of recent epidemics [7], it detects news events [8], also geolocating such events [9]. Another important feature is that it can find emergent and controversial topics [10]. Recently, it was described [11] an online monitoring system to perform trend detection over the twitter stream (although, many other systems currently exist). In the same line, we must also recall "Google Trends" as a similar system based on the user performed queries. Social networks have also been used during several emergency situations to share information [1,12].

2.2 Credibility

The perception of users with respect to the credibility of online news can be seen generically, as positive. In fact, apart from newspapers, people trust the Internet as a news source as much as other media [13]. A study conducted by Flanagin and Metzger [14] showed that in an absence of external information, the perceptions of online credibility is strongly influenced by style-related attributes, including the visual design, which is not directly related to the content itself. However, another study [15] showed that users may change their perception of credibility depending on the (supposed) gender of the author.

Meanwhile, we witness some search engines starting to display search results from social networks, particularly for trending topics. As a consequence, "spammers" are attracted to this mean of communication, which then leads the readers to a sense of distrust. The same reaction happens with some web pages that are heavily populated with offers of products or services [16].

Recently, researchers from Indiana University created the "Truthy" service, which has started to collect, analyze and visualize the spread of tweets belonging to "trending topics". The system uses features that are present in the tweets collected in order to compute a *truthiness score* for a set of tweets [17].

3 Data Retrieval

This section describes how we collected a set of messages related to pre-defined topics, from social networks

The topics, or *criteria* (using the social networks API terminology), were chosen according to what has populated, during the last weeks, the standard media headlines. Our intention was to have, as much as possible, topics that would lead to discussions, to the addition of extra/complementary information, to critics, as well as, eventually, to "passionate" arguments. All in all, we picked topics that supposedly would lead to a burst of information in the networks. The topics were:

- *Refugees*
- *Migrants*
- *Donald Trump*
- *Windows 10*

We collected the posts, the replies, the tweets, and the retweets (for the sake of simplicity we will call all these messages simply as 'posts'), during almost 72 hours. We then labeled each post according to the topic used for the respective query to the social network. In the end of the collection period we had 15980 posts taken from the three social networks, respectively a shown in Table I:

Table 1. Number of collected post per social network.

Social Network	Number of collected posts
Google+	157
YouTube	8000
Twitter	7823

3.2 The News Assessment Procedure

Our first labeling round was intended to separate posts which spread information about "news" from cases concerning personal opinions, or out of topic posts, or even simple "chat". To help us in this task we employed the Amazon Mechanical Turk service (MT), which uses workers to perform typically small and intelligent tasks (*Human Intelligent Tasks* – HITs). We presented to the evaluators the collected posts, each one labeled with the corresponding topic assigned during its retrieval. Then, we asked if the presented post was spreading news about a specific event, or if it was just conversation. The former case was labelled as 'NEWS' and the latest as 'CHAT'.

The final set of posts was reduced due to incompatibilities between our initial set and the Amazon MT system. We discarded posts that had special characters not recognized by the MT system (mainly due to different encodings), and some other because they were too short (less than eight words), or even some other that were composed only by URLs. From this new data set, we randomly we selected 481 posts to present to evaluators. Each of these 481 posts was presented as a HIT to 5 different evaluators. We, then, assessed the panorama of agreement between evaluators: majority of three; of four; and, unanimity, concerning the number of labeled posts, as illustrated in Fig. 1.

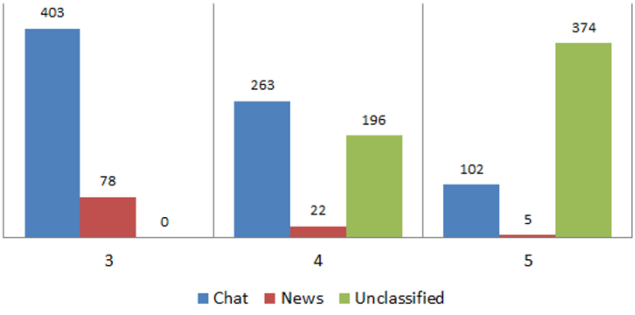


Fig. 1. Number of labeled messages according to majority levels.

We observed that unanimity for 'NEWS' was only possible in 5 posts (only 1% of the set), while at that scenario a large majority of posts (78%) was considered unclassified. For this reason, we decided to relax our level of agreement and to consider instead as an agreement, a majority of 3 evaluators. Therefore, a class label for each post was assigned if 3 out of 5 evaluators agreed on the label. In the other case, we label the posts as 'Unclassified'. Using this procedure 0% of the posts were left unclassified, being the whole sample distributed among two classes: 84% (403 cases) as 'CHAT', and 16% (78 cases) as 'NEWS'.

3.3 Credibility Assessment

After having a set of posts considered as NEWS, we focused on determining the credibility assessment of each post. We ran again a set of HITs over the collection of 481categorized posts. Using this collection of instances, we asked MT evaluators to indicate the credibility level for each message. We also provided the topic of the message in order to help them better understand the context.

In this evaluation we considered three levels of credibility: (i) "likely to be true", (ii) "likely to be false", and (iii) "I can't decide". As in the first round, we asked for 5 different assessments of each HIT. Labels for each topic were decided my majority, requiring an agreement of at least 3 evaluators. We illustrate the resulting panorama in figure 3. This result led us to pick a majority of three evaluators.

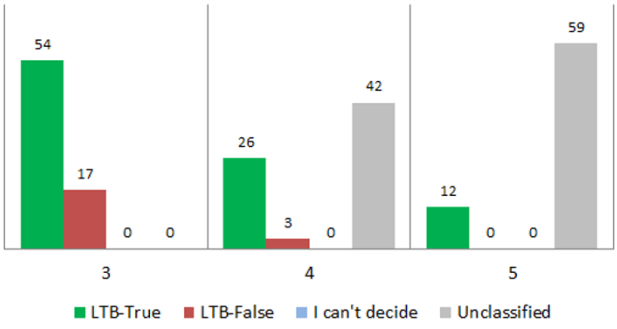


Fig. 2. Assessing credibility by majority.

In this round of evaluation, we also tried to distinguish the credibility of the messages according to the social network used. In the scenario of labeling messages by a majority of 3 we got that Google+ had 90% of "likely to be true" messages (and 10% of "likely to be false" messages), and YouTube had 73% of "likely to be true" messages (and 27% of "likely to be false" messages). Therefore, in this scenario there were no messages unclassified. This result is expressed in Table 2.

Table 2. Distribution of trustiness in the collected sample.

Social Network	Likely to be true	Likely to be false	Can't decide/Unclassified
Google+	90%	10%	0%
YouTube	73%	27%	0%

4 Creating an Automatic Analysis

4.1 Social Media Credibility

Our main hypothesis in this article is that the level of credibility of information disseminated through social media networks can be estimated automatically, up to a certain degree. We believe that there are several factors that can be observed in the social media platform itself and, in the message in particular, that are useful to assess the information credibility. However, we do also know that MT evaluators tend to fulfil every HIT as fast as they can, which usually leads to a reduced care when categorizing texts. We are aware that, as we get thousands of different evaluators, this behavior becomes common for some sub-set of the evaluators. Nevertheless, it should be taken into consideration and mitigated in future analyses.

From this experience, using our dataset, we propose, as hypothesis, that a reduced set of features take exclusively from the posts are sufficient to perform the automatic analysis with a satisfying degree of accuracy:

- The length of a post
- A set of words typically used in credible posts
- The number of occurrences of certain words
- The use of excessive punctuation
- The abundant use of smileys/emoticons

4.2 Automatically Detecting News

Consistently, the number of words in posts labeled as NEWS is bigger than those in posts labeled as CHAT. On the other hand, the use of pronouns is consistently bigger in CHAT posts. As a consequence, we created a “bag of words” that are more prone to appear in NEWS and that do not appear in CHAT posts. This set (117 words) was created using a traditional term frequency times the inverse document frequency metric (ie, the standard tf-idf). We also set thresholds for the length of a post according to the social network, and for a scoring function. This function scores when finding in a post, a word that is present in the bag, as well as the number of its occurrences. Finally, we fine-tuned the number of “symbols” for each social network setting thresholds for punctuation and smileys/emoticons.

4.3 Automatically Assessing Credibility

Similarly to the news detecting methodology, for assessing the credibility we took an approach based on the intrinsic characteristics of the post.

However, in this case it is not easy to use the bag of words because many of the words taken from the two categories, “Likely to Be True” (LBT), and “Likely to Be

False" (LBF), expressed using the tf-idf frequency are quite the same. I.e., there is much overlapping between the two sets. This situation is illustrated using word clouds (Fig. 3). Therefore, credibility cannot be assessed using only this type of criteria.

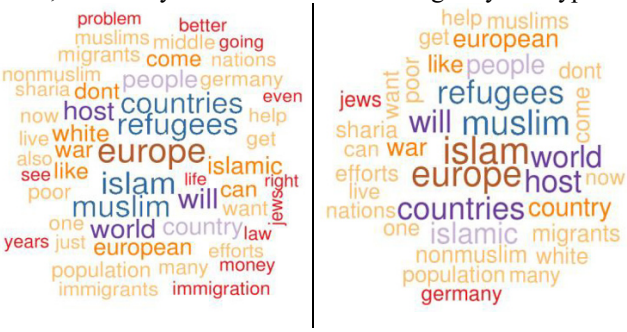


Fig. 3. Word clouds: "Likely to Be True" (left) and "Likely to Be False" (right).

Hence, we discarded the bag of words and created a function to promote/demote the resulting value according to: the post length, to the corresponding social network where the post was take from and, we set thresholds for the number of punctuation signs and smileys found. In the end of the automatic analysis, each post got a final score which was then used to categorize it.

5 Automatically Detecting News and Assessing Relevance

Using our crawlers, we retrieved a new set of posts to be categorized by our automatic classifier and by the human evaluators at Mechanical Turk in order to compare the two categorizations. Our goal was to compare the precision of our system, tuned according to the two past experiments, against the human classification, and also to perform an assessment and analysis at the feature level. We retrieved 100 posts from the same social networks and according to the same criteria as in the previous study.

5.1 The MT Assessment

For this task we submitted to MT the whole set, such that each post was presented to 5 evaluators. Therefore, we had a total of 500 posts to be categorized.
This time instead of asking the workers to distinguish between 'news' and 'chat', we asked something slightly different: we asked them to classify the posts as "relevant" or "irrelevant" according to instructions described in **Table 1**.

Table 3. MT instructions for selection criteria.

Categories	Includes	Excludes
Relevant	Facts or data relevant for a journalist to write news	-----
Irrelevant	Facts or data only relevant to a reduced set of people. Information for which you can't derive the context.	Information that could be incorporated in news.

Evaluators were also asked to not pay attention to: (1) misspelled words; (2) bad grammatical constructions; (3) verbs in the 1st person. Our rationale for these rules/instructions if that when people are asked to identify news, they are expecting to find a certain style of writing, which is characteristic from traditional media like television and radio. In our case, we don't want to be able to find a particular style; instead, we want to identify social network messages which may contain relevant information. Therefore, we ask the evaluators to check if, in the message, there is information capable of being adapted to be part of a news. Despite our intention to have 5 evaluators per post, we had some posts classified by the same person, which we immediately discarded form the resulting set to analyze, in the end we got 81% classified posts by majority and only 19, which we couldn't resolve, were left as unclassified, as illustrated in Fig. 4 (left chart).

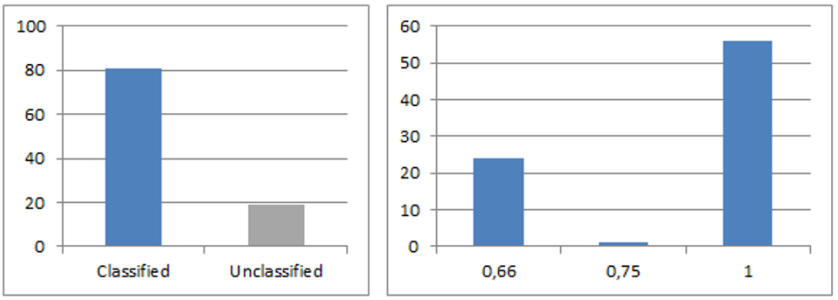


Fig. 4. Results from MT classification on the 100 posts.

We can also see (right chart of Fig. 4) that, regarding the classified posts (81 posts) more than 50 were classified in unanimity; 24 posts by majority of two-thirds (0.66) and only one by majority of three-quarters (0.75).

5.2 The Automatic Assessment

Our developed classifier took into account the features described in section 4.1 and in 4.2 of this article. In particular, we used the length of a post as a normalization process. Another important feature is the number of pronouns ('mine', 'ours', etc.) that are present in the post, usually together with sentences which include 'I', 'me' or 'you'. For example, from our results posts with more than 5 occurrences of pronouns tend to be categorized as non-relevant, or chat. We used thresholds for the amount of '!' and of smileys. The threshold is computed independently for each sentence in a post. Finally, we took into account the use of "bad language" or swear-words. In cases where these kind of words are used, the score of the relevancy for that post reduces in a percentage of the length of the post.

5.3 Assessment of the Results

Our methodology to assess our system's performance was to compare the predicted label computed for each post, against the label assigned to the post by the MT evaluator's. We recall that we tried to use up to 5 evaluators for each post (although in the end we had to discard some, as discussed in section 5.1). Therefore, in some cases we used the majority of the evaluator's opinions.

The metrics used for the evaluation were the 'precision', the 'accuracy' (or 'rand index'), and the 'F1', which are standard metrics for binary classifications. To compute these metrics we used the number of true positives (TP), true negatives (TN), false positives (FP) and false negatives (FN). In this context, we define TP as reporting a success in predicting some post to be relevant; a TN as reporting a success in predicting some post to be irrelevant; and, FP and FN as reporting errors predicting for each of the two cases, respectively.

Table 4. Computed metrics for the assessment.

Metric	Value
TP	24
TN	35
FP	38
FN	3

Metric	Value
Precision	0,38709
Accuracy	0,59
F1	0,68417
Balanced Accuracy	0,68417

Although the 'precision' is low, it corresponds to the "closeness of agreement among a set of results" (ISO 5725 definition), which is not particularly important in this cases. On the other hand, 'accuracy' corresponds to "the closeness of a measurement to the true value" (ISO 5725), which is certainly important. The 'F1' metric, which combines the precision and the sensitivity, is also at a good level. We also computed the balanced accuracy, in order to avoid the effects derived from the unbalanced dataset (i.e., the unbalanced number of relevant vs. irrelevant posts). It is defined as:

$$balanced\ accuracy = \frac{0.5 \times TP}{TP + FN} + \frac{0.5 \times TN}{TN + FP}$$

Which, in the case of this experiment, results in a value of more than 68%.

6 Conclusions

Online users have at their disposal a constantly growing number of tools to spread their opinions or share information gathered from other sources. However, more than often the information is not relevant to most readers. Therefore, it is important to design systems that can help a reader to detect on his behalf what may be relevant information, in the sense of a set of data/facts that might interest to a broad audience.

In this article we presented an approach to create a system that is able to automatically detect relevant information in messages posted on most common social networks. During our research, despite believing that the categorization made by

evaluators from Mechanical Turk may be not as accurate as a specialist would do (a journalist, for example), we found that a system based on very simple characteristics retrieved from the posts is able to achieve an accuracy of almost 70%. This result leads us to believe it is possible to achieve even higher accuracy using just the inherent characteristics of the posts.

Acknowledgments. This work is financed by the ERDF – European Regional Development Fund through the COMPETE Programme (operational programme for competitiveness) and by National Funds through the FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within project «Reminds/ UTAP-ICDT/EEI-CTP/0022/2014».

References

1. S. Vieweg. Microblogged contributions to the emergency arena: Discovery, interpretation and implications. In Computer Supported Collaborative Work, February 2010.
2. Marcelo Mendoza , Barbara Poblete , Carlos Castillo, Twitter under crisis: can we trust what we RT?, Proceedings of the First Workshop on Social Media Analytics, p.71-79, July 25-28, 2010, Washington D.C., District of Columbia [doi:10.1145/1964858.1964869]
3. Akshay Java , Xiaodan Song , Tim Finin , Belle Tseng, Why we twitter: understanding microblogging usage and communities, Proceedings of the 9th WebKDD and 1st SNA-KDD 2007 workshop on Web mining and social network analysis, p.56-65, August 12-12, 2007, San Jose, California [doi:10.1145/1348549.1348556]
4. Mor Naaman , Jeffrey Boase , Chih-Hui Lai, Is it really about me?: message content in social awareness streams, Proceedings of the 2010 ACM conference on Computer supported cooperative work, February 06-10, 2010, Savannah, Georgia, USA [doi:10.1145/1718918.1718953]
5. Pear Analytics. Twitter study. http://www.pearanalytics.com/wp-content/uploads/2009/08/Twitter-Study-August-2009.pdf, August 2009.
6. Haewoon Kwak , Changhyun Lee , Hosung Park , Sue Moon, What is Twitter, a social network or a news media?, Proceedings of the 19th international conference on World wide web, April 26-30, 2010, Raleigh, North Carolina, USA [doi:10.1145/1772690.1772751]
7. Vasileios Lampos , Tijl De Bie , Nello Cristianini, Flu detector: tracking epidemics on twitter, Proceedings of the 2010 European conference on Machine learning and knowledge discovery in databases: Part III, September 20-24, 2010, Barcelona, Spain
8. Jagan Sankaranarayanan , Hanan Samet , Benjamin E. Teitler , Michael D. Lieberman , Jon Sperling, TwitterStand: news in tweets, Proceedings of the 17th ACM SIGSPATIAL International Conference on Advances in Geographic Information Systems, November 04-06, 2009, Seattle, Washington [doi:10.1145/1653771.1653781]
9. Takeshi Sakaki , Makoto Okazaki , Yutaka Matsuo, Earthquake shakes Twitter users: real-time event detection by social sensors, Proceedings of the 19th international conference on World wide web, April 26-30, 2010, Raleigh, North Carolina, USA [doi:10.1145/1772690.1772777]
10. Ana-Maria Popescu , Marco Pennacchiotti, Detecting controversial events from twitter, Proceedings of the 19th ACM international conference on Information and knowledge management, October 26-30, 2010, Toronto, ON, Canada [doi:10.1145/1871437.1871751]
11. Michael Mathioudakis , Nick Koudas, TwitterMonitor: trend detection over the twitter stream, Proceedings of the 2010 ACM SIGMOD International Conference on

Management of data, June 06-10, 2010, Indianapolis, Indiana, USA [doi:10.1145/1807167.1807306]
12. Bertrand De Longueville , Robin S. Smith , Gianluca Luraschi, "OMG, from here, I can see the flames!": a use case of mining location based social networks to acquire spatio-temporal data on forest fires, Proceedings of the 2009 International Workshop on Location Based Social Networks, November 03-03, 2009, Seattle, Washington [doi:10.1145/1629890.1629907]
13. A. J. Flanagin and M. J. Metzger. Perceptions of internet information credibility. Journalism and Mass Communication Quarterly, 77(3):515--540, 2000.
14. A. J. Flanagin and M. J. Metzger. The role of site features, user attributes, and information verification behaviors on the perceived credibility of web-based information. New Media Society, 9(2):319--342, April 2007.
15. C. L. Armstrong and M. J. Mcadams. Blogs of information: How gender cues and individual motivations influence perceptions of credibility. Journal of Computer-Mediated Communication, 14(3):435--456, 2009.
16. F. Benevenuto, G. Magno, T. Rodrigues, and V. Almeida. Detecting Spammers on Twitter. In Collaboration, Electronic messaging, Anti-Abuse and Spam Conference (CEAS), July 2010.
17. J. Ratkiewicz, M. Conover, M. Meiss, B. Gonçalves, S. Patil, A. Flammini, and F. Menczer. Detecting and Tracking the Spread of Astroturf Memes in Microblog Streams. arXiv, Nov 2010.

Intelligent System for Soccer Referee's Position Analysis

Carlos Moreira Rego[1], Luís Paulo Reis[1,2,3], Filipe Meneses [1,3], Brígida Mónica Faria [2,4,5]

[1] DSI/EEUM - Departamento de Sistemas de Informação, Escola de Engenharia da Universidade do Minho, Guimarães, Portugal
[2] LIACC - Laboratório de Inteligência Artificial e Ciência de Computadores, Porto, Portugal
[3] Centro ALGORITMI, Universidade do Minho, Guimarães, Portugal
[4] ESTSP/IPP - Escola Superior de Tecnologia da Saúde do Porto, Instituto Politécnico do Porto, Gaia, Portugal
[5] INESC-TEC - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência, Porto, Portugal
pg25200@alunos.uminho.pt, {lpreis, meneses}@dsi.uminho.pt, btf@estsp.ipp.pt

Abstract. The role of referees and the decisions they take have, in many cases, a decisive and direct influence on the course of a game. Unfortunately these decisions are not always correct. In a large amount of times, the mistakes are due to referee's bad positioning on the field. So it is fundamental to develop a model that may determine the correct position for a soccer referee. For this research work, data with all the game participants' positions in the field during the match has been used as its basis. The data included, players, ball and referees positions gathered by an automatic system. Referees with large experience in international competitions were used to obtain correct position knowledge. The achieved results, using a data mining approach, are very positive, both for predicting the assistant referee position, regardless of the team he is accompanying or the match with 77% of success, as to predict the referee position with 82% of success, in controlled game situations. In short, despite the limitations, the models are conclusive and can efficiently estimate the correct positioning of the referee in a soccer match.

Keywords: data mining, position, modelling, data preparation, refereeing, soccer

1 Introduction

This research work is an innovative approach to determine the correct position of the referee's team in a soccer game in appropriate game situations. There are some papers and research work that focus on the assistant referees position to have the best condition to analyse the off-side, and some work that evaluate the referee ideal distance to the ball. However, there is not any research work available that points the position, nor the angle, that best suits the referee to call the right decision.

In this research, all conclusions from previous works are taken into account. Still, as pointed out, this work is innovative and there isn't any research in the field with the same approach to achieve the goal of predicting the optimal position of the referee team on the pitch.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_10

Some limitations were faced though the development of this model. The limitations of data mining itself, since it needs historical data to learn, to obtain knowledge. So this data needs to be a good example of how a referee should move on the pitch according to the game situation (direction of the ball, number of players and how they move). And consequently the lack of data, there is only one game (Italy vs France in the 2006 World Cup Final).

During the development of this research work, there were taken some assumptions. With the exception of the plays in which the referee made the wrong decision, this plays were analysed by an expert and hence corrected for the position that would have made the right call, it was assumed that the referee's position was correct.

The aim of this research work is to build a model that can, using data mining to obtain knowledge from past games with quality referee's teams, determine the correct position of the referee's team in any game situation, reducing the amount of judging errors during soccer games. Thus, we achieved two models, one for predicting the position of the assistant referee, in which it was obtained a rate of 77% success rate, and other to the referee with a percentage of 82% success rate.

2 Related Work

This section presents previous work that had some influence in this research work. Concerning the soccer referee's, their main duty is to supervise the application of the Laws of the Game. Thus, being in the right place at the right time is important in order to get a better view of the play and a correct evaluation of it [1]. According to [2] the position of the referee on the pitch it's recommended as follows: - The play should be between the referee and the lead assistant referee; The lead assistant referee should be within the referee's field of vision. The referee should use a wide diagonal system; Staying towards the outside of the play makes it easier to keep play and the lead assistant referee within the referee's field of vision; The referee should be close enough to see play without interfering with play.

In what concerns the assistant referees, as the [2] points out, the assistant referee's help the referee to enforce the Laws of the Game. Two assistant referees may be appointed whose duties, subject to the decision of the referee, are to indicate: When the whole of the ball leaves the field of play; Which team is entitled to a corner kick, goal kick or throw-in; When a player may be penalised for being in an offside position; When a substitution is requested; When misconduct or any other incident occurs out of the view of the referee; When offences have been committed whenever the assistant referees have a better view that the referee; Whether, at penalty kicks, the goalkeeper moves off the goal line before the ball is kicked and if the ball crosses the line. Of all this duties, the most important of all for an assistant referee is the offside. With that in mind, they are instructed to constantly be in line with the second last defender of a team, or the last two, or the ball if it's nearer the goal line in order to be the best conditions to analyse. Fig. 1 illustrates the zones of action of each member of the referee's team. The referee must move in a diagonal system due to the assistant referee's zones.

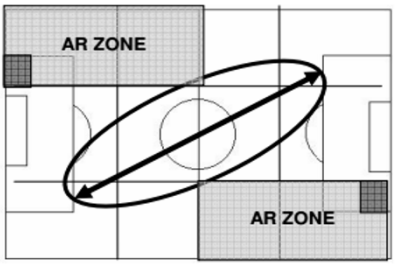


Fig. 1. Referee and assistant referee's zones of action

3 Data Mining and Methodology

Data Mining is the study of collecting, cleaning, processing, analysing and gaining useful insights from data [3]. A wide variation exists in terms of the problem domain, applications, formulations, and data representations that are encountered in real applications. Therefore, data mining is a broad umbrella term that is used to describe these different aspects of data processing [4].

Data immensity is the direct result of advantages in technology and computerization of all aspects of modern life. It's therefore natural to analyse whether it's possible to extract concise ideas and possibly knowledge of the available data for specific purposes applications. It's in these situations that data mining is required [5][6]. The original data can be arbitrary, unstructured or until a format that's not suitable for automatic processing. For example, manual data collection may originate from multiple sources and in different formats. To solve this problem it's necessary to develop a process in which data are collected, processed and cleaned in a single format. This process causes the majority of work is related to the preparation of data [7]. The data mining process can be described by Fig. 2 as [4] explains. This process meets the various stages of CRISP-DM.

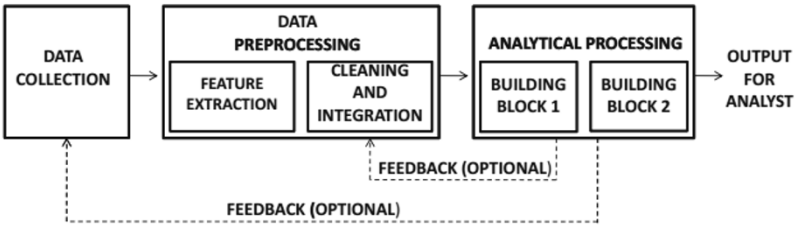


Fig. 2 Data Mining process (Source: [4])

Data collection – this phase is very specific to the application used and extremely important as correct choices at this stage can have a significant impact on the data mining process. After collection, the data is usually stored in databases or data warehouses.

Feature extraction and cleaning – the data collected is often at little proper format for processing. For example, the data can be encoded in complex logs or free writing papers (a text box is a good example because people can write anything and various

type of data can be arbitrarily mixed). To make the data ready for processing is essential to turn these in a friendly format for data mining algorithms. It's crucial to extract relevant characteristics for the data mining process. The characteristics extraction stage is usually done in parallel with the data cleaning because the missing or incorrect values are corrected or eliminated.

Analytical processing – the final part of the data mining process is the design of effective analytical methods based on the processed data. In many cases it may not be possible to directly use a standard data mining problem, such as patterns of association, clustering, classification and outlier detection. However, these problems have such a wide coverage that many applications can be broken up into components that use these different building blocks.

The most typical problems of data mining can be divided into two categories: prediction and description. The prediction is characterized by problems with specific goals, with datasets of the past as a basis for what you want to predict. The description on the other hand, has the purpose of detecting information on a complex database to increase the knowledge to be extracted [8].

Data mining has been use in sports since a long time now, and an important contribution is the ability to predict when a player may be having physical breaks through injuries prognosis. AC Milan monitors the training of their athletes [9]. The software compares the performance of an athlete's performance training and any sub-yield sign may indicate that the player is injured.

According to the work of [10] using log records of various *RoboCup Soccer* games it can identify what's the best tactical formation that a team should adopt when facing another team. To get this knowledge, several tests and classification algorithms to these records games were used.

In short, the data mining in sports is used in order to create a competitive advantage over the opponent to facilitate the challenge [11]. Currently in the scientific community there are no studies on the prediction of the location of athletes in the pitch. However, it's possible to draw some conclusions from existing work in location prediction area, such as: people use common paths and they follow the crowd. So it's easy to see that a player in a certain position of the respective tactical formation will use repeated movements throughout the game so it's possible to determine what will be their behaviour to a given situation [12]. The same principle can be applied to the referee's teams. That's the work it'll be developed in this research. Thus, in the existence of sufficient data to model behaviours of top referee teams, you can determine the ideal position of the referee team in a given moment.

The Cross-Industry Standard Process for Data Mining (CRISP-DM) methodology is a model of hierarchical processes, comprising four levels of abstraction (in descending order): phases, generic tasks, specific tasks and process instances (see Fig. 3 left side). According to the described by [13] at the top level, the data mining process is organized into number of stages, each of which consists of several generic tasks (so called because they cover all possible situations of data mining). The third level, the level of specific tasks, is the place to describe how actions in the generic tasks must be performed in specific situations. Finally, the level of process instances is a registration actions, decisions, and results of a real data mining application. A process instance is organized according to the tasks set at the previous levels but represents what actually happened in a specific job, rather than what happens in

general. The description of phases and tasks as discrete steps performed in a specific order represents an idealized sequence of events (see Fig. 3 right side). In practice, many of the tasks can be performed in a different order and will often be necessary to go back to previous tasks and repeat certain actions.

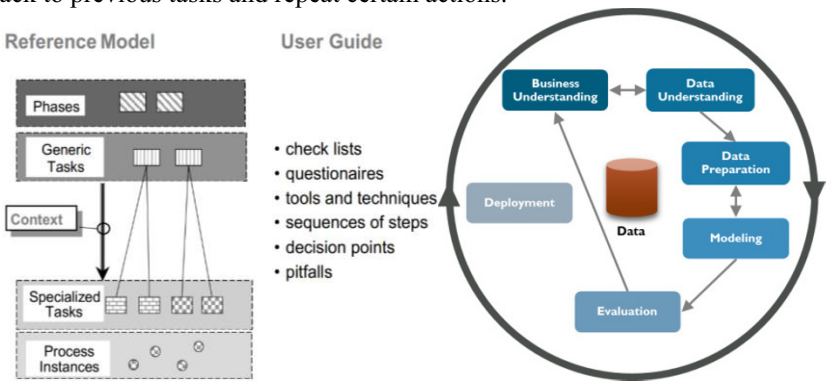


Fig. 3 Four levels of CRISP-DM for Data Mining (source: [13] and phases of CRISP-DM Process Model for Data mining (source: [14])

4 Prediction of Referee Team Position

The research followed the typical phase of CRISP-DM:

Business Understanding: This initial phase focus on understanding the project objectives and requirements. The objective of this study is to identify the ideal position for the referee team in relation to the position and direction of the ball, the offensive and defensive players.

Data Understanding: The data was provided by an international organization (confidential although may be used for academic purposes). In order to be able to predict the ideal position of all the referee's in the pitch during a game, using data mining techniques in a dataset with the Cartesian positions of all intervenient of the game (ball, players and referees), it's needed, in a first approach to the problem, understand the data available. The data understanding phase begins with the familiarization of data to identify data quality problems, discover the first perceptions of the data or detect interesting subsets to form hypotheses for hidden information. The data represents all x and y positions of all the players and referees and the x, y and z of the ball. 24 records for second of all the 120 minutes of game denotes all the data available. The game was played in the Olympic Stadium "*Olympiastadion*", in Berlin. The field has 105x68m of dimension. The data quality is very good with the biggest margin of error less than 1 meter. This conclusion was get after comparing the dataset records with a video image.

Data Preparation: The next phase of this data mining was the data preparation. According to [13] this stage encompasses all activities that lead to the construction of the final dataset (the data that will feed the modelling tools from the initial data). The data preparation was made according to the knowledge that is sought to obtain at each

time. Thus, the data were prepared in two main points. First, to prepare the prediction model of the ideal location of the assistant referees and, second, to prepare the prediction model of the ideal position of the referee. For the first problem have been removed all the values for the y-coordinate as this has no influence on the assistant referee position, since his position is influenced by the second last position (or second biggest according to which side he is). For the second problem, the ideal location of the prediction of the referee, changes to data were bigger. After analysing the game, it were pointed out all the bad decisions of the referee during the game due to bad position on the pitch. The position of the referee was edited in the data according to what the asked expert said - Assistant Referee of Portuguese First Soccer League – Liga NOS (see Table 1). Because not all soccer fields have the same dimensions, the data was normalized. The normalization mean adjusting the values measured on different scales for a subjectively common scale [15]. This way, the range of values is always the same regardless of where the game was held.

Table 1 Edited data according to the expert feedback in plays that the referee missed

Id	Time	Play description	Real Location	Correct Location
1	05:09	Malouda suffers a slight hint. The referee, although poorly positioned, made the right call	(27.5,13.84)	(17.5,12)
2	31:53	Perrota is stepped on. The referee is well positioned. This bad decision isn't due to his position	(58,22.85)	(58,22.85)
3	52:41	Penalty to France. Referee poorly positioned	Out of scene	(15.5,14.84)
4	65:55	Iaquinta receives the ball with his hand. The referee is far and with athletes in front of him	(43,18.7)	(37.5,13.84)
5	71:37	The misplaced referee is in a pass line of Italy. He's surprised with the ball and touch's it.	(66.25,21.85)	(71.75,20.85)
6	79:14	Cannavaro jumps negligently on Zidane. Nothing is indicated	(72,54.16)	(74.75,54.16)

Data Modelling: At the stage of data modelling, various modelling techniques are selected and applied and their parameters calibrated to optimal values [16]. Typically there are several techniques for the same type of data mining problem and some of these techniques require specific data formats [17]. To obtain the most accurate possible model, various experiments were made. These experiences for the assistant referee consisted of: Use of subsets of data from one third, two thirds and all data; Restriction to the x coordinate; Restriction to the team that he was accompanying; With the data normalized and not normalized; Use of 90 minutes for training and 30 minutes for test; Change the order of the data (random). Also, for the referee: Use of subsets of data from one third, two thirds and all data; Restriction on the coordinated x, y and both; With the data normalized and not normalized; Use of 90 minutes for training and 30 minutes for test; Data from just one team and both; Use of the first 15 minutes of the first half for training and the first 15 minutes of the second half for test; Use of controlled game situations – just corner kicks; Change the order of the data (random). These experiments were designed in order to select the most suitable regression algorithm to predict the ideal position of the referee's team relative to the position of the ball and players. Throughout this document, the best results will be presented.

Evaluation: Evaluation is the key point to have effective progress in data mining. There are several different methods to get data knowledge, but not all are specified. According to [18] the issue of predicting performance based on limited dataset is interesting and controversial. Despite the existence of various techniques, the cross-validation distinguished from the others and is, at the moment, the evaluation method of choice in situations with little data. On the other hand, when the dataset is large, the best method is to divide a large dataset for training and other large dataset for testing. However, despite the large amount of data, quality thereof is, in some cases, scarce. For example, using a dataset for training in which there is only one corner kick situation and then, is used for testing a dataset in which there are ten play situations of a corner kick. The values shown by the model will not indicate anything. The cross-validation method reserves a certain number of records for testing and uses the remaining for training. As this process is done randomly, the sample for training may not be representative – an extreme situation would be none of the instances in the test has been used for training. As such, it must ensure that the random sample is made so that all situations are properly represented in both, the training and the test. This procedure is called stratification [18]. For the first problem, the best mathematic model to predict the ideal position of the referee on the pitch got a success rate of 76.03% using for this the first 45 minutes of the game for training and the second 45 minutes for testing. Although, using the cross-validation method for the same quantity of data, the results are much better with the algorithm K-nearest neighbour with more than 99% of success. As the cross-validation uses all data as training, this result can be a proof that, using enough data from a very large amount of games, it's possible to predict effectively the ideal position of an assistant referee on the pitch. For the second problem, the position of the referee, the analysis was performed in order to evaluate the model for a case of specific game situations. The selected game play was a corner kick (because it is simple to detect this situation on the data). Four situations of corner kick were used for training and one for test. This is the most clear model evaluation since it's a controlled condition and the training data is very useful for analysis.

Table 2 Model evaluation to predict the referee position in a corner kick situation

	IBK	**KStar**
Correlation Coe.	0.9883	0.9727
MAE	0.0662	0.0898
RMSE	0.0778	0.1133
RAE	18.2653%	24.7615%
RRSE	19.0358%	27.706 %

Table 2 displays the two best mathematical models for the described scenario. The most close to 1 the correlation coefficient is, the better. So, both algorithms can detect an almost perfect positive correlation between the target variable and the attributes (this means that as the target variable increases, the attributes increase as well, and vice-versa). The rest of the indicators show the errors, and this ones the lowest they are, the better. The **mean absolute error (MAE)** is a quantity used to measure how

close forecasts or predictions are to the eventual outcomes. The **mean squared error** (**MSE**) and the **root mean squared error (RMSE)** of an estimator measures the average of the squares of the "errors", that is, the difference between the estimator and what is estimated. The **relative absolute error (RAE)** is the total of the absolute error with the same type of normalization as the RSE. The **root relative squared error (RRSE)** is calculated in relation to what would be a simple mathematical model would have been used. The algorithm in question is just the average of the actual amounts of training data. Thus, RSE assumes the error and normalize it by dividing by the total squared error of the standard mathematical error. After analysing the chart it can be concluded that IBK is a model with a very positive success rate (as lower error rates for every indicator). With this result, it's clear that K-Nearest Neighbour (IBK) algorithm, with more training data (more situations of corner kicks), can predict whit a even higher percentage of success the ideal position of the referee. Some other experiences resulted in worst results because it exists lots of data but this doesn't fit to any situation. For instance, we can use a uncontrolled game situation, for example, all of the first half of the regular time for training and test that data on the second half of the regular time. The mathematical model will not perform well because there are lots of situations that the model is trying to predict based on the training data that doesn't occur in the test data. That is, if in the first half there are not any corner kick situation, or the game is full of counter-attacks and in the second half there are ten corner kicks and it's everytime the same team that has the possession of the ball, the mathematical model will perform poorly.

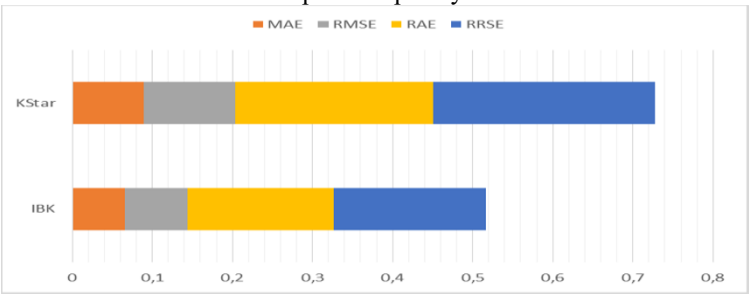


Fig. 4 Model evaluation to predict the referee position in a corner kick situation.

Deployment: For the faced challenge and the after the achievement of a model to determine the correct position of the referee team is required to implement it. This phase, to this problem consists in fulfilling a repeatable data mining process. To carry out this process is necessary to obtain data from various international competitions with experienced referee teams. After this step it's needed an expert advice to observe the referee's position and correct it if necessary. Thus is created a broad set of data to serve as training for the particular models. Thus, the model become increasingly more efficient at predicting the optimal position for soccer referees in various game situations. This is a model with great value, for example, referee academies. Figure 5 is intended to illustrate the required process to get this model.

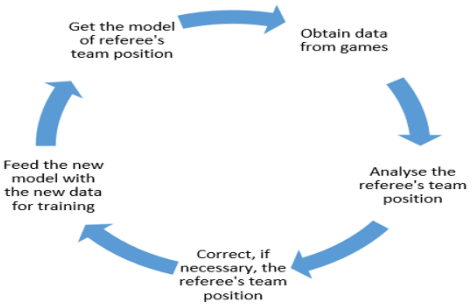


Fig. 5 Workflow for implementing the model

5 Results and Discussion

After proceed to the modelling and evaluation of various mathematical models, it's possible to see the results of the various exercises developed throughout the work.

The models related to the assistant referee's problem were achieved with a small error rates and very satisfactory results for the available data. The result of 77% of success for the experience of using the first part for training and the second for test, validates the objective of this research work. That is, using a dataset of training with the assistant referee follow one team (France), and the dataset for testing when he's accompanying another team (Italy) confirms that this model can be applied to any situation. That way, with a sufficient volumetric data for training, it's possible to predict the position of the assistant referee in any game with any team. The model obtained for the assistant referee position on the pitch showed results has expected and it's conclusive that this mathematic model can be applied to different games. That is, the model can learn from a dataset and can be successfully applied to predict the position in other games, regardless of the team. The use of cross-validation evaluation method with such high success rates can indicate that with a large amount of data for training, it's possible to predict very effectively the position of the referees on the pitch.

As expected, the models obtained for the referee, present a higher error rates that that achieved for the assistant referee. If a similar analysis to the one developed for the assistant referee is made – use of a large dataset for training such as the first 45 minutes and another large dataset for test, for example the last 45 minutes of the regular time – the results achieved have been of less than 50% of success percentage. However, when an analysis was made to a specific game situation, such as a corner kick, the results achieved have a percentage of success of 82%.

Due to the lack of studies related to this theme, and being this topic completely new, with no previous work, it can predict, with success, where does the referee should be placed in the pitch for some soccer situations such as, corner kicks. We believe that with this example, it's possible to predict, as well, for other similar game situations like goal kicks, direct and indirect free kicks in front of the goal or near the edge of the penalty box and penalty kicks. In a future release, with sufficient data for

training, this model should be able to predict the location of the referee and the movement of him, in some more complex situations, such as counter-attacks with numerical superiority of one team and react to various situations of the game depending the player' behaviour. With these results it is possible to predict the ideal position successfully for a specific situation of the game.

6 Conclusions and Future Work

This research was aimed at building a formal model to determine the best placement of the referee team on the pitch in accordance to the position of the ball, the players and even the remaining team members. To accomplish this, various data mining algorithms were studied. For this model data from a major professional soccer game was used: final of the 2006 World Cup, containing information of the Cartesian positions (*x,y*) of players, referees and ball.

The objectives were achieved and were built two mathematical models that determine what the ideal position of the referees is. It was concluded that for the assistant referee model developed can be determined with an accuracy of 77% regardless of the team. For this model it was used the 90 minutes for training and the 30 minutes of extra time for test in a situation, and the first 45 minutes for training and the second 45 minutes of regular time for test in other situation. To determine the referee's model, specific game situations were used as corner kicks, to predict the correct position of this with a success of 82%.

This study adds a further knowledge in the area in which there was nothing similar. The results obtained of the prediction models for the referee team can add tremendous knowledge to new and even experienced soccer referees. These models can, and should, be used in refereeing academies so that it can improve their students.

It should, however, be noted that the results obtained for these models have been achieved from a dataset related to a single game. A larger dataset would have help to achieve better results. However, the obtained results open the doors to new research in this area, still unexplored, and also encourage greater investment in the area of detection of the players for not intrusive systems.

In conclusion, the results from these models will contribute to a reduction of errors in soccer games due to the poor position of the referee team on the pitch.

Acknowledgments

This work has been supported by FCT - Fundacão para a Ciência e Tecnologia in the scope of the projects: PEst-UID/CEC/00319/2015, PEst-UID/CEC/00027/2015 and POCI-01-0145-FEDER-006961. The authors would like to thank also the referees that helped on the study.

References

1 Mallo, J., Frutos, P. G., Juárez, D., Navarro, E.: Effect of positioning on the accuracy of decision making of association football top-class referees and assistant referees during competitive matches, p. 9, (2012).
2 International Football Association Board, Laws of the Game 2014/2015. (2013), http://www.fifa.com/about-fifa/official-documents/index.html.
3 Ferreira, M., Goncalves, J., Reis, L. P., Rocha, A., Faria, B.M.: Data Mining and Decision Support Systems for Clinical Application and Quality of Life, Proc. 2015 10th Iber. Conf. Inf. Syst. Technol., vol. II, pp 271-276 (2015).
4 Aggarwal, C. C.: Data Mining: The Textbook. Springer, 2015.
5 Goncalves, J., Reis, L. P., Faria, B. M., Carvalho, V., Rocha, A.: Data Mining and Electronic Devices Applied to Quality of Life Related to Health Data, Proc. 2015 10th Iber. Conf. Inf. Syst. Technol, vol. II, pp 277-280 (2015).
6 Faria, B.M., Reis, L.P., Lau, N., Castillo, G.: Machine Learning algorithms applied to the classification of robotic soccer formations and opponent teams, 2010 IEEE Conference on Cybernetics and Intelligent Systems (CIS), pp. 344-349 (2010).
7 Ye, N.: Data Mining - Theories, Algorithms, and Examples. New York, New York, USA: CRC Press, 2014.
8 Almeida, R., Reis, L.P., Jorge, A.M.: Analysis and Forecast of Team Formation in the Simulated Robotic Soccer Domain, 14th EPIA - Portuguese Conference on Artificial Intelligence - EPIA 2009, pp. 239-250, (2009).
9 Flinders, K.: Football injuries are rocket science, 2002. [Online]. Available: http://www.v3.co.uk/v3-uk/news/1950164/football-injuries-rocket-science. [Accessed: 30-Sep-2015].
10 Mota, L., Reis, L.P., Lau, N.: Multi-robot coordination using Setplays in the middle-size and simulation leagues Mechatronics, Elsevier, 21 (2), pp. 434-444, (2011).
11 Leung, C. K., Joseph, K. W.: Sports Data Mining: Predicting Results for the College Football Games, Proc. Comp. Sci., vol. 35, pp. 710–719, 2014.
12 Abreu, P.H., Moura, J., Silva, D.C., Reis, L.P., Garganta, J.: Performance analysis in soccer: a Cartesian coordinates based approach using RoboCup data, Soft Computing, Springer, 16 (1), 47-61, (2012).
13 Wirth, R., Hipp, J.: CRISP-DM: Towards a Standard Process Model for Data Mining, in Proceedings of the Fourth International Conference on the Practical Application of Knowledge Discovery and Data Mining, pp. 29–39, (2000).
14 Decisive Facts, Phases of the Current CRISP-DM Process Model for Data Mining, 2015. [Online]. Available: http://www.decisivefacts.nl/wp-content/uploads/2015/01/crisp_dm.png.
15 Dodge, Y.: The Oxford Dictionary of Statistical Terms. Oxford University Press, (2006).
16 Silva N., Reis, L.P.: Poker Learner: Players Modeling Through Data-Mining, Proc. 2015 10Th Iber. Conf. Inf. Syst. Technol. (Cisti 2015)1, (2015).
17 McCue C.: Data Mining and Predictive Analysis: Intelligence Gathering and Crime Analysis. (2014).
18 Witten I. H., Frank, E.: Data Mining: Practical Machine Learning Tools and Techniques. Morgan Kaufmann, (2005).

Bat Algorithm for Efficient Query Expansion: Application to MEDLINE

Ilyes Khennak and Habiba Drias

Laboratory for Research in Artifcial Intelligence,
Computer science department, USTHB,
BP 32 El Alia 16111, Bab Ezzouar,
Algiers, Algeria
{ikhennak,hdrias}@usthb.dz

Abstract. Query expansion (QE) has long been suggested as an effective way to improve the retrieval effectiveness and overcome the shortcomings of search engines. Notwithstanding its performance, QE still suffers from limitations that have limited its deployment as a standard component in search systems. Its major drawback is the retrieval efficiency, especially for large-scale data sources. To overcome this issue, we first put forward a new modeling of query expansion with a new and original metaheuristic namely, Bat-Inspired Approach to improve the computational cost. Then, this approach is used to retrieve both the best expansion keywords and the best relevant documents simultaneously unlike the previous works where these two tasks are performed sequentially.

Keywords: Information retrieval, query expansion, metaheuristics, bat algorithm, MEDLINE

1 Introduction

The immense data and knowledge present on the Web is growing at a mind-blowing rate and even estimates are proven wrong every second. This revolution, that the Web is witnessing, has led to the following results:

- New words are introduced in the World Wide Web. According to Williams and Zobel [8], there is one new word in every two hundred words.
- Users employ these new words in their queries search. Chen et al. [2] indicated that more than 17% of query keywords are out of vocabulary.

Undoubtedly, the difficulty of exploring the meanings of these new ambiguous will certainly result in a failure of the Web search enginesn. One of the most natural and successful method to overcome this limitation is query expansion. Currently, QE is considered an extremely promising technique to improve the retrieval effectiveness. Despite its high effectiveness, it still suffers from drawbacks that have limited its deployment as a standard component in search systems.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_11

Its major weakness is the computational cost, especially for large-scale data sources, since it involves additional computations steps as compared to the standard search engines [1]. One way to bypass this drawback is to consider the problem of selecting the best expansion keywords as a combinatorial optimization problem. A combinatorial optimization problem is a problem of picking the best solutions from a finite set of solutions. Due to the practical importance of combinatorial optimization problems, many algorithms to tackle them have been developed. These algorithms can be classified as either complete or approximate algorithms. In the last two decades, a new class of approximate methods has emerged. These methods are often surprisingly efficient in practice in solving difficult optimization problems. They are called Metaheuristics algorithms, and are often nature-inspired, mimicking some successful characteristics in nature [10]. One of the new metaheuristics algorithms which has great potential is Bat Algorithm (BA) proposed by Yang in 2010 [11]. BA is a metaheuristic algorithm based on echolocation characteristic of bats and developed by mimics of bats' foraging behavior.

In this paper, a new approach based on bat algorithm is proposed for the first time to reduce the computational cost of query expansion process. The bat algorithm aims to extract the best expansion keywords, in one hand and to select the best relevant documents to the expanded query on other hand. In addition, one of its major advantages is to allow handling both treatments in parallel. We evaluate our approach using MEDLINE dataset and we use the two well-known Pseudo-Relevance Feedback (PRF): Rocchio's method, and Robertson/Sparck Jones' term-ranking function as the baseline for comparison.

2 Related works

2.1 Pseudo-relevance feedback for query expansion

One well-known query expansion technique is pseudo-relevance feedback. It uses the pseudo-relevant documents, i.e. the first documents retrieved in response to the initial query, to select the most important words to be used as expansion keywords [1]. Figure 1 illustrates the integration of the PRF technique in a classic retrieval system.

In its simplest version, the pseudo-relevance feedback starts by: (i) performing an initial search on the original query. For each query term, the inverted index is invoked to specify which documents that particular term occurs in. For each document in the list, a score is calculated and added to the ranked list of scores. This score is calculated using a document-scoring function. One widely popular and effective document-scoring function is introduced within the Probabilistic Relevance Framework: Okapi BM25. The top ranked documents are considered as pseudo-relevant documents. (ii) Then, extracting the expansion keywords from the pseudo-relevant documents and ranking them using a term-scoring function. One of the best term-scoring functions are Robertson/Sparck Jones term-ranking function (RSJ) and Rocchio. (iii) Finally, expanding the original query by adding

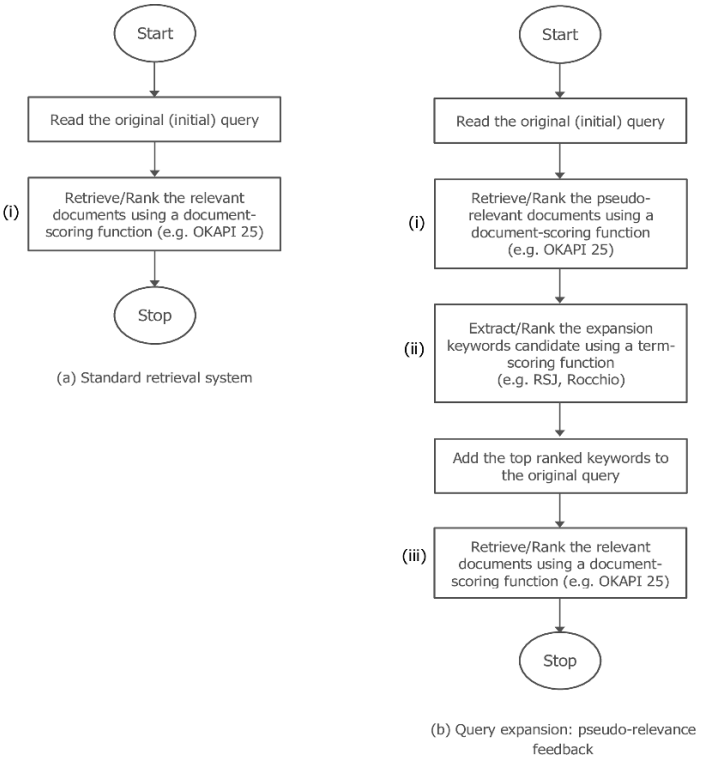


Fig. 1. Standard system vs. system using a PRF technique

the top ranked keywords and retrieving the relevant documents to the expanded query using a document-scoring function.

2.2 Probabilistic relevance framework: Okapi BM25

The probabilistic relevance framework is a formal framework for document retrieval which led to the development of one of the most successful text-retrieval algorithms, Okapi BM25 [4]. The classic version of Okapi BM25 term-weighting function, in which the weight w_i^{BM25} is attributed to a given term t_i in a document d, is obtained using Formula 1:

$$w_i^{BM25} = \frac{tf}{k_1((1-b)+b\frac{dl}{avdl})+tf} w_i^{RSJ} \tag{1}$$

Where:

tf, is the frequency of the term t_i in a document d; k_1, is a constant; b, is a constant; dl, is the document length; $avdl$, is the average of document length; w_i^{RSJ}, is the well-know Robertson/Sparck Jones weight [5]. It is calculated using Equation 2:

$$w_i^{RSJ} = \log \frac{(r_i + 0.5)(N - R - n_i + r_i + 0.5)}{(n_i - r_i + 0.5)(R - r_i + 0.5)} \tag{2}$$

Where:

N, is the number of documents in the whole collection; n_i, is the number of documents in the collection containing t_i; R, is the number of documents judged relevant; r_i, is the number of judged relevant documents containing t_i.

The RSJ weight can be used with or without relevance information. In the absence of relevance information (the more usual scenario), the weight is reduced to a form of classical *idf* shown in Formula 3:

$$w_i^{IDF} = \log \frac{N - n_i + 0.5}{n_i + 0.5} \tag{3}$$

The final BM25 term-weighting function is therefore computed using Equation (4):

$$w_i^{BM25} = \frac{tf}{k_1((1-b) + b\frac{dl}{avdl}) + tf} \log \frac{N - n_i + 0.5}{n_i + 0.5} \tag{4}$$

Regarding the internal parameters, published versions of Okapi BM25 are based on specific values assigned to k_1 and b: $k_1 = 2, b = 0.5$. The similarity score between the document d and a query q is then computed using a document-scoring function, as shown in Equation 5:

$$Score_{BM25}(d, q) = \sum_{t_i \in q} w_i^{BM25} \tag{5}$$

During the interrogation process, the relevant documents are selected and ranked using this similarity score.

2.3 Term-scoring functions for retrieval feedback

One of the best-known functions for term-scoring is the *Robertson/Sparck Jones* term-ranking function, defined by Formula 2. Another well-known function used for term-scoring is the *Rocchio weight* [6] shown in Equation 6:

$$w_i^{Rocchio} = \sum_{d \in R} w_i^{BM25} \tag{6}$$

Where:

R, is a set of pseudo-relevant documents.

2.4 Inefficiency of query expansion

Even though it has made a big leap forward by inventing more effective techniques that overcome the difficulty of providing a more precise description of user request, QE still suffers from limitations that restricted its deployment as a

standard component in search systems. The most important factor that needs to be improved is the computational efficiency. This shortcoming has begun to be addressed in recent research. For instance, the latest papers presented at ACM SIGIR, the top conference in information retrieval, tackled this issue [7][9].
The novelty of our approach compared to the prior efforts, lies in handling the two sequential query expansion steps: (ii) and (iii) in parallel while improving the computational efficiency.

3 Bat Algorithm

Metaheuristic algorithms are now becoming powerful methods for solving many tough optimization problems [3]. The vast majority of heuristic and metaheuristic methods have been derived from the behavior of biological systems in nature. One of the new metaheuristic which has great potential in solving optimization problems, is Bat Algorithm proposed by Yang in 2010 [11].

3.1 Standard bat algorithm

The echolocation behavior of Microbats can be formulated in such a way it can be associated with the objective function, and this makes it possible to formulate new optimization algorithms. The standard bat algorithm was developed with the following three rules:

- All bats use echolocation to sense distance, and they also perceive the difference between food/prey and background barriers in some magical way.
- Bats fly randomly with velocity v_i at position x_i with a frequency f_{min}, varying wavelength λ and loudness A_0 to search for prey. They can adjust the wavelength (or frequency) of their emitted pulses and adjust the rate of pulse emission $r \in [0, 1]$, depending on the proximity of their target.
- Although the loudness can vary in many ways, we assume that the loudness varies from a large (positive) A_0 to a minimum constant value A_{min}.

3.2 Bat Motion

Each bat is associated with a velocity v_i^t and a location x_i^t, at iteration it, in a d-dimensional search or solution space. Among all the bats, there exists a current best solution x_*. Therefore, the above three rules can be translated into the updating equations 7, 8 and 9 for x_i^t and velocities v_i^t:

$$f_i = f_{min} + (f_{max} - f_{min})\beta \tag{7}$$

$$v_i^{(it)} = v_i^{(it-1)} + (x_i^{(it-1)} - x_*)f_i \tag{8}$$

$$x_i^{(it)} = x_i^{(it-1)} + v_i^{(it)} \tag{9}$$

Where $\beta \in [0, 1]$, is a random vector drawn from a uniform distribution.

The loudness and pulse emission rates essentially provide a mechanism for automatic control and auto zooming into the region with promising solutions. In order to simplify the bat algorithm, we can set A and r as constants [11].

4 Bat Algorithm for efficient Query Expansion

The main goal of our proposed approach is to reduce the computational cost of QE process. This proposed approach uses the bat algorithm to quickly extract the best expansion keywords (Step ii) and select the best relevant documents (Step iii). Moreover, it handles those two steps in parallel.

4.1 Bat algorithm for retrieving/ranking the relevant documents

Following the habitual process of query expansion, we first retrieve the pseudo-relevant documents. In our proposed approach, we consider all the documents retrieved in response to the initial query as pseudo-relevant documents. This list of returned documents represents our solution space where each document d represents a solution (bat).

Representation of solution and initialization of Bat population. Actually, the inverted index is created on the basis of the document-index which describes each document d_j, as follows:

$$d_j =< w_{1j}^{BM25}, w_{2j}^{BM25}, ..., w_{|V|j}^{BM25} > \tag{10}$$

Where:

$|V|$, is the size of dictionary (vocabulary).

Based on this, each document (solution) is represented by a vector containing the weights of each term q_i of the original query and each current best expansion keyword $\grave{q}_i$, as shown in 11:

$$d_j =< w_{q_1 j}^{BM25}, w_{q_2 j}^{BM25}, ..., w_{q_{|q|} j}^{BM25}, w_{\grave{q}_1 j}^{BM25}, w_{\grave{q}_2 j}^{BM25}, ..., w_{\grave{q}_{|\grave{q}|} j}^{BM25} > \tag{11}$$

Where:

$w_{q_1 j}^{BM25}$, is the weight of current expansion keyword t_{q_1} in document d_j; $w_{\grave{q}_1 j}^{BM25}$, is the weight of current expansion keyword $t_{\grave{q}_1}$ in document d_j; $|q|$, is the number of initial query keywords; $|\grave{q}|$, is the number of expansion terms.

The population of solutions corresponds to the current relevant documents. Regarding the initial population, it is selected randomly from the solution space.

Initialization of velocity. The velocity v_j is interpreted as a set of documents from which the future new solution will be selected. Initially, $v_j = \varnothing$.

Initialization of pulse rates, loudness and frequencies. Following the work of Yang [12], the rate r and the loudness A were both set to 0.5 and the frequencies f_{min} and f_{max} were set to 0 and 2.

Objective function. The quality of solution is assessed by the document-scoring function presented in section 2 (Formula 5). It is considered as an objective function to be maximized and computed using Formula 12:

$$Score_{BM25}(d_j) = \sum_{t_i \in q} w_{ij}^{BM25} + \sum_{t_i \in \grave{q}} w_{ij}^{BM25} \tag{12}$$

Update velocity and location. Based on Formulas 8 and 9, the update of velocity and location is performed, as follows:
$x_j^{(it-1)} - x_* :$
We first compute the difference between the current best solution d_* and each given current relevant document $d_j^{(it-1)}$. This difference is measured between their vectors of weights. The result is a vector of weights which contains the best weights between the vectors d_* and $d_j^{(it-1)}$. It is given by Equation 13:

$$d_j^{(it-1)} - d_* =< w_{Q_1 b}^{BM25}, w_{Q_2 b}^{BM25}, ..., w_{Q_{|Q|} b}^{BM25} > \tag{13}$$

Where:

Q, is the current expanded query and $|Q| = |q| + |\grave{q}|$;

$$w_{Q_i b}^{BM25} = \begin{cases} w_{Q_i j}^{BM25}, \text{ if } w_{Q_i j}^{BM25} > w_{Q_i *}^{BM25} \\ w_{Q_i *}^{BM25}, \text{ if } w_{Q_i j}^{BM25} \leq w_{Q_i *}^{BM25} \end{cases}$$

$(x_j^{(it-1)} - x_*) f_j :$
At this stage, we pick out the set of documents from which the new solution will be designated. This is performed by selecting for each term t_{Q_i} of the current expanded query Q the documents where their weights $w_{Q_i j}^{BM25}$ are equal (or close) to $w_{Q_i b}^{BM25}$. The selection is done directly from the inverted index and the frequency f_j is employed at this stage to determine the exact set of documents.
$v_j^{(it)} = v_j^{(it-1)} + (x_j^{(it-1)} - x_*) f_j$:
The new velocity $v_j^{(it)}$ corresponds to the union of documents obtained by $(d_j^{(it-1)} - d_*) f_j$ and the set of documents that belong to $v_j^{(it-1)}$ and which contain the same keywords of the current expanded query that $d_j^{(it-1)}$ contains.
$x_j^{(it)} = x_j^{(it-1)} + v_j^{(it)} :$
The new solution $d_j^{(it)}$ must maintains almost the same weights contained in the vector $d_j^{(it-1)}$ and which are considered as the best weights in $d_j^{(it-1)} - d_*$. Thus, the document that belongs to $v_j^{(it)}$ and its weights are close to the ones of $d_j^{(it-1)}$ is selected as a new solution.

4.2 Bat algorithm for extracting the expansion keywords

For this second algorithm, we describe all the components: the solution representation, the search space, the fitness function and the parameters setting.

Representation of solution and initialization of Bat population. A solution for our problem is an expanded query constituted by two parts; the first includes the terms of the initial query and the second is formed by other terms belonging to D, the set of the pseudo-relevant documents retrieved with the initial query. It is represented by a vector, as shown in 14.

$$\grave{q} =< q_1, q_2, ..., q_{|q|}, \grave{q}_1, \grave{q}_2, ..., \grave{q}_{\grave{q}}, > \tag{14}$$

Where:

$\grave{q}$, is the expanded query; q_i, is a term of the initial query $i = 1..|q|$; $\grave{q}_i$, is a term different from all the other terms of $\grave{q}$ and belonging to $\grave{V}$, the set of terms of all pseudo-relevant documents; $|q|$, is the number of initial query keywords; $|\grave{q}|$, is the number of expansion keywords, which is an empirical parameter; $\grave{V} \subset V$, V being the vocabulary (dictionary) of the total collection $|C|$.

The search space includes all possible constructions of expanded queries using representation 14. The size of the search space is equal to $\binom{|\grave{q}|}{|\grave{V}|}$, where $\binom{|\grave{q}|}{|\grave{V}|}$ is the number of combinations of $|\grave{q}|$ terms among the total $|\grave{V}|$ terms, which is equal to $\frac{|\grave{V}|!}{|\grave{q}!*(|\grave{V}|-|\grave{q}|)}$. This huge number expresses the numerous possibilities to build a query expansion. Each candidate solution is encapsulated in a virtual bat, the search space is then considered as a hearth of bats. Regarding the initial swarm population of bats, it is selected randomly from the search space.

Fitness Function. The objective function has the aim to evaluate the quality of the solution. As a solution is an expanded query involving terms, the obvious way to assess its performance is to take into consideration the quality of each of its elements and sum them. Formula 6 allows to measure the performance of one term. Therefore for the whole query $\grave{q}$, we use Formula 15 to measure its fitness.

$$f(\grave{q}) = \sum_{t_i \in \grave{q}} w_i^{Rocchio} \tag{15}$$

The searched solution changes all along the bat process in an increasing order of its fitness function. The current best solution of all the previous iterations is denoted q_*. At each iteration, the algorithm computes the best solution of the iteration, which becomes the global best one if it is better than q_*. At iteration it, a query $\grave{q}$ has a position $\grave{q}^{(it)}$ and a velocity $v^{(it)}$. To update the velocity and location, the same mechanism as the Bat algorithm for retrieving/ranking the relevant documents has been adopted.

5 Experiments

5.1 Dataset

Extensive experiments were performed on a set of 348 566 references from MEDLINE, the on-line medical information database, consisting of titles and/or abstracts from 270 medical journals over a five-year period (1987-1991). The available fields are title, abstract, MeSH indexing terms, author, source, and publication type. In addition, this set of references contains a set of queries, and relevance judgments (a list of which documents are relevant to each query).

5.2 Software, efficiency, effectiveness measures

The proposed approach has been implemented in Python. All the experiments have been performed on a Sony-Vaio workstation having an Intel i3-2330M/2.20GHz processor, 4GB RAM. The CPU time and Precision metric have been used to evaluate the efficiency and effectiveness, respectively.

5.3 Results

Before proceeding to compare the quality of the suggested approach with the standard pseudo-relevance feedback methods, we fixed the different parameters linked to the Bat algorithm. For both Bat algorithms used to extract the best expansion keywords and the top relevant documents, the size of populations was set to 10, which is a typical choice [1]. The number of iteration was tuned to 300, 500 and 1000. In the first phase of testing, we computed the CPU time to evaluate the retrieval efficiency of the proposed approach and the pseudo-relevance feedback methods. Table 1 presents the time spent by the proposed approach and the pseudo-relevance feedback methods. Through Table 1, we can obviously see that Bat algorithm produces the lowest CPU time and achieves highly significant improvement over RSJ and Rocchio. In the second set of experiments,

Table 1. Efficiency comparison in terms of CPU time.

	Bat algorithm (using RSJ)			*RSJ*	*Rocchio*
Number of it	*300*	*500*	*1000*		
CPU time	0.22 sec	0.36 sec	0.61 sec	1.73 sec	2.51 sec
	Bat algorithm (using Rocchio)			*RSJ*	*Rocchio*
Number of it	*300*	*500*	*1000*		
CPU time	0.39*sec*	0.51 sec	0.72 sec	1.73 sec	2.51 sec

we evaluated and compared the results of the suggested approach with those of RSJ and Rocchio where we computed the precision values after retrieving 5 (P@5) and 10 (P@10) documents. Table 2 shows the precision values for the Bat algorithm, the RSJ and the Rocchio techniques. Although the performance of RSJ and Rocchio is better than the proposed approach, the quality of results returned by the Bat algorithm is very acceptable.

Table 2. Effectiveness comparison in terms of Precision.

	Bat algorithm (using RSJ)			*RSJ*	*Rocchio*
Number of it	*300*	*500*	*1000*		
P@5	0.1886	0.2052	0.2208	0.2376	0.2297
P@10	0.1693	0.1754	0.1899	0.2069	0.1970
	Bat algorithm (using Rocchio)			*RSJ*	*Rocchio*
Number of it	*300*	*500*	*1000*		
P@5	0.1837	0.2028	0.2190	0.2297	0.2376
P@10	0.1666	0.1714	0.1863	0.1970	0.2069

6 Conclusion

In this paper, we propose a new approach based on bat algorithm to reduce the computational cost of query expansion process and increase solutions effectiveness. This new approach uses the bat algorithm to extract the best expansion keywords, in one hand and to select the best relevant documents to the expanded query on other hand. In addition, it allows handling them in parallel.
We thoroughly tested our approach using the MEDLINE database. The experimental results show that the proposed approach succeeded to improve the retrieval efficiency and yielded a substantial enhancement compared to the state-of-the-art.

References

1. Carpineto, C., Romano, G.: A survey of automatic query expansion in information retrieval. ACM Comput. Surv. 44(1), 1:1–1:50 (2012)
2. Chen, Q., Li, M., Zhou, M.: Improving query spelling correction using web search results. In: Proceedings of the 2007 Joint Conference on Empirical Methods in Natural Language Processing and Computational Natural Language Learning (EMNLP-CoNLL). pp. 181–189. Association for Computational Linguistics (June 2007)
3. Kennedy, J.: Particle swarm optimization. In: Encyclopedia of Machine Learning, pp. 760–766. Springer (2010)
4. Robertson, S., Walker, S., Beaulieu, M., Gatford, M., Payne, A.: Okapi at trec-4. In: In Proceedings of the 4th Text REtrieval Conference (TREC-4. pp. 73–96 (1996)
5. Robertson, S.E., Jones, K.S.: Relevance weighting of search terms. Journal of the American Society for Information science 27(3), 129–146 (1976)
6. Rocchio, J.J.: Relevance feedback in information retrieval (1971)
7. Wang, H., Liang, Y., Fu, L., Xue, G.R., Yu, Y.: Efficient query expansion for advertisement search. In: Proceedings of the 32Nd International ACM SIGIR Conference on Research and Development in Information Retrieval. pp. 51–58. SIGIR '09, ACM (2009)
8. Williams, H.E., Zobel, J.: Searchable words on the web. International Journal on Digital Libraries 5(2), 99–105 (2005)
9. Wu, H., Fang, H.: An incremental approach to efficient pseudo-relevance feedback. In: Proceedings of the 36th International ACM SIGIR Conference on Research and Development in Information Retrieval. pp. 553–562. SIGIR '13, ACM (2013)
10. Yang, X.S.: Nature-inspired metaheuristic algorithms. Luniver press (2010)
11. Yang, X.S.: A new metaheuristic bat-inspired algorithm. In: Nature inspired cooperative strategies for optimization (NICSO 2010), pp. 65–74. Springer (2010)
12. Yang, X.S.: Nature-inspired optimization algorithms. Elsevier (2014)

Email Answering by Matching Question and Context-Specific Text Patterns: Performance and Error Analysis

Eriks Sneiders[1], Jonas Sjöbergh[2], Alyaa Alfalahi[1]

[1] Department of Computer and Systems Sciences, Stockholm University
Postbox 7003, SE-164 07, Kista, Sweden
{eriks,alyalfa}@dsv.su.se
Department of Information Science, Hokkaido University
Sapporo, 060-8628, Japan
js@meme.hokudai.ac.jp

Abstract. Automated answering of frequent email inquiries is a text categorization task with narrow text categories, where all messages in one text category have the same answer. Such email categorization is optimized for high precision and at least acceptable recall. We tested matching of surface text patterns to nearly ten thousand email messages and achieved around 90% precision; the corresponding recall figures were 45-75% in different text categories. In order to achieve this performance level, the text patterns are designed to identify both the context of an email inquiry and the actual need that has created the inquiry – a question, request, or complaint. Our error analysis has pinpointed 12 reasons why text pattern matching may fail.

Keywords: Email answering, email categorization, text-pattern matching.

1 Introduction

Text pattern matching has been used in Information Extraction [1], automated question [2] and email [3] answering. Any text recognition task that involves regular expressions means matching surface text patterns.

In this paper, we explore matching of manually crafted text patterns to e-mail messages in order to assign standard answers, i.e., in order to put a message into a specific text category. In a series of tests we have investigated:

- How good email categorization-by-answer can we achieve by matching manually crafted text patterns that specify a user request and the context of the request? Assuming that such text patterns are of the highest quality, our performance figures may hint at the upper performance limits of text-pattern matching.
- How does the performance of the system change when we iteratively test and then modify the text patterns, i.e., iteratively "re-train" the system?
- When text-pattern matching fails, what is the cause of the failure? We believe the mistakes made by our system are of general nature for email answering by text pattern matching, not specific to the particular text patterns.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_12

The paper is organized as follows. The next section introduces two vital elements of an email inquiry – context description and user request that triggers the response – which together determine the answer. Sections 3 and 4 introduce our experiment data, the email answering techniques, and the test cases. Section 5 discusses the experiment results. Section 6 does error analysis. Section 7 concludes the paper.

2 Context Description and Response Trigger in Email Inquiry

We have been working with email sent to contact centers for quite some time. Through observations of tens of thousands of email messages we have discovered that the initial inquiry consists of two parts – (i) a description of the subject or context of the inquiry and (ii) a response trigger. The response trigger can be a question waiting to be answered, a request to carry out an activity and report the results, or a statement that requires a response (e.g., a complaint). For automated email answering, requests for information and requests to complete a task are of interest – the system can deliver information or redirect the user to a self-service application.

In a *simple question*, explicit or implicit, both the context and the response trigger are placed in one sentence, both contain meaningful keywords. Example: "I wonder whether **I get** any **payment** in April because I haven't received any notification yet." "Get" and "payment" are the keywords that define the subject of the inquiry. "Wonder" raises the question to be answered. The second "I" disambiguates the question. "In April" specifies a detail of the inquiry pinpointed by the subject. The entire question is a response trigger.

Sometimes *relevant keywords describe the context while the response trigger does not contain any keywords*. Example: "I sent you an **application** for **parental benefits** more than a week ago, how is my case progressing?" "How is my case progressing" is the response trigger which does not contain any subject-specific keywords and acquires meaning only in the presence of a particular context.

Often *the context and the response trigger come in separate sentences*, which makes it more difficult to identify the inquiry. Let us consider the sentence "I **applied** for **housing allowance** on January 13." The statement introduces a story, yet alone it does not ask for any response. The person continues the story by telling that she has got half of the amount she expected and would like to know "When will the rest of my money come?" This is the question to be answered, the response trigger that makes sense only together with its context. The context and the response trigger are in separate sentences in a random sequence, possibly having a few other sentences in between. It may happen that the response trigger does not contain any subject-specific keywords even in a separate sentence.

A context description provides keywords that are useful for topic-related text clustering and categorization. In order to answer a message correctly, the system must take the next step and identify the request, the need, why the message was sent in the first place. So far we have found only one reference to a clear separation of context description and response trigger in automated email answering [4]: "Determining the factual content of an e-mail is not sufficient to answer it correctly – its purpose is also very important. […] In the e-mails we are analyzing, the same set of data can be

extracted from e-mails that have different purposes. The answer to be generated for these emails must therefore be different."

Resolving the purpose of an email message is not a new research problem. There exists research that applies speech-act theory in order to categorize workplace email messages according to the purpose of the message, not the topic. The purpose can be a request for action, information, permission, a proposal to meet, a promise or a commitment [5-6]. Requests and commitments may be conditional or unconditional, explicit or implicit [7]. Locus ambiguity may be a challenge: while human annotators of training data tend to agree that the message contains a request or commitment, they may not agree on exactly which utterances contain them [8]. Goldstein and Sabin [9] took a broader look at email tasks and defined 12 email genres according to their task, including also expression of feelings, document forwarding, advertising, spam, etc.

In an email message sent to a contact center, the response trigger is a task-related speech act. It may be explicit or implicit. It may be ambiguous and vague. Context is important in interpreting the request. (See Section 6 for related discussion.)

3 Experiment Data

Our test data is 9663 email messages sent by citizens to the Swedish Social Insurance Agency. We extracted the message body; if there was a dialogue thread, we took the chronologically last message. No meta-data was used. We identified the most common types of inquiries, i.e. text categories, and selected five text categories for automated answering: (Cat1) "Please send me a fill-in-form!", (Cat2) "When will you decide my housing allowance?", (Cat3) "How many days of parental benefits do remain for my child?", (Cat4) "How much will I get in my future pension?", (Cat5) "When do I get my money?". These categories had a clear information need and could be answered by a standard answer. We manually labeled each message according to its text category. Preparation of the messages is covered in [10].

The messages came in four batches, called collections A, B, C, and D. Table 1 shows the distribution of the messages across these collections and the text categories. The sum of all messages across categories in one collection is larger than the number of messages in the collection because some messages belong to two categories. In collection A there are 6 messages that belong to two categories, in B – 9 messages, in C – 6 messages, and in D – 8 messages. The size of the messages varies. The minimum, maximum, average, and median number of words per message are 4, 321, 45.5, and 35. The minimum, maximum, average, and median number of sentences are 1, 45, 5.2, and 4.

Table 1. Number of messages by collection and by text category.

	Collection	Cat 1	Cat 2	Cat 3	Cat 4	Cat 5	Rest	Sum
Collection A	2437	94	76	51	29	362	1831	2443
Collection B	1967	76	62	49	30	269	1490	1976
Collection C	2473	109	105	53	22	387	1803	2479
Collection D	2786	148	79	45	78	393	2051	2794
Total	9663	427	322	198	159	1411	7175	9692

Table 2. Format of context description and response trigger, and the number of corresponding inquiries across a sample of email messages.

Format of the inquiry	Num	Share %
Simple question (explicit or implicit)	159	52
Simple question; response trigger without representative keywords	8	3
Simple question; vaguely written message	3	1
Context description and response trigger come in separate sentences	87	28
Context description and response trigger come in separate sentences; response trigger without representative keywords	33	11
Context description and response trigger come in separate sentences; vaguely written message	14	5
Total	304	100

In order to discover the format of the context descriptions and response triggers in our data, we examined 300 random messages in Cat1 through Cat5 in collection C. Four messages belong to two text categories, therefore we have 304 message-category pairs and the corresponding number of inquiries (Table 2).

4 Text Matching Techniques and the Test Cases

Our text-pattern matching system operates 154 manually crafted text patterns. The syntax of the text patterns resembles regular expressions. In a text pattern, we can define a number of synonyms that designate a concept; we can define the order of the words and the distance between the words. The system has spelling correction, word stems, and compound splitting built into the pattern matching process. Each text pattern is designed to match a context description and a response trigger. The text patterns are optimized for precision – if the message is answered, it must be answered correctly. Closely following precision comes recall. A complete description of the text-pattern matching technique is available in [11]; relevant statistical characteristics and lexical classes of matching text patterns are discussed in [12]. This paper complements the previous publications, it discusses the accuracy of email answering and the errors.

Table 3. Evaluation cases with "training" and test data sets.

Test name	"Training" collections	Test collection
A-B	A	B
AB-C	A+B	C
ABC-D	A+B+C	D
AB-D	A+B	D

Initially we had only collection A for "training" and collection B for testing. We write "training" in quotes because manual development of text patterns is not training as in machine learning. Over some period of time collections C and D arrived, which made

it possible to measure stepwise improvement of the text patterns: we could add the test collection to the "training" data and take a new test collection. We wanted to find out how much "retraining" of the text patterns with new messages could improve the system's performance.

Different test collections, however, do not allow seeing the true effect of stepwise improvement. We fixed this in the tests AB-D and ABC-D. Unfortunately, we could not use D in order to test patterns "trained" solely on A because by the time D arrived the old A-trained text patterns were already lost.

In order to compare the pattern-matching system with a standard machine learning method we used the WEKA framework. In the previous tests with Support Vector Machine (SVM) and Naïve Bayes, and the collections A+B, SVM slightly outperformed Naïve Bayes [10]. A survey of email classification tasks [13] has also concluded that SVM and Naïve Bayes yield similar performance.

We chose SVM as the baseline. The only machine learning features were individual terms. The text pre-processing were spelling correction, lemmatization, and compound splitting. We tested them in various combinations and reached text categorization accuracy between 0.860 and 0.869; it was ten-fold cross validation on data collections A+B+C+D. We did not use advanced features such as semantic distance between terms because tools such as WordNet do not exist for Swedish. The SVM parameters were set to the WEKA default parameters. We used vectors of dimension 10 000; smaller vectors gave worse classification accuracy and longer vectors made the computer run out of memory.

SVM is a proven technique for topic-related text categorization. In our tests, identifying the response trigger is likely to be a challenge, especially because 20% of the messages are vaguely written or the response trigger does not contain representative keywords (see Table 2).

5 Experiment Results

We measured correctness of email categorization by applying the very traditional in Information Retrieval precision, recall, and F-score. The values in Table 4 and Table 5 are arranged to emphasize the trends through the consecutive tests. Figure 1 illustrates these trends.

The total precision for text-pattern matching was calculated as the number of correctly placed messages divided by the sum of correctly and incorrectly placed messages across all the categories in the test collection. The total recall was calculated as the number of correctly placed messages divided by the number of message-category pairs across all the categories in the test collection. The number of messages is slightly lower than the number of message-category pairs because a few messages belong to two categories. For SVM, "Avg" is weighted average; WEKA calculated the average value across all the text categories considering the number of messages in each category.

Table 4. Precision, recall, and F-score for the tests A-B, AB-C, and ABC-D.

	Precision			Recall			F-score		
Test	A-B	AB-C	ABC-D	A-B	AB-C	ABC-D	A-B	AB-C	ABC-D
	Text-pattern matching								
Cat1	0.91	0.92	0.93	0.54	0.63	0.59	0.68	0.75	0.72
Cat2	0.97	1.00	0.91	0.53	0.56	0.65	0.69	0.72	0.76
Cat3	0.96	0.92	0.92	0.55	0.85	0.76	0.70	0.88	0.83
Cat4	0.88	1.00	0.89	0.50	0.45	0.44	0.63	0.63	0.59
Cat5	0.84	0.91	0.88	0.41	0.63	0.59	0.55	0.75	0.71
Rest	0.86	0.88	0.87	0.99	0.99	0.98	0.92	0.93	0.92
Total	0.86	0.89	0.88	0.86	0.89	0.87	0.86	0.89	0.88
	Support Vector Machine								
Cat1	0.60	0.69	0.69	0.49	0.54	0.69	0.54	0.61	0.69
Cat2	0.73	0.85	0.69	0.60	0.77	0.86	0.66	0.81	0.76
Cat3	0.89	0.82	0.73	0.82	0.85	0.89	0.85	0.83	0.80
Cat4	0.77	0.85	0.70	0.43	0.50	0.58	0.55	0.63	0.63
Cat5	0.67	0.73	0.63	0.65	0.71	0.80	0.66	0.72	0.70
Rest	0.89	0.90	0.93	0.92	0.92	0.87	0.90	0.91	0.90
Avg	0.84	0.86	0.85	0.85	0.86	0.84	0.84	0.86	0.85

Table 5. Precision, recall, and F-score for the tests AB-D and ABC-D.

	Precision		Recall		F-score	
Test	AB-D	ABC-D	AB-D	ABC-D	AB-D	ABC-D
	Text-pattern matching					
Cat1	0.89	0.93	0.55	0.59	0.68	0.72
Cat2	0.92	0.91	0.62	0.65	0.74	0.76
Cat3	0.90	0.92	0.82	0.76	0.86	0.83
Cat4	0.91	0.89	0.40	0.44	0.55	0.59
Cat5	0.84	0.88	0.55	0.59	0.67	0.71
Rest	0.86	0.87	0.97	0.98	0.91	0.92
Total	0.86	0.88	0.86	0.87	0.86	0.88
	Support Vector Machine					
Cat1	0.75	0.69	0.55	0.69	0.64	0.69
Cat2	0.81	0.69	0.77	0.86	0.79	0.76
Cat3	0.76	0.73	0.76	0.89	0.76	0.80
Cat4	0.78	0.70	0.37	0.58	0.50	0.63
Cat5	0.73	0.63	0.72	0.80	0.73	0.70
Rest	0.89	0.93	0.93	0.87	0.91	0.90
Avg	0.85	0.85	0.86	0.84	0.85	0.85

Text-pattern matching. As expected, precision and recall mostly improve from A-B to AB-C. The test ABC-D, however, somewhat surprisingly shows a decrease in both precision and recall, despite the text patterns being presumably improved. One possible explanation of the performance drop could be over-fitting (over-training) of

the text patterns. An increased number of "training" messages leads to an increased number of text patterns and an increased level of details in each pattern, which makes the set of text patterns more complex and eventually messy, which may lead to a performance drop. Another explanation could be the use of a different test collection for each test; some test data sets may be harder or easier to categorize than other test data sets.

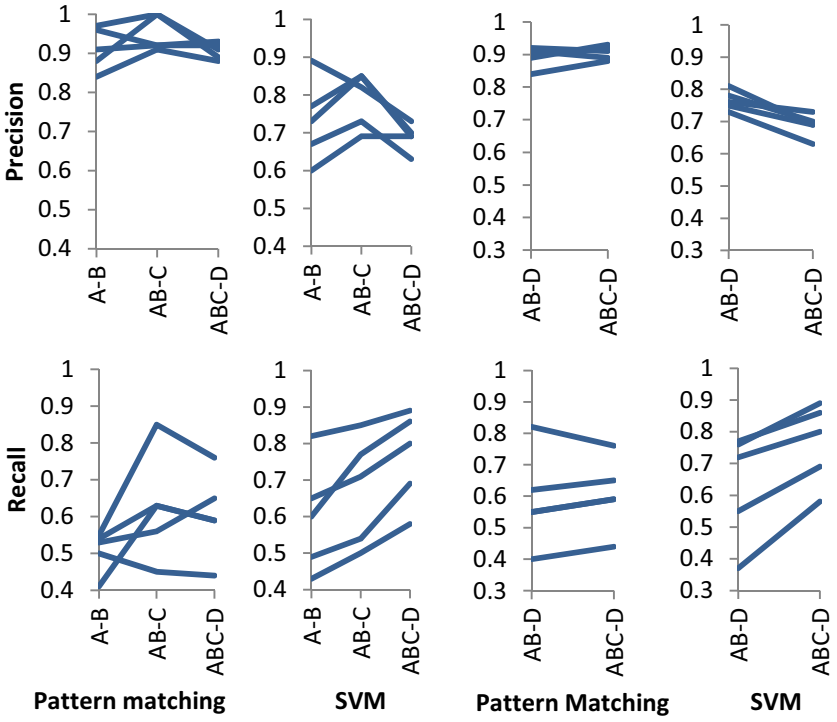


Fig. 1. Precision and recall trends for Cat1 through Cat5 between the tests A-B, AB-C, ABC-D (two left columns), and between the tests AB-D, ABC-D (two right columns). For text-pattern matching in the tests AB-D and ABC-D, the recall values in Cat1 and Cat5 are identical, therefore the lines overlap.

The tests AB-D and ABC-D use the same test collection D and demonstrate a cleaner effect of stepwise improvement between the "training" collections. The performance trends look more cheerful than those between AB-C and ABC-D. Still, precision drops for Cat2 and Cat4 while their recall rises; recall drops for Cat3 while the precision rises. These three categories are small, however, and the performance figures are influenced by only a few misplaced messages. For the entire test collection D, there is a small increase of both precision and recall between AB-D and ABC-D. McNemar's test [14] for the results of AB-D and ABC-D showed that the performance increase was statistically significant on the 5% level.

SVM. The tests AB-D and ABC-D demonstrate that more training data increase recall and decrease precision. Because Cat1 through Cat5 are relatively small text categories (e.g., Cat4 has only 59 training messages in AB-D, 81 in ABC-D), SVM gets more aggressive about classifying emails into these categories. This means more true-positive category placements – higher recall. And because the amount of the training data is still small, also more false positive category placements – lower precision.

A review of automated email answering methods [15] puts our results into context.

6 Error Analysis of Text-Pattern Matching

We manually inspected the reasons for incorrect category placements after the test AB-C. Collection C has 2479 messages. 428 messages in Cat1 through Cat5 where correctly placed, 248 were incorrectly placed into Rest. 34 messages were incorrectly placed into one of the categories Cat1 through Cat5.

Missing answer, unanswered message means that the message was incorrectly placed into Rest. We established 9 error classes for that. Table 6 summarizes the distribution of unanswered messages per error class and text category.

Err1: Unique wording. The wording in these messages does not resemble any text pattern in the system's database. There is little we can do to answer these messages. If the number of training messages rises and some of the unique messages start exhibiting common wordings, then we can create new text patterns to cover them.

Err2: Similar text pattern available. This error class is similar to Err1, except there are one or more text patterns relevant to the unanswered message. These text patterns include concepts that appear in the message, but wording of the details around these concepts is not covered by the text patterns. It is unclear how much we would benefit from modifying an existing text pattern in order to answer this particular message. If, however, the number of training messages rises, some of the unanswered messages may become useful for improving existing text patterns.

Err3: Missing synonym or word order. There exists an almost matching text pattern in the system's database, but this text pattern did not match the message because of one concept. In the text pattern, the concept was represented by a number of synonyms, whereas the message used different one. A synonym may be a word or an expression, e.g., "understand" vs. "make out". In some cases, the unanswered message used a generalization of a particular concept. If we want a text pattern to include more general synonyms, we need to redesign the text pattern and include expressions that specify the context in which these more general synonyms are used. Not specifying the context will lower precision.

In very few cases, the text pattern did not match because it stipulated the opposite sequence of two matching words.

It should not be difficult to automatically discover contextual synonyms for existing text patterns.

Err4: Missing disambiguation in the query message. This error class is similar to Err3. There exists a nearly matching text pattern in the system's database. Much of the text pattern, usually a general key phrase, did match the message. Still, the text pattern also contained a number of disambiguating expressions that specified the

context of the general key phrase, and none of these expressions matched the query message. For example, the statement "I'd like to have my money" can be placed in different contexts and mean different things. For a complete match we require that a disambiguating expression such as "for March-April" matches. Then we can assume that the writer is asking about a payment of social benefit for the given period because the message is sent to an authority whose main business is paying social benefits.

Err5: Missing subject or action word in the message. This error class is similar to Err4. There exists a nearly matching text pattern in the system's database. Still, the nearly matching piece of text in the message did not contain the subject or action word required by the text pattern for a match. Taking the subject or action word out of the text pattern would require adding disambiguating context expressions. For example, the unanswered message says "I don't have my allowance", while a matching text pattern requires something like "I don't have my allowance paid".

Err6: Too nuanced message. This error class is similar to Err2. The message is rich in specific details that describe the context of the message. Nonetheless, it is difficult to match this wealth of details to recurring text patterns.

Err7: Vague message. The message may be understood by a human who knows the overall context and can reason, but the information need or the purpose of the message is not clearly expressed, i.e., the response trigger is not clear or missing.

Err8: Untreated misspelling. Although the system does correct spelling mistakes, some misspellings may be left untreated and relevant text patterns may fail to match. Some misspellings may be correctly spelled different words, such as "maid" instead of "made". Non-standard abbreviations can be considered misspellings here.

There is little we can do with text patterns in order to treat spelling mistakes missed by a spellchecker, though we can treat non-standard abbreviations as missing synonyms in Err3.

Err9: Ill-structured message. The message lacks proper sentences, or a sentence resembles a collection of words.

Table 6. Distribution of unanswered messages per error class and text category.

	Err1	Err2	Err3	Err4	Err5	Err6	Err7	Err8	Err9	Total
Cat1	19	7	7	1	2	1	1	2		40
Cat2	20	18	3	1			1	3		46
Cat3		1	5	1			1			8
Cat4	6	2	1			1	1		1	12
Cat5	41	23	27	4	9	18	10	5	5	142
Total	86	51	43	7	11	20	14	10	6	248
Share %	34.7	20.6	17.3	2.8	4.5	8.1	5.6	4.0	2.4	100

Wrong answer means that the message was incorrectly placed into one of the categories Cat1, Cat3, or Cat5; Cat2 and Cat4 did not have any wrong answers. We established 3 error classes. Table 7 summarizes the distribution of incorrectly answered messages per error class and text category.

Err10: Related context. The system has found a matching piece of text in the message, but the meaning of the text pattern there is different because of different overall context in the message, which invalidates the standard answer.

Err11: Context changes in a subordinate clause. The system has found a matching sentence, but a subordinate clause of this sentence changes the context of the text pattern and invalidates the standard answer.

Err12: Meaning changes because of a word. The system has found a matching sentence, but there is a word or a phrase in the sentence that invalidates the expected meaning of the text pattern and the standard answer.

Table 7. Distribution of incorrectly answered messages per error class and text category.

	Err10	Err11	Err12	Total
Cat1	4		2	6
Cat3		4		4
Cat5	12	1	11	24
Total	16	5	13	34
Share %	47.1	14.7	38.2	100

7 Conclusions

In automated email answering, the system's ability to identify the context and the request (we call it response trigger) stated in a query message is crucial. In about 52% of our email messages, the context and the response trigger is one question (see Table 2). For these messages, standard question-answering and text categorization techniques may work well. Some other 20% of the messages are challenging: the message is vague or the response trigger does not contain representative keywords. Having this in mind, we tested a text-pattern matching technique where each text pattern was designed to match a context description and a response trigger.

The system achieved good precision – about 90% of the messages were correctly assigned a standard answer. The recall varied, mostly lying in its 50-ies and 60-ies. The baseline system, SVM, achieved similar or slightly better recall while having considerably lower precision (see Table 4, Table 5, Figure 1). Assuming that manually crafted text patterns yield the highest quality of text-pattern matching, we believe that our performance figures illustrate the upper performance limits of text-pattern matching, or perhaps statistical (without semantic processing) text matching for a large and diverse email collection where precision holds priority.

We have observed that more "training" data, which allows improving the text patterns, does not always increase both precision and recall simultaneously for small (around 100 messages) text categories. With different test collections (e.g., continuous email flow) the precision and recall change is even more unpredictable.

We have discovered 12 reasons why text-pattern matching may fail. 9 reasons cause a "missing answer", i.e., the system fails to place a message into the category where it belongs. About 35% of the "missing answers" could be relieved by more "training" data (see Section 6 and Table 6). 3 reasons cause a wrong answer.

References

1. Downey, D., Etzioni, O., Soderland, S., Weld, D.S.: Learning text patterns for web information extraction and assessment. In: Proc. AAAI-04 workshop on adaptive text extraction and mining, pp. 50-55 (2004)
2. Sneiders, E.: Automated FAQ Answering with Question-Specific Knowledge Representation for Web Self-Service. In: Proc. 2nd International Conference on Human System Inter-action (HSI'09), May 21-23, Catania, Italy, pp.298-305, IEEE (2009)
3. Sneiders, E.: Automated Email Answering by Text Pattern Matching. In: H. Loftsson, E. Rögnvaldsson, S. Helgadóttir (eds.): Proc. 7th International Conference on Natural Language Processing (IceTAL), August 16-18, Reykjavik, Iceland, LNAI 6233, pp. 381-392. Springer, Heidelberg (2010)
4. Kosseim, L., Beauregard, S., Lapalme, G.: Using information extraction and natural language generation to answer e-mail. Data & Knowledge Engineering, vol. 38, pp. 85-100 (2001)
5. Khosravi, H., Wilks, Y.: Routing email automatically by purpose not topic. Natural Language Engineering, 5, pp. 237-250 (1999)
6. Corston-Oliver, S., Ringger, E., Gamon, M., Campbell, R.: Task-focused summarization of email. In: Proc. ACL-04 Workshop: Text Summarization Branches Out, pp. 43-50 (2004)
7. Lampert, A., Dale, R., Paris, C.: The nature of requests and commitments in email messages. In: Proc. of the AAAI Workshop on Enhanced Messaging, pp. 42-47 (2008)
8. Lampert, A., Dale, R., Paris, C.: Requests and Commitments in Email are More Complex Than You Think: Eight Reasons to be Cautious. In: Proc. Australasian Language Technology Association Workshop, vol. 6, pp. 64-72 (2008)
9. Goldstein, J., Sabin, R.E.: Using speech acts to categorize email and identify email genres. In: Proc. 39th Annual Hawaii International Conference on System Sciences, vol. 3. IEEE (2006)
10. Dalianis, H., Sjöbergh, J., Sneiders, E.: Comparing manual text patterns and machine learning for classification of e-mails for automatic answering by a government agency. In: Proc. Computational Linguistics and Intelligent Text Processing, pp. 234-243. Springer Berlin Heidelberg. (2011)
11. Sneiders, E.: Automated FAQ Answering: Continued Experience with Shallow Language Understanding. In: Question Answering Systems. Papers from the 1999 AAAI Fall Symposium. Technical Report FS-99-02, November 5-7, North Falmouth, Massachusetts, USA. AAAI Press, pp.97-107(1999)
12. Sneiders, E., Eriksson, G., Alfalahi, A.: Exploring the Traits of Manual E-Mail Categorization Text Patterns. In: Advances in Natural Language Processing, pp. 337-344. Springer International Publishing (2015)
13. Tang, G., Pei, J., Luk, W. S.:. Email mining: tasks, common techniques, and tools. Knowledge and Information Systems, 41(1), 1-31 (2014)
14. Everitt, B.: The Analysis of Contingency Tables. Chapman & Hall, London (1977)
15. Sneiders, E.: Review of the Main Approaches to Automated Email Answering. In: Proc. WorldCist'16, Recife, Brazil, March 22-24. Springer International Publishing (2016)

Review of the Main Approaches to Automated Email Answering

Eriks Sneiders[1]

[1] Department of Computer and Systems Sciences, Stockholm University
Postbox 7003, SE-164 07, Kista, Sweden
eriks@dsv.su.se

Abstract. There were 108.7 billion business emails sent daily in 2014, many of them to contact centers. A number of automated email answering techniques have been explored in order to ease the burden of manual handling of the messages. Most techniques stem from three text retrieval approaches – text categorization by machine learning, statistical text similarity calculation, matching of text patterns and templates. The paper discusses the previous research in automated email answering and compares the techniques.

Keywords: Automated email answering, message answering, email categorization, email classification.

1 Introduction

Despite losing its popularity to social media, email remains the most pervasive form of communication in the business world with 108.7 billion daily messages in 2014 [1]. For companies and governmental organizations, email and web-based messaging services are a vital communication channel with customers and citizens, along with telephone. And is this channel cheap? A contact center in Sweden may have a cost as much as 12 EUR per message [2].

Automated email answering is not a common practice in business settings. One reason why companies may be reluctant to send automatically generated answers is fear of losing contact with their customers, as well as fear of lost sales opportunities, according to our private communication with a few contact centers in Sweden. On the other hand, a system that retrieves draft answers for contact center agents is a welcomed alternative. Automated text message answering has a future also without the traditional inbox. For example, an interactive system that handles problem reports (e.g., "trouble tickets") can benefit from an immediate feedback or solution. A similar feature can be useful in community question answering (web forums).

Tang et al. [3] offer a comprehensive overview of the main email tasks – spam detection, email categorization, contact analysis, email network property analysis, email visualization – and the corresponding techniques. This paper discusses the previous research in automated email answering, which is not as popular as automated question answering [4], yet still has a number of publications, many dated by the pre-social-media era. The method of obtaining the publications was our own years-long research and Google Scholar. We submitted a number of queries to Google Scholar

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_13

and explored the top 100 links. Also, we checked the reference section of the selected publications. A significant criterion for selecting a publication for the review was presence of an experimental evaluation of the technique.

2 Machine Learning for Email Categorization

If all messages in one text category have the same standard answer, automated email answering becomes a text categorization task.

Busemann et al. [5] tested a number of machine learning techniques – k-NN, Naïve Bayes, RIPPER, SVM. The data was 4490 email messages, sent to a technical support helpdesk, in 47 categories with at least 30 messages in each category. Optional input for machine learning was presence or absence of linguistic constructions frequent in questions and problem descriptions: negation at the sentence or phrase level, yes/no and who-when-what-why-where-which-questions, a declarative immediately preceding the question. All experiments were carried out using ten-fold cross validation. The best performing system was SVM, with accuracy (the share of correctly suggested standard answers) of 56% for a single answer, and for 78% of the email messages the correct answer was among the top 5 suggested answers.

Tobias Scheffer [6] explored SVM and Naïve Bayes for email answering in the settings of Internet-mediated education. Roughly 72% of all incoming messages could be answered by 9 standard answers; the most popular inquiry alone covered 42%. The performance of text categorization was assessed by receiver operating characteristic (ROC) curves that showed the relationship between true positive and false positive category placements as the discriminating threshold varied. A large area under the curve shows a large probability of true positive over false positive category placements. 7-to-20-fold cross validations were performed and their results averaged. SVM demonstrated superior performance, 80-95% area under the curve, even with as few as seven labeled positive training examples. SVM significantly outperformed Naïve Bayes in 8 of 9 text categories.

The same team did a parallel study [7] with email of a large online shop. A set of 805 messages was manually divided into 19 partitions with at least 10 messages in a partition where all messages in the partition had semantically equivalent answers. 10-fold cross validation with SVM reached categorization accuracy (precision equals recall) 42%. One problem was that different partitions contained similar query messages while their answers were different; determining the difference required additional information from the shop's order database. After merging the similar partitions, a number of precision-recall measurements showed 10-20% precision improvement over the same recall values.

Mercure was a 4 years long study with the goal to explore the automation opportunities in processing email sent to a contact center [8]. Two approaches were investigated: one did message categorization with machine learning, the other one pursued the paradigm of text retrieval. Text categorization was tested by k-NN, Naïve Bayes, and RIPPER . The data was 1568 inquiry-reply pairs in the domain of investor relations at a telecommunications company. Categorization accuracy was about 50%. The main cause of errors was the fact that some messages dealt with more than one

subject or were a part of a multi-message conversation. Similar tests with single-subject emails yielded 90% accuracy for 5 categories, 80% for 10 categories, and 67% accuracy for 22 categories.

Yang and Kwok [9] compared the K-means++, k-NN, and Naïve Bayes algorithms. The data was 3015 emails in 200 text categories, each having 5-13 messages, in the domain of computer technical support. 10 experiments were conducted, each time 1000 training messages used. In average, K-means++ correctly classified 96.2% of the messages, Naïve Bayes – 89.5%, k-NN – 75.5%.

Hewlett and Freed [10] helped employees of a contact center compose email replies. Given the query email, the system retrieved the answers of the 8 most similar archived messages, using cosine similarity as the text similarity measure. The archived messages had their term vectors stored and readily available. The employee selected an appropriate answer, thus creating an opportunity for machine learning: the message of the selected archived answer is most similar to the query email, the messages higher in the top-8 list are not. The system used a version of the Margin Infused Relaxed Algorithm to update the stored term vectors of the selected message and the messages above it in the top-8 list.

The performance evaluation data was email sent to the Hewlett Packard helpdesk. 8604 archived message-answer pairs were selected. Of them, 475 were grouped into 36 text categories, where all messages in one category had identical bag-of-words answers. The system matched each of the 475 messages to the 8604 messages using cosine similarity. In 231 cases of 475 a relevant answer appeared in the top-8 list, which is 49% of the cases. After adding the machine learning component to the test, this share increased to 60%.

Matching an email message to a list of FAQs on a website is another way of answering. Itakura et al. [11] uses SVM in a less traditional way. The central concept is a feature vector with similarities between one message and the FAQs. Let's say there are n FAQs in a list. An n-dimensional feature vector contains n modified Jaccard coefficients that quantify the similarity between each FAQ and the message. The modified Jaccard coefficient is calculated by adding weight to domain keywords considering their inverted document frequency. SVM is then trained with such feature vectors, one vector per message, not document vectors based on words in the message or FAQ texts.

The performance evaluation used 4 FAQs and 1845 email messages, 545 of which corresponded to the FAQs. The language was Japanese. 22 domain keywords and their synonyms were used in calculating the modified Jaccard coefficient. The resulting precision/recall figures were roughly 98/90, 85/70, 95/85, and 60/95 percent for the 4 text categories defined by the 4 FAQs.

The previous email categorization tasks (not automated answering) have used more features for machine learning than just message text. Alberts and Forest [12] have tested two sets of features – lexical features, i.e. message text, and non-lexical features, such as use of bold and capital letters, number of recipients of the message, presence of a mailing list, the sender being in the same social network as the receiver, presence of "RE:" and "FW:" in the subject line, message signed by an official signature or only by the first name, etc. A test with k-NN and 1700 messages in French from two workplace inboxes showed that categorization accuracy with non-lexical features is considerably lower than that with lexical features. The most

discriminative non-lexical features were: the sender in the same social network as the recipient, message to or from a mailing list, the number of carbon-copy recipients, use of bold letters, bilingual message.

3 Statistical Text Similarity without Machine Learning

Locating one or several inquiries in a messages and selecting one or several standard answers is a more challenging task than document categorization. Malik et al. [13] work with sentence matching. The system maintains a large number of standard answers and a variety of tag-questions, like FAQ questions, attached to each standard answer. When a query email arrives, the system matches sentences in the query to the tag-questions. When the system matches two sentences, it considers the distance between concepts in the sentences, which is obtained from WordNet. If one of the two words does not exist in the dictionary, then edit distance between the words is calculated.

During the preparation phase, a "training" system examined a large number of archived email message-reply pairs and assigned the tag-questions to the standard answers. To spot a piece of a standard answer in the reply text was easy; more difficult was to map a question in the inquiry message to that piece of a standard answer. In order to identify a question and the answer in a message-reply pair, the system had a list of domain-specific uni-, bi-, and trigrams; questions and answers had to contain these domain-specific n-grams. Further, the system calculated word overlap between the question and the answer, adjusted with respect to inverted document frequency of different words.

The experiment data was 1320 message-reply pairs and 570 standard answers in the domain of mobile phone services. On average, there were about 2 questions per customer inquiry. The email answering system was "trained" by 920 message-reply pairs: the tag-questions were assigned to the standard answers. Tested with 400 message-reply pairs, the system generated the same reply as the humans did in 61% of all cases. In 73.4% of the cases the system generated partially correct replies.

Mercure [8], whose machine learning and text categorization module was introduced in the previous section, tested retrieval of archived message-answer pairs in order to reuse old answers. The system compared query messages with archived email messages applying cosine similarity; term weights were made of term frequency and inverted document frequency. Precision of the retrieval reached 57.9%. A difficulty of email text matching is the lexical gap - a large variety of wordings used by different people to express the same thing. The vocabulary of the answers written by the employees of the contact center, on the contrary, is more uniform. It would be good if instead of comparing inquiry messages (dispersed vocabulary) we could compare their answers (uniform vocabulary). The idea was implemented through query expansion. During the preparation phase, the system measured co-occurrence of words between archived messages and their answers. When a query message arrived, the system used this co-occurrence to find "synonyms" for the query expansion. The precision improved to 62%. In one text category, where the reply was a generic redirection to a web page, the improvement was from 51% to 80.1%.

Alfalahi et al. [14] reused the Mercure's idea and introduced the concept of shadow answer. A shadow answer is a query message re-written in the terms of its likely answer. The term translation is done according to message-answer term co-occurrence between archived messages and their answers. The shadow answer becomes a new query in the database of previous answers. A test with archived emails as queries was conducted; the researchers were looking for the position of the original answer in the result list. Messages were bags-of-words – unigrams and/or bigrams. The best performance was achieved with bigrams only, the result was mediocre: the average position of the original answer of an archived email submitted as a query was 28.

While most text categorization applications in email answering assume that each message in one text category has the same standard answer, for Weng and Liu [15] message categorization is only a half way to the answer. Deployment of the system begins with selecting at least 10 domain concepts attached to a number of text categories; one concept may be attached to several categories. The concepts contain weighted domain terms, where the weights are calculated considering "inverted concept frequency" (a term may appear in several concepts) and term frequency in the training data. When a query message arrives, its term weights are multiplied with the concept term weights, and the "heaviest" concepts lead to a category placement. The category placement and the "heaviest" concepts together determine one or two standard answers.

The evaluation used 612 FAQs and their answers in the domain of Windows NT/2000. 191 simulated user emails and downloaded forum posts were used as queries. Precision and recall were around 80%, with the recall being slightly lower than the precision.

4 Answer Generation

Answer generation is a minority approach in automated email answering. It is not a technique. Rather, it is the outcome of the application of the techniques. Still, the outcome is so different from the usual standard answer selection that it deserves a separate section. We have identified three studies. Two studies involve information extraction and filling answer templates; the third study is answer generation by collating sentences from previous answers.

Kosseim et al. [16] use information extraction templates in order to (i) identify the query message – the purpose, the sender, etc., (ii) extract names entities from the query message, (iii) extract relations between the main concepts, and (iv) capture domain-specific relations. The next step is semantic validation – the system verifies whether the extracted data and the respective templates all together make any sense as an answer. The third step is analysis of the obtained information and querying some external sources for new data to complete the answer. Finally, the system fills the answer template with the data and generates the answer text.

The prototype was tested with 191 email messages about printer-related problems. 122 messages were used for analysis, 69 messages for the test. 27.7% of the test messages were answered correctly, 13.3% were answered incorrectly. 38.7% of the

test messages were correctly redirected for manual processing, 20.3% were redirected incorrectly. In total, 66.4% of the responses were correct.

Probability that a word appears in a certain context is central for Al-Alwani [17]. The system answers emails that belong to a few text categories; each text category has one standard answer template that needs to be filled with details before the answer is sent to the user. The system has two dictionaries that are populated during the training phase. One dictionary contains words and the probability that a word appears in a message of a certain text category; it is used for message classification. The second dictionary is used for information extraction from query messages. It contains words and the probability that a word appears next to an item to be extracted from a query message, e.g., a product name, a meeting place and date.

Pre-processing of the messages starts with part-of-speech tagging and lemmatization. Negations are merged with their target words. For example, "didn't receive" becomes "not-receive", a new terms different from "receive". Considering negated words as new terms is not a common practice in automated email answering. After that prepositions, pronouns, interjections, and conjunctions are removed. The message becomes a bag-of-words. Synonymy of the remaining words is resolved. The query message is categorized using the first dictionary. When the system knows which answer template is to be filled and what items need to be extracted from the query message, the second dictionary is applied in order to locate the items in the query text. There is no external source of additional information for the answer. Information extraction and filling the answer template serves only the purpose of a more personalized answer.

Three text categories with 400, 200, and 400 messages were selected for the performance evaluation. Dividing the data into the training and test collections is not discussed. The precision/recall values were 80/69, 72/60, and 76/65 percent.

Yuval Marom and Ingrid Zukerman have worked with email answer generation where the answers are collated by reusing sentences from the previous human-written answers to similar messages. One of their earlier works [18] explains the foundation of the approach. Answers to recurring email inquiries to a contact center consist of two parts – generic information common for a number of similar inquiries and details specific to the particular inquiry. Marom and Zukerman applied multi-document summarization techniques in order to create the generic portion of the email answer.

The process is following. Similar archived responses are clustered so that one model response can be generated. The model response is built by collating the most representative sentences from the cluster responses. The quality of the model response depends on the semantic compactness of the cluster. The more similar the cluster responses are, the more accurate and representative the model response is.

The domain of the email corpus was helpdesk at Hewlett Packard. The corpus was 8000 message-response pairs clustered into topic-related datasets with 300-1500 pairs in each dataset. The quality of a model response was assessed by comparing it with each original response in the cluster. Precision and recall were measured for each comparison, then the average was calculated. Precision gave the proportion of the words in the model response that matched those in the original response; recall gave the proportion of the words in the actual response that were included in the model response. Generally, the achieved precision was above 50%, recall below 50%.

5 Text-Pattern Matching for FAQ Retrieval

Text-pattern matching is another minority approach. Sneiders [19] has developed a technique that operates a set of manually crafted text patterns assigned to FAQs. A text pattern resembles a regular expression. It contains stems of words and their synonyms. It can match phrases and stand-alone words, also compound words. Each FAQ has one or several required text patterns (they have to match a query) and one or several forbidden text patterns (they must not match the query). Experiments in two languages (Swedish and Latvian) and two domains (insurance and telecom) showed consistent results: if the system did retrieve an answer, the answer was correct in about 90% of the cases. The recall values were 68% and 76% in the respective language and domain.

A test of the same technique with almost 10 thousand emails in the domain of Swedish social welfare [20] showed comparable results. Five FAQs formed five text categories with 2517 messages. Email categorization with text-pattern matching reached precision around 90% and recall values 59, 65, 76, 44, and 59 percent per category. The baseline SVM and single-term bag-of-words reached precision/recall values 69/69, 69/86, 73/89, 70/58, and 63/80 for the same five text categories.

6 Task Related Email Categorization

Sneiders at al. [20] argue that a good email answering technique has to identify the context of the inquiry and the request stated in the inquiry; topical text similarity is not enough. The request designates the purpose of the inquiry. Although resolving the purpose of an email message is not automated email answering, it is a closely related research area.

There exists research that applies speech-act theory in order to categorize workplace email messages according to the purpose of the message, not the topic. Khosravi and Wilks [21] analyzed 1000 email messages and developed a text-pattern matching system that tagged sentences in messages with 10 nuanced request labels, where requests for action, information, and permission were expressed directly or implicitly in statements and questions. Corston-Oliver et al. [22] had an ambition to create a system that would analyze an email message and add action items to the receiver's to-do-list. Sentences in a message were labeled "salutation", "social chit-chat", "task", "proposal to meet", "promise", "farewell", and various components of email signature. Best candidates for action items were "task", "proposal to meet", and "promise".

Cohen et al. [23] tagged entire messages, not individual sentences, according to the intent of the sender. The intent was identified with help of a small ontology of email acts, where the main actions were "request", "propose", "amend", "commit", "deliver", and the subjects of these actions were "information", "meeting", "data", etc. Goldstein and Sabin [24] took a broader look at email tasks and defined 12 email genres by task, including not only the familiar directives, commitments, requests for information, but also expression of feelings, document forwarding, ads and spam, etc.

Lampert et al. [25] added details to the analysis of requests and commitments in workplace email. Requests and commitments may be conditional or unconditional, explicit or implicit. An example of implicit request is "Can you send me the curves and trades for Jan 18?" Although the request appears as a yes/no question, the receiver is expected to act upon it, not to answer it. Neither do we answer rhetorical questions or pleasantries – polite social utterances like "How are you?" Requests and commitments may be made on behalf of the writer or a third person. Clarifying these details proved crucial for improving agreement between human annotators who labeled utterances containing requests and commitments. Lampert et al. [26] pinpoints the difficulties in identifying requests and commitments, where the most prominent one is locus ambiguity: while human annotators tend to agree that the message contains a request or commitment, they may not agree on exactly which utterances contain them.

7 Highlights of the Approaches

We have selected a few features of email answering, features that we find important, in order to highlight the strengths and weaknesses of the automated email answering approaches. Table 1 shows the features and how well they are served by each automated email answering approach. Answer generation is included as the feature "correctness of custom answers".

Table 1. Features of the email answering approaches.

	Machine learning text categorization	Statistical text similarity	Text patterns, templates
Correctness of fixed answers	Medium	Medium	Good
Correctness of custom answers	N/A	Medium	Medium
Database data in the answer	No	No	Yes
Nuances in the query text	Poor	Poor	Good
Diversity of answers	Large	Unlimited	Small
Domain dependency	Medium	Little	Significant
Same domain, new language	Easy to medium	Easy	Difficult

When people send an email they expect first of all a *correct answer*. Unfortunately, most email answering techniques, except text-pattern matching, reach the level of answer correctness suitable mostly for internal use by contact center agents.

Ability to deliver *custom answers* is limited. Only a few systems have been developed, their performance is mediocre, or the tests are not convincing.

Inclusion of *database data* into the answers is very limited – only Kosseim et al. [16] have customized the answers by data from a knowledge base. The line of development by Sneiders [27]→[19] may have a potential: templates for question answering from a structured database could be applied in email answering, but it has not been tested.

The bag-of-words document representation, which is typical for statistical text similarity calculations with and without machine learning, has a limited ability to

distinguish nuances in the query text. Text patterns are better for matching nuanced pieces of text.

With a sufficient amount of training data we can train the system to categorize email into any number of text categories linked to a large *variety of answers*. The difficulty is manual labelling of the training data, unless this data is readily available. Statistical text similarity can be calculated for any two pieces of text. Text patterns and templates can cope with only a small number of answers, therefore they are best used for retrieval of the most popular FAQs.

Statistical text similarity calculations with and without machine learning have limited *domain dependency*, unless domain specific ontological and linguistic knowledge is developed to enhance the system's performance. For machine learning, new training data has to be labeled. As for text patterns and templates – they have to be developed from scratch.

This applies also to *language dependency*.

Most researchers in automated email answering calculate topic-related text similarity based on presence of individual domain specific words in both texts. This most often yields mediocre precision. Sneiders et al. [20] argue that good automated email answering requires a combination of *topic- and task-related* email categorizations (see Section 6) which considers also the purpose of the message.

References

1. Radicati, S.: Email Statistics Report, 2014-2018. Radicati Group, April (2014)
2. Suneson, B.: E-post är dyrare men ger kunden bättre svar. Svenska Dagbladet (April 4, 2005). In Swedish.
3. Tang, G., Pei, J., Luk, W. S.: Email mining: tasks, common techniques, and tools. Knowledge and Information Systems, 41(1), pp. 1-31 (2014)
4. Andrenucci, A., Sneiders, E.: Automated Question Answering: Review of the Main Approaches. In: Proc. 3rd International Conference on Information Technology and Applications (ICITA). IEEE, Vol. 2, pp.514-519 (2005)
5. Busemann, S., Schmeier, S., Arens, R. G.: Message classification in the call center. In: Proc. Sixth Conference on Applied Natural Language Processing, pp. 158-165. ACL (2000)
6. Scheffer, T.: Email answering assistance by semi-supervised text classification. Intelligent Data Analysis, vol. 8, no. 5, pp. 481-493. IOS Press (2004)
7. Bickel, S., Scheffer, T.: Learning from message pairs for automatic email answering. Machine Learning: ECML 2004. Springer Berlin Heidelberg, pp. 87-98 (2004)
8. Lapalme, G., Kosseim, L.: Mercure: Towards an automatic e-mail follow-up system. IEEE Computational Intelligence Bulletin, vol. 2, no. 1, pp. 14-18 (2003)
9. Yang, W., Kwok, L. Improving the automatic email responding system for computer manufacturers via machine learning. In: Proc. Information Management, Innovation Management and Industrial Engineering (ICIII), Vol. 3. IEEE (2012)
10. Hewlett, W.R., Freed, M.: An Email Assistant that Learns to Suggest Reusable Replies. In: Papers from the 2008 AAAI Workshop, Technical Report WS-08-04, pp. 28-35 (2008)
11. Itakura, K., Kenmotsu, M., Oka, H., Akiyoshi, M.: An Identification Method of Inquiry E-mails to the Matching FAQ for Automatic Question Answering. Distributed Computing and Artificial Intelligence, pp. 213-219. Springer Berlin Heidelberg (2010)

12. Alberts, I., Forest, D.: Email pragmatics and automatic classification: A study in the organizational context. Journal of the American Society for Information Science and Technology 63, no. 5, pp. 904-922 (2012)
13. Malik, R., Subramaniam, V., Kaushik, S.: Automatically Selecting Answer Templates to Respond to Customer Emails. In: Proc. IJCAI, Vol. 7, pp. 1659-1664 (2007)
14. Alfalahi, A., Eriksson, G., Sneiders, E.: Shadow Answers as an Intermediary in Email Answer Retrieval. In: Experimental IR Meets Multilinguality, Multimodality, and Interaction, pp. 209-214. Springer International Publishing (2015)
15. Weng, S.S., Liu, C.K.: Using text classification and multiple concepts to answer e-mails. Expert Systems with applications 26, no. 4, pp. 529-543 (2004)
16. Kosseim, L., Beauregard, S., Lapalme, G.: Using information extraction and natural language generation to answer e-mail. Data & Knowledge Engineering, vol. 38, pp. 85-100 (2001)
17. Al-Alwani, A.: Improving Email Response in an Email Management System Using Natural Language Processing Based Probabilistic Methods. Journal of Computer Science 11, no. 1, pp. 109-119 (2015)
18. Marom, Y., Zukerman, I.: Towards a Framework for Collating Help-desk Responses from Multiple Documents. In: Proc. IJCAI Workshop on Knowledge and Reasoning for Answering Questions, Edinburgh, Scotland, pp. 32–39 (2005)
19. Sneiders, E.: Automated Email Answering by Text Pattern Matching. In: H. Loftsson, E. Rögnvaldsson, S. Helgadóttir (eds.): Proc. 7th International Conference on Natural Language Processing (IceTAL), LNAI 6233, pp. 381-392. Springer, Heidelberg (2010)
20. Sneiders, E., Sjöbergh, J., Alfalahi, A.: Email Answering by Matching Question and Context-Specific Text Patterns: Performance and Error Analysis. In: Proc. WorldCist'16, Recife, Brazil, March 22-24. Springer International Publishing (2016)
21. Khosravi, H., Wilks, Y.: Routing email automatically by purpose not topic. Natural Language Engineering, 5, pp. 237-250 (1999)
22. Corston-Oliver, S., Ringger, E., Gamon, M., Campbell, R.: Task-focused summarization of email. In: Proc. ACL-04 Workshop: Text Summarization Branches Out, pp. 43-50 (2004)
23. Cohen, W.W., Carvalho, V.R., Mitchell, T.M.: Learning to Classify Email into “Speech Acts”. In: Proc. EMNLP, pp. 309-316 (2004)
24. Goldstein, J., Sabin, R.E.: Using speech acts to categorize email and identify email genres. In: Proc. 39th Annual Hawaii International Conference on System Sciences, vol. 3. IEEE (2006)
25. Lampert, A., Dale, R., Paris, C.: The nature of requests and commitments in email messages. In: Proc. of the AAAI Workshop on Enhanced Messaging, pp. 42-47 (2008)
26. Lampert, A., Dale, R., Paris, C.: Requests and Commitments in Email are More Complex Than You Think: Eight Reasons to be Cautious. In: Proc. Australasian Language Technology Association Workshop, vol. 6, pp. 64-72 (2008)
27. Sneiders, E.: Automated Question Answering Using Question Templates that Cover the Conceptual Model of the Database. In: Natural Language Processing and Information Systems. Proc. NLDB'2002. Springer LNCS series 2553, pp. 235-239 (2002)

Towards Semantic Fusion using Information Quality Awareness to Support Emergency Situation Assessment

Valdir Amancio Pereira Junior[1] , Mathues Ferraroni Sanches[1], Leonardo Castro Botega[1], Caio Saraiva Coneglian[2]

[1] Computing and Information Systems Lab (COMPSI), Marília Eurípides University (UNIVEM), Marília, São Paulo, Brazil
{valdir.a.junior, matheussanches531, leobotega}@gmail.com
[2] Information Science Department, State University of São Paulo, Marília, São Paulo, Brazil
{caio.coneglian}@gmail.com

Abstract. Information Fusion is the integration of synergic information to support high-level decision-making. Emergency management systems are applications that may take advantage of such integration by supporting system's operators on developing situation awareness (SAW) and dealing with the critical and dynamic nature of real emergency scenarios. Semantic models help to describe and to determine synergy among entities that may be useful for fusion and situation assessment routines (SA). In this context, the awareness of information quality issues can enrich even more the knowledge that humans and system hold about situations. The objective of this paper is to present advances towards a new semantic fusion approach supported by information quality inferences and semantic web concepts to improve the assessments about emergency situations and hence supporting situation awareness. A previous fusion approach based on a syntactic integration with quality indexes is used to illustrate the improvements on information fusion results with the semantic models.

Keywords: Semantic Fusion, Information Fusion, Situation Awareness, Situation Assessment, Emergency Management Systems, Information Quality.

1 Introduction

Emergency events require building effective operational responses. Frequently, unexpected incidents arise and demand time-critical decisions from a specialist of the state police, security managers or governmental members. Such decisions involve the deployment of new tactics and the allocation of human resources and equipment.

The assessment systems of emergency events are highly complex due the need of comprehension by specialists about what is going on at the event location. Such comprehension is supported by Data Fusion systems, fed by multiple sources (hard sensors, social networks, databases, etc.) offer a more precise notion more consistent about what is happening in an environment [1].

Devices and innovative fusion algorithms are being used for better supporting the assessment process for situation awareness for decision-making. Such assessment

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_14

systems may have to be used even under informational adverse conditions of low quality information, leading to humans uncertainty and poor decisions. Information quality, data mining and classification algorithms are aspects of extreme relevance in this process and present several challenges regarding the determination of synergic information and the definition of fusion criteria [1, 2] and consequently new relations among information.

In the literature, different solutions have been proposed and implemented, resulting in data and information with several quality issues. As a result of this technological development. e.g., proliferation of diverse algorithms and platforms, such as Nearest Neighbors, Probabilistic Data Association, Kalman Filter and Semantic Methods extends systems abilities to develop a more precise, complete, consistent and timely information in a minor dimensionality. In a wider view, information fusion aims to provide a richer knowledge to promote the acquisition, maintenance and resumption of situation awareness of specialists in a variety of contexts [3].

However, as far as the authors investigated, there are few studies that deal more specifically with semantic information as input and the construction of an incremental knowledge for the identification of new entities and relations among them.

Intelligent systems to support specialists in critical situations (that could compromise lives and patrimony) can benefit from the diversity of available criteria (including quality) for exhaustive fusion to improve the evaluation of critical situations, reducing imperfections of information and present a reliable selection of integrated possibilities.

To overcome some of these challenges, the contributions of this paper are: The specification and application of a multi-criteria fusion algorithm, which includes information quality indexes for its parameterization. Also, semantic elements are systematically included in such information fusion approach, also aware of information quality, indicate the first steps to reveal new objects, attributes and relations among them by meaning, through ontology properties, which will be able to define the context and link the various elements contained in the fusion process. Then, such approaches are submitted through a case study and the results are analyzed by the optics of syntactic and semantics means.

The paper is organized as follows: Section 2 describes the applicability of Situation Awareness in the Emergency Management Domain and Section 3 presents the Process for Semantic Fusion with Information Quality Awareness, followed by a Case Study and Conclusions.

2 Situation Awareness in the Emergency Management Domain

SAW is the ability of understanding and project a real monitored environment, in this case by an operator of the emergency system, who based on the SAW developed during the observation of the support system, will make a decision.

According to Kokar and Endsley, SAW is being aware of what is happening around you and understanding what that information means to you now and in the future [1]. In the emergency field, on a particular situation, SAW is developed by means of an enormous range of information collected from various sources, and for

the most part, in real time. With this huge amount of information to be observed by the operator, the development of SAW is difficult and complex.

SAW-oriented systems, such as applications of Emergency Management, also rely on information quality to provide specialists an insightful view of a scenario for making quality decisions [4]. A suitable SAW-oriented fusion should determine which information can be synergically integrated into the situation at hand, perform an accurately search for the input information and also be committed to deliver an information that is conformable with the specialist's SAW needs and expectations [5].

Data fusion systems are able to deliver the needed processing to provide information for SAW purpose, however, they still require human interpretation of the results to give meaning and relevance for information. Supported by a semantic approach, opportunities referring to the improvement of fusion criteria became imminent given the need for knowledge about data and produced information, strengthening possibilities of effective contributions to the data fusion process [6]. However, such systems can propagate imperfection due to data acquisition failure, processing or even in the representation of the produced information, making user uncertain about what s/he perceives and understands.

To overcome such an issue, innovative fusion techniques must be present in the assessment system to provide a truly knowledge representation about situations. Also, quality issues must be always known in order to build a better SAW [7]. In a decision making complex environment, commanders need a clear, concise and accurate assessment of the current situation, what may be degraded by an uncertainty about where the assets are located, what their capabilities are, the nature of their intentions and if there is any kind of risk to people or patrimony. One technology that may help to support the new requirements of data and information integration is the Semantic Web.

Thus, the present paper proposes a multi-criteria fusion process, which supports both approaches (syntactic and semantic), as part of an emergency assessment system. In such a process, the reader can identify, besides data integration, information acquisition, quality assessment and knowledge representation modules, able to merge and link information previously considered unrelated or irrelevant to the situation.

3 The Process for Semantic Fusion with Information Quality Awareness

In order to fulfill the objectives proposed in this paper, it is proposed a process that specifies the information management for the assessment and acquisition of SAW, guided by the requirements and needs of decision-makers of São Paulo State Police (PMESP), in managing criminal situations.

This process can be abstracted into four main sub-processes. The fusion one (highlighted in Light Gray in Fig. 1) is composed by: Information Integration Requirements for determining the rules and needs for information integration, Multi-Criteria Data Fusion responsible for associating the synergic information and the Synergic Information Mining, which is responsible for performing the search for synergic information and bring this to the current process.

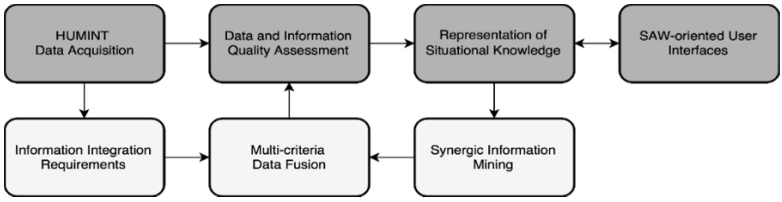


Fig. 1. Process for Semantic Fusion with Information Quality Awareness.

The first step of the fusion process described here is the capture of a natural speech, in this case a crime report made to emergency answering services.

The report is then transcribed into words that is analyzed to find elements defined as important by the requirements elucidation. Then, the identified objects are encapsulated in a JSON object.

This JSON characterizes the main objects, their attributes and basic relationships between them, such as which attributes belong to each object, then these objects are subjected to quality calculations to assess their initial quality scores.

The quality indexes are applied in a local and global contexts and recalculated every time an information is transformed (updated) or inferred by assessment routines, such as the information fusion [8]. The product of this phase is then a collection of objects that may or may not be related in some dimension.

Such collection of objects corresponds information of Level L1 of fusion, according to the JDL (Joint Directors of Laboratories) and other taxonomies [2], along with quality scores assigned to each object and attribute, according to the methodology for information quality assessment [8].

3.1 Performing the First steps of a Semantic Information Fusion using Quality Assessments

From the identified objects and attributes included in a the JSON object, a preliminary ontology is instantiated with the classes of *victim*, *criminal*, *robbed object* and the location/place, considered the fundamental objects to define a robbery situation, each with their respective attributes and relationship properties, representing the initial semantic meanings of the information, as shown in Fig. 2.

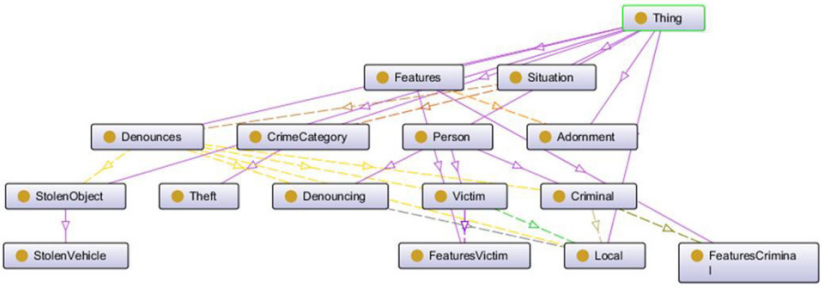


Fig. 2. Ontology of an Emergency Situation.

With the instantiated ontology, the information set is once more transformed into a JSON object, now with the semantic meaning between objects and attributes. This semantic information is related by means of their present properties.

This JSON object is now the input of the fusion process. In addition, there will be other input parameters and criteria sets provided by the human operator, defined at runtime at the user interface, such as: which objects to specifically associate, which external sources to use, which properties must exist and a new threshold of minimum quality of the information, for example: "criminal: {"completeness": 45, "clothes":{"red shirt", "black pants"}}".

Once the fusion process is started, there is the synergy search among classes already present in the ontology, taking into account the objects, attributes, data properties, quality scores and their properties set into the semantic model.

After the synergy search among the information already stored in the ontology, a search on other sources of data is started in order to obtain new information about the associated objects, aiming to validate and build greater consistency to the already set information. Considering that the input of this process is isolated information or information already associated among objects, the output of this process is a L2 fusion information, ie information with a certain level of relationship.

This process will be carried out by an algorithm based on data mining techniques, using the Apriori technique, which infers the frequency of certain information when analyzed in relation to the rest of an environment (information of the situation and requested sources). This inference is made from a proposed calculation of the information support, according to Fig. 3, as follows:

```
foreach(resultSinergicSearch as oneResult){
  if(isArray(oneResult)){
    for(var iT = 0; iT < count(oneResult);iT++) fP = oneResult[it]/count(oneResult)
    oneResult[iT+1] = fP;}
  else{
  fP = oneResult/count(resultSearch);
  resultSearch[fT]+=fP;}}
```

Fig. 3. Part of the core of data mining algorithm.

For the process herein proposed, it is used the principles of data mining in databases, but some changes will be made in order to analyze the frequency of such information by a single ontology knot or a proposed parameter, that is, it searches for the covariance between the data.

The result of this process is obtained through the initial information plus the new information with their respective attributes, quality scores, properties and the relationship score among such information.

This result is validated in the next step (multi-criteria association), which deals with the association between the information submitted to the fusion process and the synergistic information found. This association meets certain pre-defined criteria such as quality scores and pre-defined properties as satisfactory for each association or type of information. The following process inserts the new information found within the context of the original information submitted to the process, in order to achieve and meet the multi-criteria defined in the previous process.

Multi-criteria fusion generally obeys two requirement sources: an input of a human expert entry/interaction during system operation or based on well-defined criteria established during requirement elucidation conducted during project phase.

As a result, every initial information submitted to the fusion process is generated, however, with new attributes, properties and even new objects found during the fusion process, thus making results explicitly L2 level (Situation Assessment).

This result can be submitted again to the previous process of synergy search, increasing its capability to find new information and consolidate the information already available. In this manner, information increasingly specializes in the current situation, or in a single part of the situation, depending on the input. This cycle is performed when the result of the Multi-criteria Association, objects, attributes, indexes of quality and properties are not within the parameters required, defined by human input or delimited by the system.

If this second process is not carried out, the resulting information will be submitted to the quality assessment process, now scoring the new information found and reconsidering the general scores of information. After this process, the information re-evaluated by the quality assessment is re-instantiated in the ontology and represented in the system, according to the request of the operator.

In the primary fusion phase, in the automated process performed immediately after the acquisition and evaluation of the quality of information, it is made the most associations possible between objects, their attributes, properties and their rates of pre-determined quality and quality thresholds, considering the existence of two or more data sets available from the same source or from different sources.

The primary fusion meets informational requirements that are, the criteria of priorities defined the analysis of requirements, such as minimum levels of quality and main properties between information, which is useful to define what should be built first and consequently shown to the human expert. These informational requirements are based on an analysis questionnaire applied to several police officers of different positions, functions, and career time, thus ensuring a heterogeneous view of the subject, and also managing to validate the most important criteria to a given situation.

In the case of the fusion on the demand of the operator, the algorithm is activated once again, but the criteria for integration are entirely selected by the operator via

interface, instead of all possible combinations of automatic objects, attributes and properties identified in the acquisition phase.

This association process, now manual, is operated via interface by the expert, and besides being based on objects and attributes, these associations is strongly supported in related quality scores, and suggest hypotheses about information relating to previously identified objects with other objects identified by other sources related to the real environment.

Since this input process is performed by the operator via interface, the criteria for the data fusion process can be chosen and changed by the same operator, who is able to add new features, as well as removing criteria pre-defined by the requirement analysis. This capability demonstrates the flexibility of the framework to receive and process different criteria for a given situation, and allows the agents to better interact with the system based on their experiences and knowledge, thus ensuring a process of construction and development of SAW very close to the real environment.

4 Case Study

To analyze the processing of the algorithms described in the previous section, semantic fusion techniques were adopted and a simulation was performed with an actual case using reports transcribed of the same crime, reported service 911 to PMESP. Such reports were submitted to the process of Fig. 1 and the results were compared with and without the use of the semantic approach.

With the first report no information fusion occurs, considering that its information is unique and there are no parameters for an integration. Hence, objects and classes are just listed, found on the possible occurrence and created as the first Situation.

Report 1: "**a crime has just happened** here on **domingos setti**. A driver was threatened and ordered to leave the vehicle without taking anything. **The robber fled toward the subway klabin**";

As there is no other occurrence or report in the database, only the objects present in the report, marked in bold, were identified, such as time, place, criminal, data about how the escape occurred and the new calculated quality scores. This process will have the same result, regardless of fusion as it is done through the process of acquisition and classification of incoming information, best explained in section 3 of this paper.

At the following moment, a fusion between the Situation 1 and a new report occurs, considering the moment a second report reaches the system. Such report goes through the process of acquisition and classification of the information normally. By this moment, the differences between the syntactically fused information and the semantic information fusion arise.

Report 2: "**a guy was robbed** in front of me by **someone armed.** It happened so fast and was in **domingos setti near the restaurant don paladino. The thief had a gun was tall and had tattoos on his arms.** He hit **the man and he looks very hurt"**

In the second report, we have more information on the occurrence, such as: the victim, the place and the criminal.

Again without the use of semantics, a fusion of the situation already instantiated in the system, with the new report 2, occurs, generating the Situation 1:

Situation 1: "**just happened** a crime here on **domingos setti** a driver was threatened and ordered him to leave the vehicle without taking anything **the robber fled toward the subway klabin**";

In this situation already instantiated, we find the following objects: time, place, stolen object and criminal. The fusion examines the objects that are already instantiated in the situation and their quality scores, places of each object and the overall situation. Thus, there is a Boolean and syntactic analysis and parsing operation between objects of Situation 1, with data from the new report, validating which are present and if the information has some level of similarity, considering minor syntactic variations, also with the quality indexes, validating if both are sufficient and will contribute to better quality of general information.

Depending on the result, new possible situations are generated, filled with the information present in both previous objects. The quality indexes are not yet updated, but only kept together with the information for future usage as calculation parameter.
In this example, the only objects with some similarity are those regarding the location information, "domingos setti", this result is obtained by a syntactic analysis. As the result from this information, we have the update of the criminal information, the update of the location information and the addition of a victim object. The result is shown in Fig. 4.


```
"criminal":{
      "sex":"male",
      "status":"fleeing",
      "escapeTo":"Klabin subway",
      "height": "tall",
      "weapon":{"armed", "pistol"},
      "tattoo": {"arms"},
      "completeness":42.85,
   },
   "object":{
      "completeness":9.09,
   },
"victim":{
   "sex":"male",
   "condtion":"bruised",
   "wordReference":{"a guy", "man"}
   "completeness":42.85,
},
"place":{
   "street":"domingos setti",
   "reference":"restaurant don paladino ",
   "gps":{"-22.2208"," -49.9486"},
   "completeness":41.66,
}
```


Fig. 4. Objects after syntactic fusion with quality score.

After this fusions process, the quality indexes are not updated. This resulting situation is resubmitted to the quality assessment process, which will re-evaluate the quality scores considering the new information presented.

This was the syntactic fusion process information using quality indices which presents the information and the situation as a general and generic context.

The fusion between the first situation, as instantiated in the system, with the new report received, which has passed through the process of acquisition, classification and evaluation of information quality, will again be performed using ontologies techniques to improve the results of the process, making the semantic fusion of information.

At this point the synergistic search process and association between the information not only occurs in a Boolean form, evaluating the presence information, and syntax, considering word constructs, with minor variations and quality scores assigned to information and the complete situation. The semantic process considers the meaning of the word that regards an information and not only its structure.

Considering the synergistic search algorithm and applying the techniques of semantic proposals, it is possible to have a wider search and more possibility of synergy points between the existing situation and new reports obtained.

At this stage, using semantics we may obtain a bigger and better synergistic amount of information between the situation and the new objects.

This synergy, in this case, also gives the location because it matches the exact description of it ("domingos setti") but looking at the two reports, it is clear that they refer to the criminal as "the robber" while other treats they as "a thief" and "someone armed".

In the conventional synergistic search process, these data were not related. They have a very distinct syntax, however, the terms have the same meaning, which is the criminal of this situation. The synergistic information is highlighted.

Report 1: "a crime has just happened here on **domingos setti**. A driver was threatened and ordered to leave the vehicle without taking anything. **The robber** fled toward the subway klabin";

Report 2: "a guy was robbed in front of me by **someone armed.** It happened so fast and was in **domingos setti** near the restaurant don paladino. **The thief** had a gun was tall and had tattoos on his arms. He hit the man and he looks very hurt ".

This process is possible because the ontology proposal already has a basic knowledge, listing the main and most common terms, such as thief, bandit, criminal and other variations of these words, which express the same meaning when fusing the analyzes, generating a situation with much more complete and accurate information (Fig. 5).


```
"criminal":{
    "sex":"male",
    "status":" fleeing",
    "escapeTo":"Klabin subway",
    "height": "tall",
    "weapon":["armed", "pistol"],
    "tattoo":["arms"],
    "wordReference":["the thug", "the thied", "armed someone"],
    "completeness":42.85,
  },
  "object":{
    "completeness":9.09,
  },
```

```
  "victim":{
    "sex":"male",
    "status":"hurt",
    "condtion":"bruised",
    "wordReference":["a guy","man"],
    "completeness":42.85,
},
"place":{
    "street":"domingos setti",
    "reference":"restaurant don paladino ",
    "number":null,
    "gps":["-22.2208"," -49.9486"],
    "completeness":41.66,
  }
```


Fig. 5. Objects after semantic fusion with quality score.

In Fig. 5, the information highlighted was considered synergistic semantic information during the fusing process. This demonstrates the algorithm's ability to interpret contexts and situations, which expands the search and integration of data using semantics. Current inferred information feeds the knowledge about situations (aka situational knowledge) represented by the ontology, which is updated every cycle and reused to perform new inferences.

Before this resulting information is presented to the operator, it can be once more submitted to the fusing process in case they are not within the related criteria or submitted to the quality assessment, which will re-evaluate the quality scores based on new information found. After the quality re-assessment, this information will be

set in a new ontology that represents the current situational knowledge and then it will be presented to the operator via interface.

5 Conclusions

This paper presented an approach for including semantics into the fusion process by feeding the inference routines with the awareness of information quality and using their indexes as part of the multi-criteria fusion algorithms. Such approach was presented initial steps of a new solution that process may be coupled into situation assessment systems for specialists to reason about information of lower dimensionality and better quality.

For such, this work also presented methods for information fusion, natural language processing, information quality assessment and knowledge representation to be employed in such process.

The application of the process and associated methods generated valid results regarding the obtaining of expected information useful for developing SAW, according to the requirements defined by the domain specialists. Such information was successful incrementally built using syntactical and semantical input. The use of multi-criteria information fusion empowered the assessment of situations by generating several integration possibilities of synergic information for the analysis of a specialist. Also, the specialist has the possibility to define the criteria (through user interfaces) and the information quality threshold for the parameterization of the fusion algorithm.

Subsequently, the comparisons made between the simple data fusion with the semantic information fusion show that new components, such as Semantic Web technologies, can bring improvements to the processes, making more efficient the discovery of information. This comparison makes explicit the need to insert mechanisms that bring greater intelligence to processes dealing with fusion and SAW.

Finally, with the establishment of new relations empowered by semantics and information quality, authors stated that the situation awareness of decision-makers may be improved once uncertainty about situations and their assets can be mitigated.

As future work, the authors intend to expand and optimize the techniques of acquisition and natural speech processing, as well as methods that make fusion engine, expanding the ability to search and synergistic association data. Also, study and improve the data-mining algorithm from semantic data, as well as the power of its association of multiple criteria, increasing the power to process different inputs, given the multitude of criteria, linguistic or quantitative.

References

1. Kokar, M. M., Endsley, M. R.: Situation Awareness and Cognitive Modeling. In: IEEE Intelligent Systems, vol. 27, no. 3, pp. 91–96, May. (2012)
2. Llinas, J., Bowman, C., Rogova, G., Steinberg, A.: - Revisiting the JDL data fusion model II. In: 7th International Conference on Information Fusion (2004)

3. White Jr, F. E.: Data Fusion Lexicon. In: Technical Panel for C3, Data Fusion Sub-Panel. Naval Ocean Systems Center, San Diego: Joint Directors of Laboratories (1987)
4. Rogova, G., Bosse, E.: Information quality in information fusion. In: 13th Information Fusion (2010)
5. Batini, C., Cappiello, C., Francalanci, C., Maurino, A.: Methodologies for data quality assessment and improvement. In: ACM Computing Surveys, vol. 41, no. 3, pp. 1–52, Jul. (2009)
6. Blasch, E.: High Level Information Fusion (HLIF): Survey of models, issues, and grand challenges. In: IEEE A&E Systems magazine, pp. 4–20 (2012)
7. Laskey, K. Ng, G., Nagi, R.: Issues of Uncertainty Analysis in High Level Information Fusion. In: Fusion2012 Panel Discussion (2012)
8. Souza, J. Botega, L., Santarém Segundo, J.E., Berti, C.: Conceptual Framework to Enrich Situation Awareness of Emergency Dispatchers. In: 17th International Conference on Human-Computer Interaction, Los Angeles. Lecture Notes in Computer Science (LNCS), (2015)

Antiphospholipid Syndrome Risk Evaluation

João Vilhena[1], Henrique Vicente[2], M. Rosário Martins[3], José M. Grañeda[4], Filomena Caldeira[4], Rodrigo Gusmão[4], João Neves[5] and José Neves[6*]

[1] Departamento de Química, Escola de Ciências e Tecnologia, Universidade de Évora, Évora, Portugal
jmvilhena@gmail.com
[2] Departamento de Química, Centro de Química de Évora, Escola de Ciências e Tecnologia, Universidade de Évora, Évora, Portugal
hvicente@uevora.pt
[3] Departamento de Química, Instituto de Ciências Agrárias e Ambientais Mediterrânicas, Escola de Ciências e Tecnologia, Universidade de Évora, Évora, Portugal
mrm@uevora.pt
[4] Serviço de Patologia Clínica do Hospital do Espírito Santo de Évora EPE, Évora, Portugal
graneda1@sapo.pt, filomenacaldeira1@gmail.com, dir.patcli@hevora.min-saude.pt
[5] Drs. Nicolas & Asp, Dubai, United Arab Emirates
joaocpneves@gmail.com
[6] Centro Algorithmi, Universidade do Minho, Braga, Portugal
jneves@di.uminho.pt
* Corresponding author: phone: +351-934201337; fax: +351-253604471
e-mail: jneves@di.uminho.pt

Abstract. The antiphospholipid syndrome is an acquired autoimmune disorder produced by high titers of antiphospholipid antibodies that cause both arterial and veins thrombosis as well as pregnancy-related complications and morbidity, as clinical manifestations. This autoimmune hypercoagulable state, often associated with coronary artery disease and recurrent Acute Myocardium Infraction, has severe consequences for the patients, being one of the main causes of thrombotic disorders and death. Therefore, it is extremely important to be preventive; being aware of how probable is to have that kind of syndrome. Despite the updated of the APS classification published as Sydney criteria, diagnosis of this syndrome remains challenging. Further research on clinically relevant antibodies and standardization of their quantification are required to improve clinical risk assessment in APS. This work will focus on the development of a diagnosis support system to antiphospholipid syndrome, built under a formal framework based on Logic Programming, in terms of its knowledge representation and reasoning procedures, complemented with an approach to computing grounded on Artificial Neural Networks.
The proposed model allowed to improve the diagnosis, classifying properly the patients that really presented this pathology (sensitivity about 92%) as well as classifying the absence of APS (specificity ranging from 89% to 94%).

Keywords: Antiphospholipid Syndrome · Logic Programming · Artificial Neural Networks · Knowledge Representation and Reasoning.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_15

1 Introduction

The AntiPhospholipid Syndrome (APS) is an acquired autoimmune disorder defined by the presence of persistently increased titers of antiPhosphoLipid antibodies (aPL), such as antiCardioLipin antibodies (aCL), Lupus Anticoagulant (LA) and anti-β2 GlycoProtein I (aβ_2GPI) in the presence of one of clinical criteria, such as thrombo-embolic complications and pregnancy morbidity [1]. The most frequent venous occlusions comprise deep vein thrombosis affecting the veins of the lower members [2], but small vessels might also be involved causing sporadically superficial thrombophlebitis [3]. Strokes, often preceded by transient ischemic attacks, are the most frequent arterial events in these patients [2]. Pregnancy morbidity in the APS includes recurrent fetal losses and premature births, frequently associated with thrombosis of the placental vessels and subsequent infarction resulting in placental insufficiency, fetal growth retardation, and ultimately fetal loss [2, 4]. Many diverse clinical manifestations due to vascular occlusions in the central nervous system, heart, lungs, liver, adrenal glands, kidneys, skin or eyes, may to be associated with the presence of antiphospholipid antibodies [5, 6]. Furthermore, this syndrome is often associated with incidence of coronary artery disease and recurrent Myocardium Infraction [5, 7].

According to the revised Sidney criteria, the classification of APS syndrome requires the combination of at least one clinical and one laboratory criteria (persistent LA, aCL or aβ2GPI) [5, 8]. In this classification, the risk stratification of APS patients was divided into four categories: I, more than one laboratory criteria present (any combination); while patients with a single positive test were classified in category II (IIa, if LA is a single positive test; IIb if aCL antibody is a single positive test or IIc, if anti-β2 glycoprotein-I antibody is present alone) [1, 7]. Patients carrying both aCL/anti-β2GPI antibody isotypes display a higher risk of developing clinical events, strongly associated with venous and arterial thrombosis [5, 7]. Triple positivity, defined by the presence of LA and medium/high titers of aCL and anti-β2GPI antibodies is the most predictive profile for the APS Syndrome [6, 7, 10]. An association of aCL and aβ2GPI antibodies in coronary artery disease and recurrent Myocardial Infarction has been reported in several studies [11].

Therefore, the early diagnosis of APS syndrome is crucial due to its high prevalence as an acquired thrombophilia, as well as to the high morbidity and mortality associated to these thrombotic events. This work reports the founding of a computational framework that uses knowledge representation and reasoning techniques to set the structure of the information and the associate inference mechanisms. We will centre on a Logic Programming (LP) based approach to knowledge representation and reasoning [12, 13], complemented with a computational framework based on Artificial Neural Networks (ANNs) [14, 15].

ANNs are computational tools which attempt to simulate the architecture and internal operational features of the human brain and nervous system. ANNs can be defined as a connected structure of basic computation units, called artificial neurons or nodes, with learning capabilities. Multilayered feed-forward neural network architecture is one of the most popular ANNs structure often used for prediction as well as for classification. This architecture is molded on three or more layers of

artificial neurons, including an input layer, an output layer and a number of hidden layers with a certain number of active neurons connected by modifiable weights. In addition, there is also a bias, which is only connected to neurons in the hidden and output layers. The number of nodes in the input layer sets the number of independent variables, and the number of nodes in output layer denotes the number of dependent variables [16]. Several studies have shown how ANNs could be successfully used to model data and capture complex relationships between inputs and outputs [15, 17, 18].

Solving problems related to APS requires a proactive strategy. However, the stated above shows that the APS assessment should be correlated with many variables and require a multidisciplinary approach. With this paper we make a start on the development of an APS risk assessment system using LP complemented with ANNs.

This paper is organized into five sections. In the former one an introduction to the problem presented is made. Then the proposed approach to knowledge representation and reasoning is introduced. In the third and fourth sections is introduced a case study and presented a solution to the problem. Finally, in the last section the most relevant conclusions are described and the possible directions for future work are outlined.

2 Knowledge Representation and Reasoning

Many approaches to knowledge representation and reasoning have been proposed using the Logic Programming (LP) epitome, namely in the area of Model Theory [22, 23], and Proof Theory [15, 16]. In present work it is followed the proof theoretical approach in terms of an extension to the LP language. An Extended Logic Program is a finite set of clauses, given in the form:

$$
\begin{aligned}
&\{\\
&\quad p \leftarrow p_1, \cdots, p_n, not\ q_1, \cdots, not\ q_m\\
&\quad ?\,(p_1, \cdots, p_n, not\ q_1, \cdots, not\ q_m)\ \ (n, m \geq 0)\\
&\quad exception_{p_1}\ \ \ldots\ \ exception_{p_j}\ \ (j \leq m, n)\\
&\}:: scoring_{value}
\end{aligned}
$$

where "*?*" is a domain atom denoting falsity, the p_i, q_j, and p are classical ground literals, i.e., either positive atoms or atoms preceded by the classical negation sign $\neg$ [11]. Under this formalism, every program is associated with a set of abducibles [19, 20], given here in the form of exceptions to the extensions of the predicates that make the program. The term $scoring_{value}$ stands for the relative weight of the extension of a specific *predicate* with respect to the extensions of the peers ones that make the inclusive or global program.

In order to evaluate the knowledge that stems from a logic program, an assessment of the *Quality-of-Information* (*QoI*), given by a truth-value in the interval [0, 1], that stems from the extensions of the predicates that make a program, inclusive in dynam-

ic environments, aiming at decision-making purposes, was set [21, 22]. Indeed, the objective is to build a quantification process of *QoI* and measure one's confidence (here represented as *DoC*, that stands for *Degree of Confidence*) that the argument values of a given predicate with relation to their domains fit into a given interval [23].

Therefore, the universe of discourse is engendered according to the information presented in the extensions of a given set of predicates, according to productions of the type:

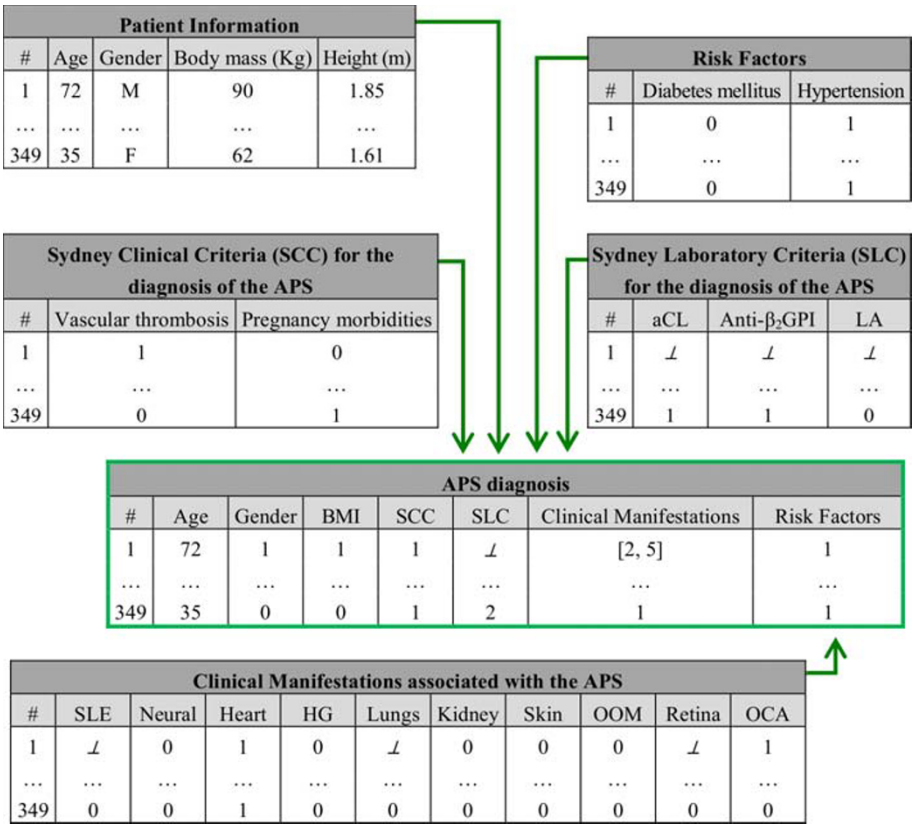
$$predicate_i - \bigcup_{1 \leq j \leq m} clause_j(x_1, \cdots, x_n) :: QoI_i :: DoC_i \quad (1)$$

where $\bigcup$ and *m* stand, respectively, for *set union* and the *cardinality* of the extension of $predicate_i$ [23].

3 A Case Study

As a case study consider the knowledge base given in terms of the extensions of the relations depicted in Fig. 1, which stand for a situation where one has to manage information about AntiPhospholipid Syndrome (APS). The knowledge base includes features obtained by both objective and subjective methods, i.e., the physicians may populate some issues while executing the health check. Others may be perceived by laboratorial tests (e.g., this happens with the issues of the *Sydney Laboratory Criteria* table). Under this scenario some incomplete and/or unknown data is also present. For instance, for patient 1 the parameters regarding the *Sydney Laboratory Criteria* (*SCC*) are unknown while the *Clinical Manifestations* ranges in the interval [2, 5].

The *Sydney Clinical Criteria*, *Clinical Manifestations* and *Risk Factors* tables are filled with 0 (zero) or 1 (one) denoting, respectively, *absence* or *presence*. The first two columns of the *Sydney Laboratory Criteria* (*SLC*) table are populated with 0 (zero), 1 (one) or two (2) denoting, respectively, *absence*, *medium-titer* or *high-titer* of aCL or Anti-β_2GPI antibody. The *LA* column, in turns, is populated with 0 (zero) or one (1) denoting, respectively, *absence* or *presence* of lupus anticoagulants. The values presented in the *SCC*, *SLC*, *Clinical Manifestations* and *Risk Factors* columns of *APS Diagnosis* table are the sum of the attributes values of the correspondent tables, ranging between [0, 2], [0, 5], [0, 10] and [0, 2] respectively. The domain of *Body Mass Index* (*BMI*) column is in the range [0, 2], wherein 0 (zero) denotes *BMI* < 25; 1 (one) stands for a *BMI* ranging in interval [25, 30[; and 2 (two) denotes a *BMI* ≥ 30. The *BMI* is evaluated using the equation $BMI = Body\ Mass/Height^2$ [24]. In the *Gender* column 0 (zero) and 1 (one) stand, respectively, for *female* (*F*) and *male* (*M*). In *Clinical Manifestations* table (Fig. 1) SLE, Neural, Heart, HG, Lungs, Kidney, Skin, OOM, Retina and OCA stand for Systemic Lupus Erythmatosus, neurologic, cardiovascular, hepatic and gastrointestinal, pulmonary, renal, skin, and other organ manifestations, retinal and other coagulation abnormalities, respectively.



Patient Information

#	Age	Gender	Body mass (Kg)	Height (m)
1	72	M	90	1.85
…	…	…	…	…
349	35	F	62	1.61

Risk Factors

#	Diabetes mellitus	Hypertension
1	0	1
…	…	…
349	0	1

Sydney Clinical Criteria (SCC) for the diagnosis of the APS

#	Vascular thrombosis	Pregnancy morbidities
1	1	0
…	…	…
349	0	1

Sydney Laboratory Criteria (SLC) for the diagnosis of the APS

#	aCL	Anti-β_2GPI	LA
1	⊿	⊿	⊿
…	…	…	…
349	1	1	0

APS diagnosis

#	Age	Gender	BMI	SCC	SLC	Clinical Manifestations	Risk Factors
1	72	1	1	1	⊿	[2, 5]	1
…	…	…	…	…	…	…	…
349	35	0	0	1	2	1	1

Clinical Manifestations associated with the APS

#	SLE	Neural	Heart	HG	Lungs	Kidney	Skin	OOM	Retina	OCA
1	⊿	0	1	0	⊿	0	0	0	⊿	1
…	…	…	…	…	…	…	…	…	…	…
349	0	0	1	0	0	0	0	0	0	0

Fig. 1. A fragment of the knowledge base for AntiPhospholipid Syndrome Risk Evaluation.

Applying the rewritten algorithm presented in [23], to all the fields that make the knowledge base for *APS diagnosis* (Fig. 1) and looking to the DoC_s values obtained in this manner, it is possible to set the arguments of the predicate referred to below, that also denotes the objective function with respect to the problem under analyze.

$$aps_{diagnosis}: Age\ ,\ Gen_{der}\ ,\ B_{ody}M_{ass}\ I_{ndex}\ ,\ \ S_{ydney}\ C_{linical}\ C_{riteria}\ ,$$

$$S_{ydney}\ L_{aboratory}\ C_{riteria}\ , C_{linical}\ M_{anifestations}\ ,\ R_{isk}\ F_{actors}\ \rightarrow\ \{0,1\}$$

where 0 (zero) and 1 (one) denote, respectively, the truth values *false* and *true*.

Exemplifying the application of the rewritten algorithm presented in [23], to a term (patient) that presents feature vector (*Age* = 69, *Gender* = 1, *BMI* = 1, *SCC* = 1, *SLC* = [2, 4], *CM* = [3, 5], *RF* = ⊿), and applying the procedure referred to above, one may get:

Begin,

The predicate's extension that map the Universe-of-Discourse for the term under observation is set ←

$$\{$$

$$\neg\, aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$\longleftarrow aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$aps_{diagnosis}(\underbrace{69,\quad 1,\quad 1,\quad 1,\quad [2,4], [3,5],\quad \perp}_{attribute`s\ values}) :: 1 :: DoC$$

$$\underbrace{[2,90][0,1][0,2][0,2]\ [0,5][0,10][0,2]}_{attribute`s\ domains}$$

$$\}:: 1$$

The attribute's values ranges are rewritten ←

$$\{$$

$$\neg\, aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$\longleftarrow aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$aps_{diagnosis}(\underbrace{[69,69], [1,1], [1,1], [1,1], [2,4],[3,5], [0,2]}_{attribute`s\ values}) :: 1 :: DoC$$

$$\underbrace{[2,90]\ \ [0,1]\ \ [0,2]\ \ [0,2]\ \ [0,5][0,10][0,2]}_{attribute`s\ domains}$$

$$\}:: 1$$

The attribute's boundaries are set to the interval [0, 1] ←

$$\{$$

$$\neg\, aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$\longleftarrow aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$aps_{diagnosis}\left(\underbrace{[0.8,0.8], [1,1], [0.5,0.5], [0.5,0.5], [0.4,0.8],[0.3,0.5], [0,1]}_{attribute`s\ values}\right) :: 1 :: DoC$$

$$\underbrace{[0,1]\quad [0,1]\quad [0,1]\quad [0,1]\quad [0,1]\quad [0,1]\quad [0,1]}_{attribute`s\ domains}$$

$$\}:: 1$$

The DoC's values are evaluated ←

$$\{$$

$$\neg\, aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$\leftarrow aps_{diagnosis}(Age, Gen, BMI, SCC,\ SLC, CM, RF)$$

$$aps_{diagnosis}(\underbrace{1, \quad 1, \quad 1, \quad 1, \quad 0.92, \quad 0.98, \quad 0}_{attribute`s\ confidence\ values}) :: 1 :: 0.84$$

$$\underbrace{[0.8, 0.8] \quad [1, 1][0.5, 0.5][0.5, 0.5][0.4, 0.8][0.3, 0.5][0, 1]}_{attribute`s\ values\ ranges\ once\ normalized}$$

$$\underbrace{[0, 1] \quad [0, 1]\ [0, 1] \quad [0, 1] \quad [0, 1] \quad [0, 1] \quad [0, 1]}_{attribute`s\ domains\ once\ normalized}$$

$$\}:: 1$$

End.

4 Artificial Neural Networks

One's model for APS diagnosis set above displays how the information comes together to shape a diagnosis. In this section, a data mining approach to deal with this information is considered. It was set a hybrid computing approach to model the universe of discourse, based on Artificial Neural Networks (ANNs) [15, 17, 18]. As an example, let us consider the case given above, where one may have a situation in which an APS diagnosis is paramount. In Fig. 2 it is shown how the normalized values of the interval boundaries and their *DoC* and *QoI* values work as inputs to the *ANN*. The output depicts the APS diagnosis, plus the confidence that one has on such a happening.

In this study 349 patients were considered, with an age average of 48 years, ranging from 2 to 90 years old. The gender distribution was 68% and 32% for female and male, respectively. The APS was diagnosed in 38 cases, i.e., 10.9% of the population.

To ensure statistical significance of the attained results, 30 (thirty) experiments were applied in all tests. In each simulation, the available data was randomly divided into two mutually exclusive partitions, i.e., the training set with 67% of the available data, used during the modeling phase, and the test set with the remaining 33% of the cases, used after training in order to evaluate the model performance and to validate it. The back propagation algorithm was used in the learning process of the ANN. As the output function in the pre-processing layer it was used the identity one. In the other layers we used the sigmoid function.

A common tool to evaluate the results presented by the classification models is the coincidence matrix, a matrix of size $L \times L$, where L denotes the number of possible classes. This matrix is created by matching the predicted and target values. L was set to 2 (two) in the present case. Table 1 presents the coincidence matrix (the values denote the average of the 30 experiments).

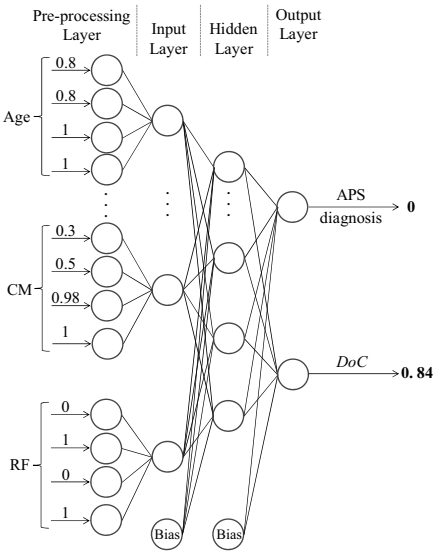


Fig. 2. The artificial neural network topology.

Table 1 shows that the model accuracy was 93.6% for the training set (219 correctly classified in 234) and 89.6% for test set (103 correctly classified in 115). Thus, the predictions made by the ANN model are satisfactory, attaining accuracies close to 90%. Based on coincidence matrix it is possible to compute sensitivity, specificity, Positive Predictive Value (PPV) and Negative Predictive Value (NPV) of the classifier. Briefly, sensitivity and specificity are measures of the performance of a binary classifier. Sensitivity evaluates the proportion of true positives that are correctly identified as such, while specificity translates the proportion of true negatives that are correctly identified. Moreover, it is necessary to know the probability of the classifier that give the correct diagnosis. Thus, it is also calculated both PPV and NPV, while PPV stands for the proportion of cases with positive results which are correctly diagnosed, NPV is the proportion of cases with negative results which are successfully labeled. The sensitivity ranges from 92.0% to 92.3%, while the specificity ranges from 89.2% to 93.8%. PPV ranges from 52.2% to 63.9%, while NPV ranges from 98.9% to 99.0%.

Moreover, the Receiver Operating Characteristic (ROC) curves for the training and test sets are shown in Fig. 3. The areas under ROC curves are higher than 0.9 for both cases, denoting that the model exhibits a good performance in the diagnosis of APS.

Table 1. The coincidence matrix for ANN model.

Target	**Predictive**			
	Training set		Test set	
	True (1)	False (0)	True (1)	False (0)
True (1)	23	2	12	1
False (0)	13	196	11	91

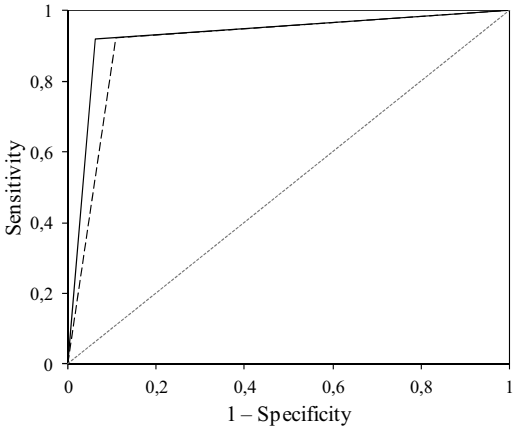


Fig. 3. The ROC curves for training set (—) and for test set (− −).

The present model allows to integrate the results of the Sydney Clinical Criteria (SCC) and Sydney Laboratory Criteria (SLC) for the diagnosis of the APS with other factors such as, family story of patients of antiphospholipid syndrome and risk factors associated and integrate them with the main associated clinical manifestations, allowing to be assertive in the diagnosis of the APS. This model showed a high sensibility, enabling the diagnosis of APS comparing with the patients that really presented this pathology as well as classifying properly the absence of this autoimmune hypercoagulable state (i.e., specificity). Therefore it can be a major contribution to the early recognition and prevention of APS. Thus, it is our claim that the proposed model is able to diagnose the APS properly. The inclusion of the associated risk factors and associated clinical manifestations, such as systemic lupus erythmatosus, neurologic, cardiovascular, hepatic and gastrointestinal, pulmonary, renal, skin, and other organ manifestations, retinal and other coagulation, may be responsible for the good performance exhibited by the presented model.

5 Conclusions

Diagnosing antiphospholipid syndrome has shown to be a hard task, as the parameters that cause the disorder are not fully represented by objective data. The classification of APS syndrome and the risk stratification of this disease require the combination of at least one clinical and one laboratory criteria (persistent LA, IgG/IgM aCL or aβ2GPI). Thus, it is difficult to assess to the APS diagnosis since it needs to consider different conditions with intricate relations among them, where the available data may be incomplete, contradictory, and even unknown. In this work the founding of a computational framework was presented. It uses powerful knowledge representation and reasoning techniques to set the structure of the information and the associate inference mechanisms (ANNs based). The ANNs were selected due to their proper dynamics, like adaptability, robustness, and flexibility. This approach not only allows to obtain

the diagnosis of APS but it also permits the estimation of the Degree of Confidence (DoC) associated with the diagnosis. In fact, this is one of the added values of this approach that arises from the complementarily between Logic Programming (for knowledge representation and reasoning) and the computing process based on ANNs.

Future work may recommend that the same problem must be approached using others computational formalisms, namely Case Based Reasoning [25], Genetic Programming [13], or Particle Swarm [26], just to name a few.

Acknowledgments. This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope UID/CEC/00319/2013.

References

1. Miyakis, S., Lockshin, M., Atsumi, T., Branch, D., Brey, R., Cervera, R., Derksen, R., De Groot, P., Koike, T., Meroni, P.L., Reber, G., Shoenfeld, Y., Tincani A., Vlachoyiannopoulos, P.G., Krilis, S.A.: International consensus statement on an update of the classification criteria for definite antiphospholipid syndrome (APS). Journal of Thrombosis and Haemostasis 4, 295–306 (2006)
2. Cervera R., Asherson R. A.: Clinical and epidemiological aspects in the antiphospholipid syndrome. Immunobiology 207, 5–11 (2003)
3. Amengual, O., Atsumi, T., Khamashta, M. A.: Tissue factor in antiphospholipid syndrome: shifting the focus from coagulation to endothelium. Rheumatology 42, 1029–1031 (2003)
4. Cervera R., Asherson R.A.: Antiphospholipid syndrome. In: Shoenfeld, Y., Cervera, R., Gershwin, M. E. (eds.) Diagnostic Criteria in Autoimmune Diseases, pp. 9–14. Humana Press, Totowa, (2008)
5. Devreese K., Hoylaerts, M. F.: Challenges in the Diagnosis of the Antiphospholipid Syndrome. Clinical Chemistry 56, 930–940 (2010)
6. Pierangeli, S.S., Chen, P.P., Raschi, E., Scurati, S., Grossi, C., Borghi, M.O., Meroni, P.L.: Antiphospholipid antibodies and the antiphospholipid syndrome: pathogenic mechanisms. Seminars in Thrombosis and Hemostasis 34, 236–250 (2008)
7. Groot, P.G., Derksen, R.H.W.M.: Pathophysiology of the antiphospholipid syndrome. Journal of Thrombosis and Haemostasis 3, 1854–1860 (2005)
8. Rand, J.H., Wolgast, L.R.: The Antiphospholipid Syndrome. In Victor J. Marder, V.J., Aird, W.C., Bennett J.S., Schulman, S., Gilbert C. White II, G.C. (eds.) Hemostasis and Thrombosis – Basic Principles and Clinical Practice, 6th edition, pp. 1216–1231. Lippincott Williams & Wilkins, Philadelphia (2013)
9. Meroni, P.L, Chighizola, C.B., Rovelli, F. Gerosa, M.: Antiphospholipid syndrome in 2014: more clinical manifestations, novel pathogenic players and emerging biomarkers. Arthritis Research & Therapy 16, 209–223 (2014)
10. Pengo, V., Ruffatti, A., Legnani, C., Testa, S., Fierro, T., Marongiu, F., De Micheli, V., Gresele, P., Tonello, M., Ghirarduzzi, A., Bison, E., Denas, G., Banzato, A., Padayattil, J.S., Iliceto, S.: 2011. Incidence of a first thromboembolic event in asymptomatic carriers of high-risk antiphospholipid antibody profile: a multicenter prospective study. Blood 118, 4714–4718 (2011)
11. Cooper, R., Cutler, J., Desvigne-Nickens, P., Fortmann, S. P., Friedman, L., Havlik, R., Hogelin, G., Marler, J., McGovern, P., Morosco, G., Mosca, L., Pearson, T., Stamler, J., Stryer, D., Thom, T.: Trends and disparities in coronary heart disease, stroke, and other

cardiovascular diseases in the United States: findings of the national conference on cardiovascular disease prevention. Circulation 102, 3137–3147 (2000)
12. Neves, J.: A logic interpreter to handle time and negation in logic databases. In: Muller, R., Pottmyer, J. (eds.) Proceedings of the 1984 annual conference of the ACM on the 5th Generation Challenge, pp. 50–54. Association for Computing Machinery, New York (1984)
13. Neves, J., Machado, J., Analide, C., Abelha, A., Brito, L.: The halt condition in genetic programming. In: Neves, J., Santos, M.F., Machado, J. (eds.) Progress in Artificial Intelligence. LNAI, vol. 4874, pp. 160–169. Springer, Berlin (2007)
14. Cortez, P., Rocha, M., Neves, J.: Evolving Time Series Forecasting ARMA Models. Journal of Heuristics 10, 415–429 (2004)
15. Vicente, H., Dias, S., Fernandes, A., Abelha, A., Machado, J., Neves, J.: Prediction of the Quality of Public Water Supply using Artificial Neural Networks. Journal of Water Supply: Research and Technology – AQUA 61, 446–459 (2012)
16. Haykin, S.: Neural Networks and Learning Machines. Prentice Hall, New York (2008)
17. Vicente, H., Couto, C., Machado, J., Abelha, A., Neves, J.: Prediction of Water Quality Parameters in a Reservoir using Artificial Neural Networks. International Journal of Design & Nature and Ecodynamics 7, 309–318 (2012)
18. Vicente, H., Roseiro, J., Arteiro, J., Neves, J., Caldeira, A. T.: 2013. Prediction of bioactive compounds activity against wood contaminant fungi using artificial neural networks. Canadian Journal of Forest Research 43, 985–992 (2013)
19. Kakas, A., Kowalski, R., Toni, F.: The role of abduction in logic programming. In: Gabbay, D., Hogger, C., Robinson, I. (eds.) Handbook of Logic in Artificial Intelligence and Logic Programming, vol. 5, pp. 235–324. Oxford University Press, Oxford (1998)
20. Pereira, L., Anh, H.: Evolution prospection. In: Nakamatsu, K. (ed.) New Advances in Intelligent Decision Technologies – Results of the First KES International Symposium IDT 2009, Studies in Computational Intelligence, vol. 199, pp. 51–64. Springer, Berlin (2009)
21. Lucas, P.: Quality checking of medical guidelines through logical abduction. In: Coenen, F., Preece, A., Mackintosh A. (eds) Proceedings of AI-2003 (Research and Developments in Intelligent Systems XX), pp. 309–321. Springer, London (2003)
22. Machado J., Abelha A., Novais P., Neves J., Neves J.: Quality of service in healthcare units. In Bertelle, C., Ayesh, A. (eds.) Proceedings of the ESM 2008, pp. 291–298. Eurosis – ETI Publication, Ghent (2008)
23. Fernandes, F., Vicente, H., Abelha, A., Machado, J., Novais, P., Neves J.: Artificial Neural Networks in Diabetes Control. In Proceedings of the 2015 Science and Information Conference (SAI 2015), pp. 362–370, IEEE Edition (2015)
24. World Health Organization: Obesity and overweight. Fact Sheet Number 311, http://www.who.int/mediacentre/factsheets/fs311/en/
25. Carneiro, D., Novais, P., Andrade, F., Zeleznikow, J., Neves, J.: Using Case-Based Reasoning and Principled Negotiation to provide decision support for dispute resolution. Knowledge and Information Systems 36, 789–826 (2013)
26. Mendes, R., Kennedy, J., Neves, J.: The Fully Informed Particle Swarm: Simpler, Maybe Better. IEEE Transactions on Evolutionary Computation 8, 204–210 (2004)

Using Bayesian Networks for Knowledge Representation and Evaluation in Intelligent Tutoring Systems

Ramirez-Noriega Alan*, Juarez-Ramirez Reyes*, Martinez-Ramirez Yobani**, Jimenez Samantha*, Inzunza Sergio*

Autonomous University of Baja California *, Autonomous University of Sinaloa **

Abstract. Assessing knowledge acquisition by the student is a main task of an Intelligent Tutoring System. Assessment is needed in order to adapt learning materials and activities to students capacities. To evaluate knowledge acquisition, different techniques can be used, such as probabilistic inference. In this paper we present a proposal based on Bayesian Networks to infer the level of knowledge possessed by the student. We implemented a kind of test to know what student knows. During the test, the software system chooses the new questions based on the responses to the previous ones, that is, the software system makes an adaption in real time. To get the inferences, we use a network of concepts, which contains the relationships between those concepts. This work is focused on the design of the Bayesian Network and the algorithm to do inferences about students knowledge.
Keywords: Knowledge representation, Bayesian Network, Evaluation, Intelligent Tutoring System.

1 Introduction

Learning can be defined as internal processes of change, as the result of learners personal experience. Also, it can be defined as the acquisition or adding of something new, which involves any variation or modification previously acquired [17].

Teachers guide students during the learning and must perceive the students needs in order to improve the teaching. However, in group tutoring environments, one-on-one time dedicated by professors to each student decreases considerably. For that reason, some authors propose the use of a software system [1][2][7][20] to satisfy that needs. Furthermore, the software system should be adapted to the students needs.

Adaptability to students needs is a challenge for software engineering [10]. Adaptability is defined as the software adaptation to individual user characteristics according to user aims [14].Different types of software adaptations are defined [14][16], but this research focuses on the content adaptation; that is, what information is shown to the user according to the software interaction and user characteristics. This adaptation of the learning environment can be achieved with artificial intelligence strategies [16], carrying out intelligence for deducing user needs.

A special type of software that meets the characteristics mentioned above is called the Intelligent Tutoring System (ITS). This can be defined as a software system that uses artificial intelligence techniques to interact with students and teach them [7][20] in the same way as a teacher does to his students [2]. Carbonell [1][2] proposed a generalized architecture for ITS, which considers three basic modules [2][20]:which are the tutoring model, domains model, students model, further of users interface.

An important problem in ITS development is the assessment of student knowledge [4]. ITS must be able to determine accurately and quickly the student cognitive level to decide what is important

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_16

to teach them. Probability theory has been proposed by some authors for handling the uncertainty in diagnosing student knowledge [7][20][4]. The Bayesian Network (BN) theory is proposed, within a framework of probability and artificial intelligence, for modeling the way how an intelligence system should infer causality [21]. Besides, this theory has a representation and behavior similar to peoples mind [17].

Our research project considers the causal relationships to refer to nodes that represent concepts, and they are related to other nodes to obtain the domain knowledge representation [12]. This paper proposes a knowledge evaluation module for ITS, to diagnose the student learning needs efficiently, in order to reinforce topics. This research is supported in the BN theory considering uncertainty handling, knowledge representation, and the wide use in diagnostic and pattern recognition [20][8][9][13].

We selected BN to this study over Fuzzy Cognitives Maps (a similar technique) because they have important attributes as [3]: (1) Forward and backward chaining, (2) efficient evidence propagation mechanism, (3) enough implementation and support tools, (4) mathematical theorems derivable from well-defined basic axiom, and (5) correctness of the inference mechanism is provable.

This paper is organized in six sections. Section 2 defines some related work. Section 3 explains our proposal for knowledges assessment. Also, it shown how the BN is implemented for knowledge representation and its assessment; moreover, it presents a question-based evaluation design that we used for student evaluation. Also this section explains the algorithms employed in the module. Section 4 defines the methodology for experimentation that we employed. Section 5 shows the experiment results and discussions. Lastly, Section 6 presents the conclusions and future work.

2 Related works

In this section we present the related work, emphasizing the use of BN for improve learning and education. Taking into acount that BN are used to assess the knowledge.

Liu et al. [9]proposed a student modeling method built with BN. To assess the students performance, they adopted a logistic model with three parameters to calculate the conditional probability distribution of the testing item. They were focused on course of Data Structures, especially on Binary Trees. This work just was a proposal, but they did not implementation of the model.

Goguadze et al. [6] presented the design and evaluation of a Bayesian approach for modeling student misconceptions in the domain of decimals. The results showed that the models predictions reach a high level of precision, especially in predicting the presence of student misconceptions. They did not explain precisely how the BN was built.

Torabi et al. [22] worked on predicting the student courses score based on the students educational history. They proposed a BN model for the inference process. The results show that applying their proposed method has primary effects on the quality of the students learning and can be used as a helpful tool for them.

Millan et al. [12] developed, integrated and evaluated a Bayesian student model. This work is focused on the mathematics area, specifically on first-degree equations. They used twelve concepts to assess the knowledge. Each concept is evaluated in batches of four questions or exercises, this mean you need answer four questions as one.

The main model used is similar to the Millan et al. [11]. But, some differences are considered with the previous work. Our model evaluates the fundamentals of algorithms as learning topic. We did a complete analisis of domain knowledge for represent it. Also, to adapt the questions according Student's knowledge level, Bloom's taxonomy [5] was implemented organizing the questions into

five levels of complexity. Finally, we used own algorithms to switch-on the levels and to select the appropriated question to the student.

3 Implementing a module for knowledge representation

3.1 Setting the diagnostic of the student using Bayesian Networks

BN help us determine the students cognitive degree; this means we can assess areas of superior knowledge and areas in development. Firstly, we define essential elements for using BN to diagnose students problems. The elements are variables, links between variables and parameters. This work is based on the method used by Millan [12], where they consider the following aspects:

- Variables for measuring students attained knowledge: we use three levels of granularity. The concepts are found in the lower level. These represent the smallest unit to dividing the knowledge. The topics are the next level, these are clusters of concepts. Finally, the las level is represented by units that involve topics.
- Variables for gathering evidence: These are multiple choice questions and can be right or wrong.
- Links between variables to measure the knowledge: Dominating knowledge has causal influence on knowing preceding, immediate levels in the related granularity hierarchy. Regarding links between the nodes and the questions, we consider that knowledge has a causal influence on correctly answering the questions [12].
- The word parameters signify dependence on probability values of the child nodes given their parents

3.2 Building the Bayesian Network

We use a building process divided into six phases [15]: (1) Defining a knowledge domain: selecting the work area. (2) Developing a hierarchical scale of knowledge: classification of the knowledge in different levels. (3) Building the Bayesian Network: creating nodes and establishing dependence relations between them. (4) Designing the conditional probability tables (CPT): assigning probabilities to nodes, according to relationships with parents. (5) Designing questions to evaluate knowledge: creating a bank of questions and assigning relations with the concepts contained in nodes. (6) Creating the CPT for the questions: assign probabilities to the question nodes according to their parents.

The phases 1, 2, 3, and 5 are used for creating the network structure, and the phases 4 and 6 to calculate the estimated probability values for each node. The phases 4 and 6 could be combined in a single step, but they were divided into two phases allowing us better organization and clarity.

For our experiment we considered the course Algorithms and Computer Logic, which is part of the curriculum for the Software Engineering undergraduate program in the Autonomous University of Sinaloa, Mexico. This course has a set of programming topics. Following the methodology presented above, we created the BN, which contains the course structure ordered hierarchically as concepts, themes and the unit name.

We considered the first unit that contains introductory topics, such as: program, programmer, data, algorithm concepts, variables (concept, assignment, and types), constant, algorithms characteristics, algorithms types (qualitative and quantitative), and algorithm classification (sequential, conditional, and repetitive).

3.3 Creating questions

We generated a total of 73 questions divided into levels. The questions are similar to the next example: Which kind of algorithms make decisions based on a given condition? This question is related to the topic of algorithms and their types. The answers are known (multiple choice) and their values are expressed in percentages (Algorithm concept 10%, Sequential algorithms 30%, Conditional algorithms 30%, Repetitive algorithms 30%). The value of the first response (algorithm concept 10%) means that the question is 10% related to the concept of Algorithms. That is, if the student knows the concept of Algorithm, then he has a 10% probability of answering the question correctly. The other three answers are the same, but with different values.

As we indicated earlier, values are assigned based on the expert proposal when s/he creates the exam. There is the possibility that experts will assign different values to questions and answers, depending on who creates the questions and responses. In order to prove the correct formulation of the questions and their answers we apply a survey with professors of the Software Engineering curricular block, who gave feedback on the formulation as: readiness, clarity, and so on.

Particularly, professors who teach the Algorithms and Computer Logic course collaborated on the survey. The feedback suggested us to improve the following aspects: (1) some concepts were not covered in the classroom. (2) Some questions and answers were ambiguous. (3) Some questions were located in a wrong category.

Attending to this feedback, we improved the set of questions and answers to increase reliability. Questions were organized based on Blooms Taxonomy [5]. We only work with the first five levels. Table 1 illustrates the organization.

Table 1. Levels of complexity

Bloom's taxonomy	Name of level	Number of question
Knowledge	Basic (B)	11
Comprenhension	IntermediareA (IA)	21
Application	IntermediateB (IB)	17
Analysis	AdvancedA (AA)	18
Synthesis	AdvancedB (AB)	6
	Total	73

According to Table 1, the questions (knowledge) of basic level recognize and retrieve relevant information from long-term memory to use in the short-term memory. The questions of intermediate level (comprehension) are questions that require building significance from educational material [5] [18].

The intermediate level (application) contains questions where a learning process is applied. The advanced level (analysis) divides the knowledge in parts and reasoning is required. Finally the advanced level (synthesis), this level joins elements to form a whole. Students reasoning are deepened; questions are slightly more complicated than the advanced level. The module aims for students to achieve their maximum potential to use at this level [5][18].

3.4 Knowledge Evaluation System

The software module is based on two algorithms, in order to adapt to the student. The first is based on level selection, and the second on question selection. Below each one is detailed.

Level selection algorithm Each question is randomly selected, starting from the basic level. The student can move through the levels, according to the knowledge of the course concepts. The algorithm 1 moves the student through the levels of questions. We use a data structure to save answered questions and their answer (right or wrong) by each level. Thus, we have a record of questions (*QuestionsRecord*). A loop is kept until the software decides to finish the exam. The exam may finish for four reasons: 1) low knowledge, 2) high knowledge, 3) do not approve a level, and 4) excess of questions. The last one limits the exam duration to 25 questions and avoids showing all 73 questions.

The *ShowQuestion*() procedure in algorithm 1 is not defined until this section, because it belongs to the questions selection and needs another algorithm; therefore, the section below is dedicated to that. The *EvaluateQuestion*() procedure defines if the question is right or wrong. The *AddtoQuestionsRecord*() procedure permits saving questions, answers, and level within the defined structure (*QuestionsRecord*()).

The *GoDownLevel*() and *GoNextLevel*() procedures allow movement through levels, either up or down, as the case may be. The *FinishTest*() procedure is used to finish the exam for one of the aforementioned reasons. The *ReachLevel*() procedure determines if a student should return to a previous level, and makes decisions based on question number. The *DiscontinuousQuestions*() procedure refers to question evaluation when a student cannot answer two or more questions in row, either right or wrong. The algorithm considers a level passed if most questions are correct.

Finally, the *ExtraQuestion*() procedure handles levels with five evaluated questions, when, according the software rules, an extra question is needed to decide if the student should go up or down a level, or finish the exam. Thus, the software controls the students movements through levels, deciding if the student goes down a level, proceeds to the next level, or ends the exam.

Algorithm 1 Algorithm for the levels

```
1: QuestionsRecord=Structure for control the questions by level
2: while not FinishTest() do
3:     ReachLevel();
4:     ShowQuestion();
5:     EvaluateQuestion();
6:     AddtoQuestionsRecord();
7:     if question=true then
8:         if three questions are corrects in a row and level in {B, IA, IB, AA} then
9:             GoNextLevel();
10:        end if
11:        if question=true and level=AB then
12:            FinishTest();
13:        end if
14:    end if
15:    if question=false then
16:        if two question are corrects in a row then
17:            if level in {IA, IB, AA} then
18:                GoDownLevel();
19:            end if
20:            if level=B then
21:                FinishTest();
22:            end if
23:        end if
24:        if level = AA then
25:            GoDownLevel();
26:        end if
27:    end if
28:    if five questions are showed in the level then
29:        DiscontinuousQuestions();
30:    end if
31: end while
```

Selecting questions To select a question, node ranges must be classified as known, unknown, or indeterminate. Probability values are between 0 and 1, by a probability axiom [19].

This research defines the next classification: (1) Known Question (KQ): A node that has a value greater or equal to 0.7 and less or equal to 1 ($0.7 <= KQ <= 1$). (2) Unknown Question (UQ): A node that has a value greater or equal to 0 and less to 0.3 ($0 <= UQ < 0.3$). (3) Indeterminated Question (IQ): A node that has a value greater or equal to 0.3 and less to 0.7 ($0.3 <= IQ < 0.7$).

The $ShowQuestion()$ procedure chooses the question and shows it. The question probability value may be in the indeterminate range to be selected. The software module has not been able to classify those questions due to the ranges. Thus, the known and unknown concepts are discarded. Moreover, this procedure displays the selected question. The $EvaluateQuestion()$ procedure evaluates the question shown; it can only be right or wrong. This evaluation is evidence to update the network values using the $UpdateNodeValues()$ procedure.

Question selection based on probability values Table 2 contains questions and values to decide which question will be the next to be shown. It is simulated by Elvira and Genie software. This table has 17 questions at the IntermediateB level with related concepts, for now, do not interest know how questions are related.

We Suppose that the start level is IntermediateB. In the beginning have not evidence. This means that the student has not answered a question. The software always proceeds to select a question randomly, according to the probability value, this must be in the indeterminate range ($0.3 <= IQ < 0.7$). The simulation just started; therefore, all questions are candidates to be selected. Supossing

Table 2. A priori and a posteriori probability

Questions	A priori probability	A posteori probability (2Q)	A posteriori probability (4Q)
1	0.6125	0.7453	0.7711
2	0.5562	0.7183	0.7318
3	0.5375	1.000	1.000
4	0.5188	0.7437	0.7699
5	0.5188	0.7437	0.7699
6	0.5188	0.7437	0.7699
7	0.5012	1.000	1.000
8	0.5094	0.5668	0.7774
9	0.5094	0.5668	1.000
10	0.5094	0.5668	0.7774
11	0.5094	0.5668	0.7774
12	0.6125	0.6125	0.6148
13	0.6125	0.6125	1.000
14	0.6125	0.6125	0.748
15	0.6125	0.6125	0.6148
16	0.4756	0.4756	0.4466
17	0.550	0.6922	0.7092

that question 7 was selected randomly; this is shown to the student and is correctly answered. The probability values must be updated according to the evidence; these values are not displayed in Table 2 to simplify. Afterward, another question was selected in the indeterminate range, this was the question 3, and was answered correctly.

Column 3 in Table 2 presents the probability values for each question after two questions were correctly answered. Some questions increased their values while other did not, since they are not related to the question concepts 3 and 7. According to column 3, questions 1, 2, 4, 5, and 6, are

now in the known questions range, therefore, are discarded from selection. The other questions (8, 9, 10, 11, 12, 13, 14, 15, 16, and 17) are candidates to be selected and shown to the student.

The fourth column in Table 2 presents questions probability values, after questions 9 and 13 are answered correctly, as well as the previously answered questions. Some questions already discarded increase their probability values, while other that had not been considered to the known questions range, now are considered (questions 8, 9, 10, 11, 14, and 17). Hence, those questions are not considered candidates for being selected and shown to the student.

After 4 answered questions only questions 12, 15, and 16 are available. 10 questions are discarded because the module infers that the student knows the answers. We only consider correctly answered questions for this example. If we had incorrectly answered questions, we probably would have to discard those questions that are in the unknown questions range, but the operation would be the same, only taking those questions in the indeterminate range.

We can see the inference level of the BN, inferring 10 known questions with only 4 pieces for evidence. In this scenario, we do not consider the rules for level moves, to exemplify best the BN inference. In summary, the module algorithm works by taking into account the level where the student is, the previously answered questions chosen based on probability, and a random factor.

4 Experimental evaluation

This investigation considered 4 tests to prove module work, each defined below:

- Concepts inference: determines how many and which questions the module software deduce as known or unknown, according student evidence.
- Testing question inference: proves software accuracy in the inference. This with the next method: once that students completed the software exam, those questions that the module software infers as right or wrong are selected, in order to make a written exam. The same student that answered the software exam also answered the written exam; the students answer was compared to determine the inference effectiveness. This test expects that inferred questions as correct or incorrect will have the same result in the written exam.
- Time comparison: determines which kind of exam is faster, if the software exam or written exam. The software exam of a student was taken as a base; this exam was answered in writing by other students with the same academic level.
- Determining the student knowledge: to reach this, the software module does values analysis of the concepts, determining those concepts that are in the known and unknown range. Here we can define a new scale to achieve high or low accuracy; this depends on teacher judgement.

This study selected students majoring in software engineering to test the project. They are third semester students from the Autonomous University of Sinaloa. They are evaluated with a minimum grade of 0 and maximum grade of 10.

These students were selected because of the appropriateness of the exam for them. The groups are in a major focused mainly on the software system development; therefore, they already should have a sufficient basis to answer the exam with acceptable skill. Sampling by conglomerate combined with simple random sampling was utilized to select the section of the population.

First, sampling by conglomerate was selected because we needed to group students according to their grades to compare results of students with similar averages (9 or 10) to maintain a balanced match. Second, simple random sampling was used due to a very small population (62 students).

Student classrooms and schedules were known and selected students were available to be examined. This method consists of making a prospect list and selecting them randomly.

Students were separated into groups according to their grades, as Advanced Students (AS) with averages greater or equal to 8.5. ($AS >= 8.5$), Regular Students (RS) with average greater or equal to 7.0 and less to 8.5. ($7.0 <= RS < 8.5$), and Irregular Students (IS) with average less to 7.0. ($IS < 7$).

Finally, the advanced group have 21 students, the regular group have 26 students and the irregular group have 15 students. Students were randomly selected with a simple program that sorted student names alphabetically according the classification. Each student had an index of 0 to 20 for the advanced group, of 0 to 25 for the regular group, and of 0 to 14 for the irregular group. Seven random students were selected per group. A total of 21 students were selected of 62 possible, equivalents to 33.8% of the population.

5 Results and discussion

We highlight the big amount of inferred questions with few answered questions. Taking into account the 21 evaluated students, we obtained an average of 2.3 inferred questions for each student-answered question. We got a standard deviation of 0.90 and a median of 2.38. This allows us to evaluate more knowledge with fewer questions.

We tested concept inference with a written exam with questions inferred by the software. This exam was applied to the same student. According to the result, the software module had a success in 75.6% of the cases. In other words, when the module inferred a question as known or unknown, this hit almost in 3 on 4 occasions, compared with the written exam. This section gave us a standard deviation of 12.5 and a median of 78.4.

There is one mistake for each four questions explained by the following reasons: a) Students may have doubts the first time the exam was answered, implying that a second time the students were already academically prepared. Nevertheless, they were not told they would, do a second exam. b) Students may have the knowledge to answer questions, but conducted poor analysis. c) Finger errors, i.e., knowing the answer, but select the incorrect option due a distraction, may have occurred. d) A wrong approach to the question may have caused confusion, although questions were reviewed by some teachers before being applied to the student. e) Students may not have taken the exam, either written or by software, leading to inaccuracies.

Students times answering the exam in software are lower than the students that do the written exam. They answered the same questions in less time and make best use of the resource to achieve the same results. This means they are efficient and use 36.8% of the time generally utilized in a traditional exam.

Figure 1 shows the results of a selected student (solid line) and all the students (dotted line). This line graph evaluated concepts on the X axis. On the Y axis are the values of each concept (between 0 and 1). Analysis shows the student has a high probability of knowing most concepts. This section could be interpreted by the teacher. Teachers can define their own ranges to analyze results. For this case, we considered the same previously defined rules-known, unknown, and indeterminate questions.

Concepts where the student performed poorly are most important; those concepts require special attention. We can see that this student was confused by questions about Program, Algorithm, and Variables Types. We can measure the knowledge possessed by the group calculating the average of concepts, as we see on the figure 1 indicated with dotted lines. Instead of serving only a student, we

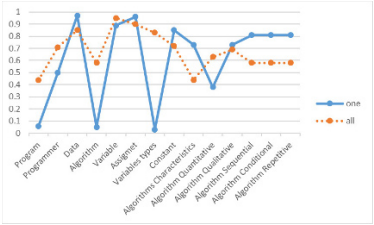


Fig. 1. State of the concepts

could focus on content for a students group with similar problems and help more students. Through this procedure we can detect the concepts less acquired and then reinforce these weak points.

6 Conclusions and future work

Using the software module based on BN we found that it is more efficient and effective than the computer exam and a traditional pen and paper exam. Also, we found that students can answer exams 2.7 times faster than traditional exams or computer exam but without intelligence; in addition, the software system can infer 2.3 known or unknown concepts per student answer. Also, this study proved that those concepts determined as know or unknown have 75.6% of probabilities of being right.

Our testing showed software module development based on BN reflected student deficiencies and skills. For this reason, we can say that Bayesians Networks are an appropriate model for assessing student cognitive levels.

Our proposal involves two levels of adaptation:

1. Exam integration. The selection of questions is based on the student responses; this is the adaption. The software module takes questions that are not related (or are related to low value) to the question with concepts already evaluated; this means that the system only takes the questions that are not classified as known or unknown according to probability values.
   Also, software takes into account question complexity and shows questions to students according to knowledge level. Difficulty of questions is increased or decreased based on the correctness of responses. Thus, the software provides a real-time adaptation in questionnaire construction.
2. By knowing current student knowledge levels, learning material can be adapted. Considering this Kind of adaptation, we have a basis to implement this approach inside an automated tutoring system.

For future work, we are considering including the evaluation module in an Intelligence Tutoring System. Inferring current student knowledge, the software can reinforce topics with low levels of understanding. Moreover, in order to gain accuracy in evaluation, other variables can be considered even if it is the first interaction with the student. Examples of these variables are grades in previous and current courses, the general average, student behavior, related concepts, and so on.

References

1. Carbonell, J.R.: AI in CAI: an artificial intelligence approach to computer assisted instruction. IEEE transaction on Man. Machine System 11, 190–202 (1970)
2. Cataldi, Z., Lage, F.J.: Modelado del Estudiante en Sistemas Tutores Inteligentes. Revista Iberoamericana de Tecnologia en Educación y Educación enTecnología 5, 29–38 (2010)
3. Cheah, W.P., Kim, K.Y., Yang, H.J., Kim, S.H., Kim, J.S.: Fuzzy Cognitive Map and Bayesian Belief Network for Causal Knowledge Engineering: A Comparative Study. The KIPS Transactions:PartB 15B(2), 147–158 (2008)
4. Conejo, R., Millán, E., Pérez, J., Trella, M.: Modelado del alumno : un enfoque bayesiano. Revista Iberoamericana de Inteligencia Artificial 12, 50–58 (2001)
5. De Bruyn, E., Mostert, E., Van Schoor, a.: Computer-based testing - The ideal tool to assess on the different levels of Bloom's taxonomy. 2011 14th International Conference on Interactive Collaborative Learning, ICL 2011 - 11th International Conference Virtual University, VU'11 (September), 444–449 (2011)
6. Goguadze, G., Sosnovsky, S., Isotani, S., McLaren, B.M.: Evaluating a Bayesian Student Model of Decimal Misconceptions. In: Proceedings of the 4th International Conference on Educational Data Mining. p. 5 (2011)
7. Huertas, C., Juárez-Ramírez, R.: Developing an Intelligent Tutoring System for Vehicle Dynamics. Procedia - Social and Behavioral Sciences 106, 838–847 (2013)
8. Kammerdiner, A.: Bayesian networks Bayesian Networks. In: Floudas, C.A., Pardalos, P.M. (eds.) Encyclopedia of Optimization SE - 32, pp. 187–196. Springer US (2009)
9. Liu, Z., Wang, H.: A Modeling Method Based on Bayesian Networks in Intelligent Tutoring System. Structure pp. 967–972 (2007)
10. Luckey, M., Engels, G.: High-Quality Specification of Self-Adaptive Software Systems pp. 143–152 (2013)
11. Millán, E.: Sistema bayesiano para modelado del alumno. Ph.D. thesis (2000)
12. Millán, E., Descalço, L., Castillo, G., Oliveira, P., Diogo, S.: Using Bayesian networks to improve knowledge assessment. Computers & Education 60(1), 436–447 (2013)
13. Misirli, A.T., Bener, A.B.: Bayesian networks for evidence-based decision-making in software engineering. IEEE Transactions on Software Engineering 40(6), 533–554 (2014)
14. Radenkovic, B.: Web portal for adaptive e-learning. Telecommunication in Modern Satellite Cable and Broadcasting Services (TELSIKS), 2011 10th International Conference on pp. 365 – 368 (2011)
15. Ramírez-Noriega, A., Juárez-Ramírez, R., Huertas, C., Martínez-Ramírez, Y.: A Methodology for building Bayesian Networks for Knowledge Representation in Intelligent Tutoring Systems. In: Congreso Internacional de Investigación e Innovación en Ingeniería de Software 2015. pp. 124–133. San Luís Potosí (2015)
16. Razek, M.a., Bardesi, H.J.a.: Adaptive course for mobile learning. Proceedings - 5th International Conference on Computational Intelligence, Communication Systems, and Networks, CICSyN 2013 pp. 328–333 (2013)
17. Rivas Navarro, M.: Procesos cognitivos y aprendizaje significativo. BOCM, Madrid (2008)
18. Rodrigues, F.H., Bez, M.R., Flores, C.D.: Generating Bayesian networks from medical ontologies. 2013 8th Computing Colombian Conference, 8CCC 2013 (2013)
19. Russell, S., Norving, P.: Artificial Intelligence: A Modern Approach. 3rd edit. edn. (2009)
20. Santhi, R., Priya, B., Nandhini, J.: Review of intelligent tutoring systems using bayesian approach. arXiv preprint arXiv:1302.7081 (2013)
21. Taborda, H.: Modelos bayesianos de inferencia psicológica: Cómo predecir acciones en situaciones de incertidumbre? Universitas Psychologica 9(2), 495–507 (2010)
22. Torabi, R., Moradi, P., Khantaimoori, A.R.: Predict Student Scores Using Bayesian Networks. Procedia - Social and Behavioral Sciences 46, 4476–4480 (2012)

Interoperability of Systems and Monitoring for Alert Itajaí River Basin – SaDPreai v.3

Luis Augusto Silva[1], Francielle M. F. Vieira[2], André Fabiano de Moraes[3]
[1] Federal Institute Catarinense, Internet Systems Technology, Camboriú, Brazil
luis.bc@hotmail.com [1], fm.fiori@gmail.com [2]
[3] Federal Institute Catarinense, Information System TI, Camboriú, Brazil
afdmoraes@ifc-camboriu.edu.br [3]

Abstract. The project consists in developing a portal for public access to information for monitoring and alert levels of the rivers of the basin of Itajaí, with data collected from telemetric stations, derived from existing systems and consolidated, mainly provided by civil defense each municipality and regulatory agencies, leveraging resources through the internet of things. All obtained data will be available and updated at intervals, serving compiler multiple data sources for integration of information to local arrangements, citizens and also to institutions interested in predicting floods in the valley of Itajaí. All encompassed by a web application, centralizing, organizing, providing data for each station properly georeferenced maps accessible through the internet network. The proposed system aims to build a technology for collecting, interoperability and presentation of information freely, while preserving the security and privacy of people. Emphasis on free software contemplated in open code, using various other technologies like the i3geo, open layers, Google Maps and others. Also additionally allow the registration of people interested in receiving warnings by mobile phone text messages (SMS) or other forms of communication with the updated information to the levels of nearby rivers, reference points and the coverage of this project perimeters.

Keywords: Systems Interoperability, Spatial Databases, Web Application, Monitoring of Rivers and Technological Sensors, Internet of Things.

1 Introduction

The long-standing problems which comprise the history of flooding [1] and [2] successful in Basin Itajaí in Santa Catarina - Brazil, added to soil degradation process was being built next to the history of colonization that took place from the year 1850 according [3] and [4]. The review carefully all the process of managing the waters of this basin, dating back to various environmental socioeconomic contexts of the region. Faced with all this history is common to all who suffer directly or indirectly pallets caused by natural disasters [5], to modernize, create solutions and keep track constantly and promote predictions based on climatological models. This work is continuing investigations performed for the development and implementation through SADPREAI project (Support System Decision and Prediction for Floods, Flooding

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_17

and Inundations) [6], to assist in understanding, dissemination and informing the general public according [7] around perimeters considered medium and high risk. Still, the risks were measured from data historically collected several decades and especially the last five years, providing analysis of data to the simulation of specifics metrics that influence the interpretation of the data for an alerts frame. Because the area does not have a portal with the union of data and information compiled and presented dynamically.

The central objective is development of new system of public access to information monitoring and alert levels of the rivers in the basin of the Itajaí. With integrating data collected from telemetric stations, arising from existing and consolidated systems. Also, the study to automate the collection of data and information derived from devices and other technological means, available through maps, location of stations and their information. Providing through the send alerts for messages (SMS) containing details of the levels of rivers and assist in the dissemination and informing the general public around perimeters considered medium and high risk.

1.2 Methodological Procedures

Initially will be dedicated efforts to continue the surveys carried out in the field to collect data and cartographic databases. Existing public data will also be integrated to provide technical background, research construction and provision of cartographic products according [8,9,10] and [11]. Parallel to this step, prioritize actions to identify emerging topics dedication to studies, which are listed: study on technological resources available to implement the functionality in PHP / PHPMapscript, MapServer [8], GeoServer, PostgreSQL and PostGIS [12,13] and [14]. Due to the need for multiple testing before the release through the web portal, in accordance [15], the water resources of the Itajaí valley will be chosen, especially in the city of Itajaí SC - Brazil. Since stored data transmitted by sensors and other warning systems distributed along the river in points specifics.

The research also aims to integrate the study area with regional data to be obtained for analysis because of its geographical location and relevance for the entire local community. With results obtained by other projects, they will also be incorporated into this assessment work classes for monitoring river levels and occurrences. For this, are adopted infrastructure of providing interoperability for spatial data is proposal [16], also these challenges require the development of systems specifics integration and collaboration to address problems inherent environment, architecture, engineering, construction and facilities management. However, for the development and implementation of the web portal, will run tests on the local lan and will later be incorporated benchmark [17] and [18] for functionality and detection of events to better assess performance and platform usability explored in [19,20] and [21].

In data presentation phase, the user interface will allow the visualization of events in a cartographic database spatially showing the events and their description, users can add other indicators and measures to the point that places the event, like photos,

videos, audios and other relevant data. In figure 1 is represented the schema computational for the integration of services and consumer data collected by sensors from each installation at strategic points.

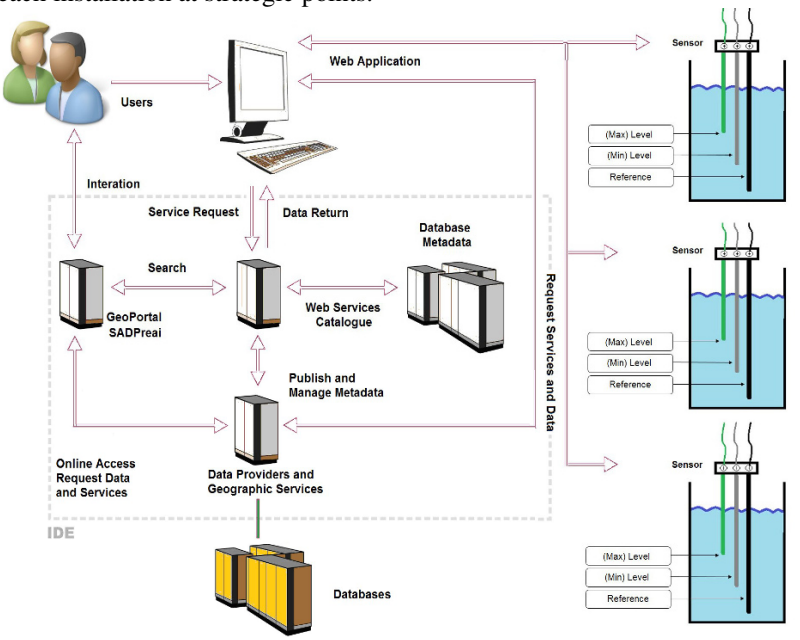


Fig. 1. Schema integration for GeoPortal.

However, the first organization of the system proposed architecture is shown in figure 2, which illustrates its decomposition, including a division into components, class, utilities and subsystems for processes and threads to progress implementations.

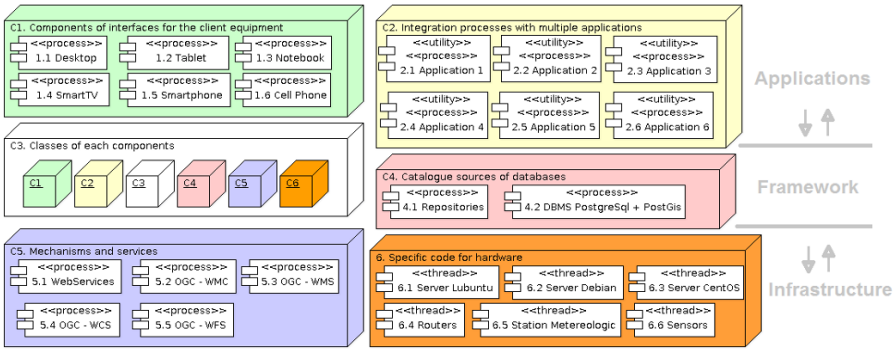


Fig. 2. Diagram of components for SADPreai.

2 Relevance and Risks in Project

Concerning scientific relevance, the project is of paramount importance for the enrichment academic and professional. But the project proposal aspects work aimed

to investigate the data coming from natural, disasters, calamities and other inherent situations. The technological relevance, providing web portal together with the SaD-Preai System with the application of methods and techniques to assist in risk management in cities (urban and rural areas) [22], with integration of various types of different places data, even to meet the goals, but in a way that can be integrated further studies to research conducted throughout the project. Social relevance: Promote actions and mechanisms to address deficiencies access to public domain information for small, medium and high complexity. Easier access to information and alerts in case of emergencies. Risks in project development, not all weather prediction services provide resources through web services for public consultation, a situation that in some cases can bring difficulty in obtaining the necessary data, but does not prevent the development of the project.

2.1. Case Study Area

The study area has a watershed of Alto Vale do Itajaí-Açu with their occurrences, and in this paper the first analyzes of the Itajaí-SC. Particularly given the fact that it has the main output channel from all volume of water from feeder rivers of the watershed. Ie all flow of rainwater and other water factors end up reflecting the constant changes in river levels. Figure 3 illustrates the basin of the Itajaí River, with its major cities, telemetric network and contention dam.

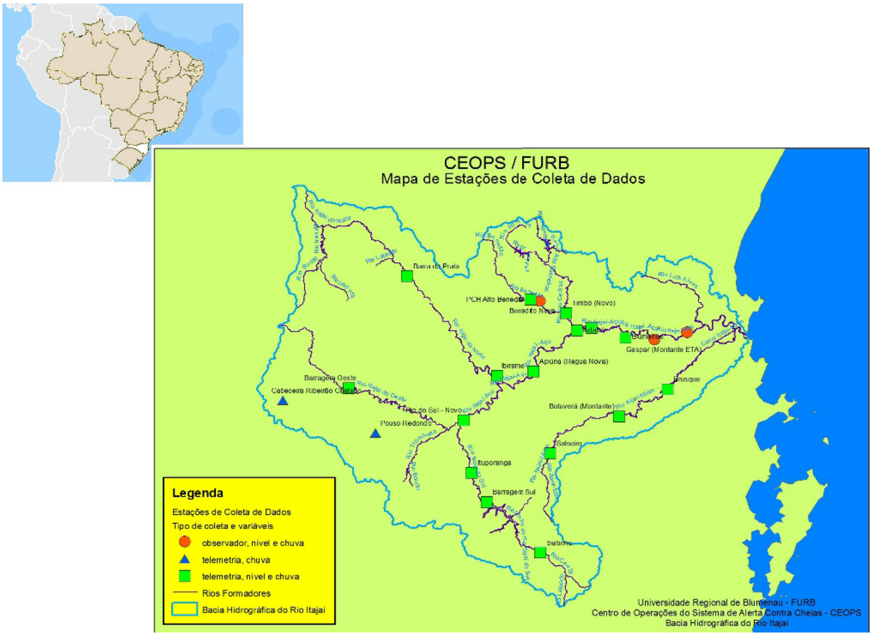


Fig. 3. Sensor coverage area for distributed telemetry. CEOPS (2015).

For monitoring, along the route are installed several gauged stations among other sensors, maintained by CEOPS [23] and accessible by Internet network providing free

access to data collected by sensors distributed. However, rainfall in the catchment area of the Itajaí-Açu river occur so distributed throughout the year, that being in warm periods are more intense, but usually short-lived and prone to cause flooding. In colder periods the rains are less intense but more lasting, which are the most favorable rains generators flood events. For better understanding, in Table 1 are set rules that help to identify situations to send alerts, decision-making and help to prevent or escape risk areas.

Table 1: Rules of the flooding for cities in basin of rivers (meters) - adapted [23].

City (x,y)	Normal	Caution	Alert	Emergency
Blumenau	LW ≤ 4,0	4,0 < LW ≤ 6,0	6,0 < LW ≤ 8,5	LW > 8,5
Indaial	LW ≤ 3,0	3,0 < LW ≤ 4,0	4,0 < LW ≤ 5,5	LW > 5,5
Apiúna	LW ≤ 4,0	4,0 < LW ≤ 6,0	6,0 < LW ≤ 8,5	LW > 8,5
Rio do Sul	LW ≤ 4,0	4,0 < LW ≤ 5,0	5,0 < LW ≤ 6,5	LW > 6,5
Ibirama	LW ≤ 2,0	2,0 < LW ≤ 3,0	3,0 < LW ≤ 4,5	LW > 4,5
Ituporanga	LW ≤ 2,0	2,0 < LW ≤ 3,0	3,0 < LW ≤ 4,0	LW > 4,0
Taió	LW ≤ 4,0	4,0 < LW ≤ 6,0	6,0 < LW ≤ 7,5	LW > 7,5
Rio do Oeste	LW ≤ 4,0	4,0 < LW ≤ 6,0	6,0 < LW ≤ 9,0	LW > 9,0
Trombudo Central	LW ≤ 3,0	3,0 < LW ≤ 4,0	4,0 < LW ≤ 6,0	LW > 6,0
Timbó	LW ≤ 3,0	3,0 < LW ≤ 5,0	5,0 < LW ≤ 7,0	LW > 7,0
Benedito Novo	LW ≤ 1,5	1,5 < LW ≤ 2,5	2,5 < LW ≤ 3,5	LW > 3,5
Rio dos Cedros	LW ≤ 2,0	2,0 < LW ≤ 4,0	4,0 < LW ≤ 6,0	LW > 6,0
Brusque	LW ≤ 3,0	3,0 < LW ≤ 4,0	4,0 < LW ≤ 5,0	LW > 5,0
Botuverá	LW ≤ 3,0	3,0 < LW ≤ 4,0	4,0 < LW ≤ 8,0	LW > 6,0
Vidal Ramos	LW ≤ 3,0	3,0 < LW ≤ 4,0	4,0 < LW ≤ 5,0	LW > 5,0
Gaspar	LW ≤ 4,0	4,0 < LW ≤ 6,0	6,0 < LW ≤ 8,5	LW > 8,5
Ilhota	LW ≤ 6,0	6,0 < LW ≤ 8,0	8,0 < LW ≤ 10,5	LW > 10,5
Itajaí	LW ≤ y	y < LW ≤ x	y < LW ≤ x	LW > y

2.2 Achieved and Expected Results

The implementation of portal of public access to information monitoring and alert levels of rivers in the basin of the Itajaí, will be available for Free, open access through (http://opencgfw.eng.br/portal-sadpreai/). With the implementation of the portal are treated numerous features that later will provide interoperability between different data sources to collaboration with public or private foundations systems.

The concept the use of the internet of things for intensifying the integration and interoperability with systems that require monitoring data and alerts, became certified. And initially in prototyping visualization layer for user interfaces are tested through (http://alertaitajai.com.br/), as shown in figure 4 for analysis of data collected from sensors different along the sampling river.

The work is being developed with partial results and limited to experiments with hardware (sensors) specific. But the conceptual model has been refined as the need arises integration with new systems, becoming more robust the proposed work forward the demands of the region [24]. The project aims to provide a computational environment of great capacity for collecting, processing and analysis, low cost of

implementation and acquisition of equipment, made possible through the web portal the database and share hardware resources with open and free standards in accordance [25,26 and 27].

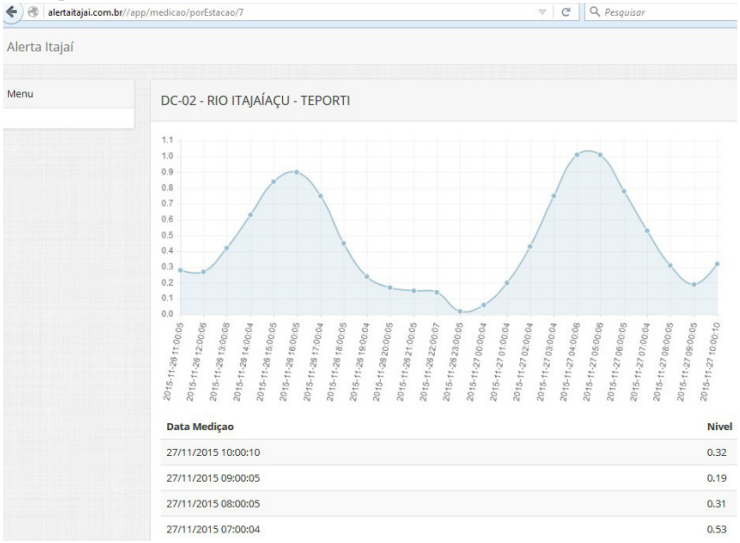


Fig. 4. Screen for monitoring by analysis of the collection of sensor data collected.

3 Conclusions

However, it was presented an interoperable computing architecture model for data collection and storage applied to alert the basin of the Itajaí-SC-Brazil. With the development of software to capture data from sensors and starting the storage proposed architecture portal users can perform complex queries and tasks from collection, processing, storage and analysis of data. Through the proposed portal is to share resources in position tack technologies, allowing to explore new resources, especially those powered by real-time data for flood prevention, flooding and inundation. Through the sharing of computing resources can enhance interoperability, transparency and fault redundancy at critical moments, as the use of large servers, where many times the cost of acquiring and retaining impeding the development of innovative actions. This work provides the first steps computational integration of hardware and software which will be presented and specified in future work as sensors built from the Arduino and Raspberry architecture. Finally, with adherence to OGC standards specifications will be implemented in work futures, observation of standards for interfaces services, service planning, standardization for the formats information model of representation of water observations data, with the intent of allowing the exchange of such data sets across information systems, especially the SADPreai.

References

1. MOMO, R. Marcos; REFOSCO, C. Julio; Arquitetura computacional baseada em computação GRID, aplicada a sistemas de informação geográfica na gestão de risco e alerta da bacia do rio Itajaí. Anais XV Simpósio Brasileiro de Sensoriamento Remoto - SBSR, Curitiba, PR, Brasil, INPE, pp.8865 (2011)
2. CORDERO, Ademar; MOMO, R. Marcos; SEVERO, L. Dirceu; Previsão de cheia em tempo atual, com um modelo Armax. XIX Simpósio Brasileiro de Recursos Hídricos, (2011)
3. Embrapa. Sistema Brasileiro de Classificação de Solos. 2.ed. Rio de Janeiro: Embrapa Solos, (2006)
4. SILVA, M. Jakson. Desenvolvimento de sistema computacional de apoio à tomada de decisão em situações de risco de Enchente, Inundações e Alagamentos (SAD-PREAI). Instituto Federal Catarinense – Câmpus Camboriú. ETIC, (2013)
5. GOMES, L. R.; ASSIS, D. L.; MORAES, A. F.; Based System on Decisions Making for Environmental Preservation. New Contributions in Information Systems and Technologies - Volume 353 of the series Advances in Intelligent Systems and Computing pp 665-669 (2015)
6. THEISS, Juliano. SAD-PREAI v.2 – Sistema de predição para apoio à tomada de decisão em situações de risco de enchente, alagamentos e inundações. IFC – Câmpus Camboriú, (2014)
7. SILVA, S. Gelson. Sistema de Informações para Apoiar o Sistema de Alerta da Bacia do Itajaí. TCC Graduação em Sistemas de Informação - Fundação Universidade Regional de Blumenau, (2009)
8. DAZA, Javier Medina; AGUILAR, Luis Joyanes r; RUIZ, Carlos Pinilla;. Aplicativo Web para la Fusión de Imágenes Satelitales. RISTI – Revista Ibérica de STI, Nº 11, pp.17 (2013)
9. COLETTE, Maria Madalena, SILVA, Maria Helena C.; Novos Cenários de Aprendizagem, Inovação e Sustentabilidade: Uma Pesquisa-Ação na Gradução em Ciências e Tecnologia. RISTI – Revista Ibérica de STI, Nº E2, pp.55 (2014)
10. Ministério do Meio Ambiente. (2015) < http://www.mma.gov.br/>
11. DÍAZ, Pablo; PARAPAR, Jorge; SANTÉ, Inés; David MIRANDA, Rafael CRECENTE. Sistema SIG-Web para la Gestión de las Alegaciones a un Plan General de Ordenación Municipal. RISTI – Revista Ibérica de STI, Nº 3, pp.65 (2009)
12. i3GEO - Ferramentas de processamento de dados geográficos web. (2015) <http://www.i3geo.com.br/>
13. Projeto MapServer – Open Source Web Mapping. (2015) <http://mapserver.org >
14. Projeto OSGeo - Open Source Geospatial Foundation. (2015) <http://www.osgeo.org/home>
15. GISCloud - Cloud in GIS Cloud. (2015). < http://giscloud.com >
16. MORAES, F. André; BASTOS, C. Lia. Framework of Integration for Collaboration and Spatial Data Mining Among Heterogeneous Sources in the Web. ACM SIGSPATIAL 18th International Conference Advances in Geographic Information Systems - Data Mining for Geoinformatics, v. 1, pp. 19-28, (2010)
17. MAYOL , Jaime Jaume; NADAL, Gabriel Fontanet; COLL, Antonio Bibiloni. Análisis y procedimiento de mejora de la accesibilidad web. RISTI – Revista Ibérica de STI, Nº 7, pp.61 (2011)
18. PORTA, Juan; PARAPAR, Jorge; GARCÍA, Paula; FERNÁNDEZ, Gracia; TOURIÑO, Juan; ÓNEGA, Francisco; DIAZ, Pablo; MIRANDA, David; CRECENTE, Rafael. Sistema de Información del Banco de Tierras de Galicia. RISTI – Revista Ibérica de STI, Nº 9, pp.27 (2012)
19. Portal Brasileiro de Dados Abertos. Secretaria de Logística e Tecnologia da Informação do Ministério do Planejamento, Orçamento e Gestão. (2015) < http://dados.gov.br/dados-abertos/ >
20. Software Público Brasileiro – (2015) < https://softwarepublico.gov.br/social/ >
21. SigmaCast - Sistema de Informações Geográficas para uso dedicado à Meteorologia. CPTEC/INPE. (2015) < http://satelite.cptec.inpe.br/sigmacast/ >
22. VÁZQUEZ, Yolanda García; SEXTO, Carlos Ferrás. Conflicto, interacción e identidad on-line. Fundamentos teóricos y estudio de caso de una comunidad virtual rural. RISTI – Revista Ibérica de STI, Nº 1. pp.52 (2008)
23. Centro de Operação do Sistema de Alerta da Bacia do Rio Itajaí. (2015) <http://ceops.furb.br>
24. CEMADEN. Centro Nacional de Monitoramento e Alertas de Desastres Naturais. (2015) < http://www.cemaden.gov.br/ >
25. OGC® Sensor Observation Service Interface Standard (2012) <https://portal.opengeospatial.org/files/?artifact_id=47599>
26. OGC® Sensor Planning Service Interface Standard 2.0 - Earth Observation Satellite Tasking Extension (2014) < http://portal.opengeospatial.org/files/?artifact_id=40185 >
27. OGC® Sensor WaterML 2.0: Part 1- Timeseries (2014) < https://portal.opengeospatial.org/files/?artifact_id=57222 >

Cognitive Learning Strategies of Information Technology Students in UAE University

Nabeel Al-Qirim[1], Aishah Rashid Yammahi, Maraim Ahmed Yammahi

[1]College of Information Technology, United Arab Emirates University, Al-Ain, UAE,
nalqirim@uaeu.ac.ae

Abstract. This research identifies the learning strategies of UAE University (UAEU) students. The importance of this research in UAE stems from the fact that learning strategies may vary from one country to another and hence, UAE students may (hypothesized) possess unique cultural and behavioral learning strategies. This research introduces a theoretical pedagogical framework made of seven learning strategies and endeavored to shortlist their perspective items and measures through a focus-group (FG) methodology. The selected learning strategies were the students' motivation, time-poorness, mastery effort, assessment focus, competitiveness, and listening. The research examined and explained their importance using a survey research on a random sample of 179 UAEU students. This research provided interesting insights and contrasts pertaining to the learning strategies of UAEU students. Implications arising from the framework are discussed highlighting different theoretical as well as professional contributions and contentions and portrayed a path where pending issues are addressed by future research.

Keywords: Learning strategies, motivation, mastery effort, assessment focus, time-poorness, competitiveness, listening, UAE University, IT female students.

1. Introduction

It was reiterated by the literature that students employing cognitive strategies and organizing oneself at a high level have a direct impact on their achievements [4]. It also endorses the notion that students need to develop sound strategies to increase their learning effectiveness and to excel [12] and be an independent learner as well [4]. However, the challenging task of identifying the different predictors of academic performance could shed more light into the learning process [6]. Learning strategies can be defined as "behaviors and thoughts in which a learner engages and which are intended to influence the learner's encoding process" [5: p.3]. They are perceived as a schematic structure in the form of a chain of learning activities performed by the learner to get hold of new information [4]. Thus, affecting the way a learner selects,

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_18

acquires, organizes, or integrates new knowledge [10]. Strategy is like an arrangement to achieve something or employment of a plan that is developed to reach a goal [12]. Teachers attempt to teach students what and how to learn, remember, think, and motivate themselves [10].

Thus, Learning strategies cover both cognitive and meta-cognitive and affective strategies [4]. Therefore, it is important to know what drives learning. Those are the features that keep students continue working to fulfill their objectives [4].

In a review of the literature [4], the following implications were highlighted. Initially, meeting the diverse needs of different higher-education students (further compounded recently) represent a challenges for teachers. Secondly, the introduction of technological tools in education did help but in part as identifying students' individual differences and their learning needs should come first. Stemming from this perspective this research is interested in focusing at different learning strategies and explaining their impact on student learning. It is clear that this topic is vast and spans different contexts and disciplines. Accordingly, the following research question is posited, how can UAEU students acquire life-long effective learning strategies. This leads to the following sub-questions and expected objectives:

i. What are the possible impacting factors or models of student learning strategies?
ii. How those factors impact student learning strategies.

Thus, the purpose of this research is to identify the different learning strategies. Then the research will discuss their importance from the perspective of UAEU students. In the following the research introduces the literature review followed by the research methodology, findings, discussion and conclusion respectively.

2. Determinants of learning

According to the literature review in this research, six factors were identified to influence students' learning strategies and their academic achievement (AA).

2.1 Student motivation

Motivation can be considered as student's needs, wants, interests and desires to participate in the learning process to excel in his/her AA [4]. Motivated student shows great desire, drive or emotion to participate in the learning process and it is directly related to academic success unless there is a problem with cognitive skills [4]. Wolters [11] found that the importance of motivational self-regulation strategies could be revealed by finding a positive relationships between students' use of these strategies and indicators of their cognitive engagement, effort, and classroom performance. He contended that models of self-regulated learning may need to be upgraded to include more directly students' purposeful control of their behavior or thinking for the purpose of impacting their effort and tenacity in fulfilling their different tasks. In a review of the literature [4], three main motives of learning

emerge: surface (memorizing), deep (understanding) and competitive where each motive entails adopting a different learning strategy.

2.2 Time-poorness

Time perspective in academia and industry has proved to be a good predictor of students' learning behavior and academic achievement. Time-poor students feel pressurized as they feel they lack the time to complete their learning activities and this puts high cognitive and metacognitive demands on students [4]. They tend to engage in surface rather than deep learning. Managing time has been associated with better learning performance. Many students find themselves unable to spend as much time on their studies because they are part-time or even full time work and because of family commitments [4]. It is not a matter of having more time to finish a lengthy task rather utilizing better time management techniques could allow for the completion of the task within adequate time. Such techniques involve making to-do-lists, priority lists, task to complete daily, divide the task to smaller pieces [3].

2.3 Mastery effort

Effort can be defined as the amount of time spent on studying [1]. Also, effort refers to whether a student tries hard, asks for help, and/or contributes in the class. Studies of student effort propose that the more difficult a task appears, the less likely it is that the student will be motivated to take the task on. However, studies of student effort also propose that effort is linked with achieving well on a task. Therefore, students might be expected to find out what they need to study, study it, and be successful–if they have the ability to do the assigned task, confidence in this ability, and no concern about the task [2].

2.4 Assessment focus

Goal focus or assessment focus [4] is defined as information provided by an agent (e.g., teacher, peer, book, parent, self, and experience) regarding what the agent believed was important and what was required by the assessment procedure [11]. In this regard students consider highly the assessment requirements and making sure that in the game of learning, the lecturer holds the key to their success [4]. On other hand, when teacher clearly specified the assessment requirements, students were more comfortable and focused on signs and other information given by the lecturer about what counts as important material and what would be in the examination. The same researchers believed that achieving what the lecturer wanted is an important strategy for success [4]. Assessment focus affects what and how students learn, student motivation, and sense of well-being [1]. If used appropriately assessment could substantially improve learning, but that most of the time, the impact of assessment practices was to limit, and even to reduce, student learning. It was only recently that researchers started to realize that using assessment as an integral part of instruction

could improve learning outcomes for students, and at the same time, attempts were made to connect classroom practice to related bodies of research, notably feedback, motivation, attribution, and self-regulated learning [1].

2.5 Competitiveness

Competition is a contest between individuals or groups. It arises when two or more parties strive for a goal. The person who wants to win the competition thinks creatively and works for doing the best [3]. Competitiveness has usually been viewed as a negative trait as it leads to suboptimal outcomes. However, other research indicated that competitiveness may hold different meanings for people from individualist and collectivist cultures. More specifically, some research viewed competition as something that can lead to self-improvement and personal growth [9].

2.6 Listening

Sight and sound and touch are considered important in learning [4]. Listening is a passive skill that students could acquire spontaneously during classroom activities. In a listening activity, some students like to listen to the text once or twice to understand and hold more information [1]. In a listening process, the listener must use a wider variety of knowledge sources, linguistic and non-linguistic, to understand and take the incoming information [2].

3. Research Methodology

Information about UAE's society and culture could be found at (UAEInteract.com). Information about United Arab Emirates University (UAEU) could be found at (UAEU.ac.ae). UAEU has nine colleges. There were 14,024 students registered at the University during the academic year 2013/2014. Enrolled male students represented 23%, while female students represented 77% of the entire student population.

3.1 Item development and selection

Data for the study was collected by means of a survey questionnaire. Standard measures (valid, reliable) were adopted where possible during the design of the questionnaire [7,8]. Motivational regulation measures (28) were based on Wolters [11]. Measures for time-poorness (4), mastery effort (6), competitiveness (5), assessment focus (4) and listening (5) were based on Lynn's [4] converging factors. Some of the previously validated measures had to be adapted to meet the specifications of UAEU students. Individual characteristics of respondents were based on basic demographic details of students like their age, education level, gender, laptop ownership, college, and nationality. However, before delving into the survey research, there was a need to generate initial insights around the different measures in terms of

their importance to learning strategies and hence, an attempt was made to reduce some of the measures found unimportant or irrelevant using focus group research.

Insights from the FG has helped in reducing the number of measures to the ones depicted in Appendix 1. Some of the measures had to be adapted to best suite UAEU students' needs. Two items were introduced into mastery-effort (3,4) as they were raised by the FG discussions as important strategies. Respondents provided their answers using a 5-point Likert-scale.

3.2 Survey research

An Arabic translation was provided under each question in the survey questionnaire. A sample made of 350 students was identified from UAEU students. The survey questionnaires were given to students by hand. This actions in addition to the Arabic translation are expected to increase the response rate. After several reminders this has resulted in having 193 responses from which only 179 were legible questionnaires in terms of their completeness. The effective response rate was around 51 percent and this seemed adequate in line with prior research [7,8]. Responses were coded and keyed into the SPSS statistical software tool. At this stage, this research is interested in looking at students' responses and in providing analysis around each response (average).

4. Findings and Analyses

As shown in Table 1, the majority of respondents came from the College of IT (CIT) and hence, this study was more biased towards this segment of students. This is maybe attributed to the fact that this study was conducted by a team from CIT and to the formal and informal follow-up reminders to respondents to complete the survey questionnaires. Due to its strategic importance to UAE, enrollments in CIT is confined to UAE's nationals who yield 80% or above on their high school (secondary) certificate.

The majority of respondents were singles (87%), females (90%), UAE citizens (98%) and the reminders were from other Arab origins. Most of the responses came from students in their second (22.3%) third (19.0%), fourth (26.8%) and fifth (13.4%) year in UAEU. All respondents owned a laptop. The dominance of the female segment over males is attributed to the inherent dominance of the female segment across the whole university as highlighted above.

Table 1. Distribution of responses across the different colleges in UAEU

College	Frequency	Percent
College of IT	130	72.6
College of Science	20	11.2
College of Engineering	3	1.7
College of Education	1	.6
College of Humanities and Social Sciences	13	7.3

College of Law	2	1.1
College of Business and Economics	9	5.0
College of Medicine and Health Sciences	1	.6
Total	179	100.0

As shown in Table 2, the majority of UAE respondents came from the Emirate of Abu Dhabi and Al-Ain city (39.7%) followed by Fujairah (20.1%), Sharjah (17.3%), and Ras Al Khaima (RAK) (15.1%).

Table 2. Distribution of responses across the different Emirates in UAEU

Emirate	Frequency	Percent
Abu Dhabi and Al-Ain cities	71	39.7
Dubai	5	2.8
Sharjah	31	17.3
Ajman	8	4.5
Ras Al Khaima	27	15.1
Fujairah	36	20.1
Umm Al Quwain	1	.6
Total	179	100.0

4.1 Motivation

Motiv3,4,5,6,7,8 scored relatively the highest in this context (Table 3). This indicates that students resort to reminding themselves about the importance of getting good grades, to push their limits to see if they can do better, work hard in order to learn, try to become good at what they are learning or doing and study at times when they can be more focused. It is interesting to know about the mechanisms put in place by students to act upon such motivating issues. It is also worth investigating whether such views were sporadic or as a result of a continuous effort (i.e., lifelong learning). In the second set of views, it shows that UAEU students try to make university work more enjoyable by focusing on the fun part of it, try to relate the materials to their life activities and get rid of distractions that are around them but at a moderate level. In line with the above discussions, students had a lesser view about the enjoy-ability of their courses and the detachment of such courses from their real world. This is an interesting contrast between the two sets of views which shows a void between what the students learn in the classroom and their outside world. This calls for extending surrogates to what is being taught to students and link it to the outside world.

Table 3. Motivation

Item	Mean	Std. Deviation
Motiv7	4.30	.910
Motiv8	4.30	.934
Motiv4	4.14	.935
Motiv3	4.14	.953
Motiv5	4.13	.956
Motiv6	4.08	1.008

Motiv9	3.82	.991
Motiv2	3.75	1.036
Motiv1	3.66	1.006
Overall averages	4.04	0.97

Overall, the research findings suggested that UAEU's students are motivated.

4.2 Time-poorness

The items of this factor scored moderately above the average on the 5-point Likert-scale (Table 4) and hence, agreeing that time-poorness impact their learning negatively. This is due to: not having enough time to study, work and family commitments, and not putting sufficient time to understand what they read. It would be interesting to investigate students' teaching loads each semester and whether it is adequate and balanced. Also to investigate their study-time utilization inside and outside the campus and between students that live inside and outside (usually in UAE's internal hostel) Al-Ain city.

Table 4. Time-poorness

Item	Mean	Std. Deviation
Time1	3.35	1.088
Time2	3.35	1.138
Time3	3.26	1.103
Overall averages	3.32	1.11

Overall, the research findings suggested that UAEU's students are moderately time-poor.

4.3 Mastery effort

Student responses showed overall modest effort (Table 5). As per the measures, students almost understand things though seemed to be difficult at the first instance, being strict in their studying habits, more dependent on the illustrative course slides than any other learning tools, and understand the assessment requirements earlier on in the course. It is interesting to correlate such items with student's i.e., GPA by any future study. On the other hand, they spend less effort on reviewing the additional readings, as suggested by the lecturer, and they don't rely on the prescribed textbooks in studying (Effort2,4 scored the lowest). The above contrasts may suggest a separation between students' habits to learn and their actual learning confined to the course slide. For example, although students viewed themselves as strict in their studying habit contradicts the depth of such studies. This is worth for further investigation by any future study.

Table 5. Mastery effort

Item	Mean	Std. Deviation
Effort7	3.94	.910

Effort1	3.70	.988
Effort6	3.60	.962
Effort5	3.35	1.007
Effort3	3.18	1.124
Effort4	2.97	1.052
Effort2	2.87	1.083
Overall averages	3.37	1.018

4.4 Assessment focus

According to the high scores in Table 6, most UAEU students pay close attention to information that the lecturer provides about exams, they scout out for any hints, they try to keep in mind exactly what the particular lecturer want when working on assignments.

Although such findings suggest consistent ambitious-attitude at the students' side in order to pass and to excel in the different assessments such new insights, in the light of the above contrasts, suggests a possible void between what is happening inside and outside the classroom. The fear is that UAEU students are more concerned with passing a corresponding course than learning per se. This predisposition is worth of further investigation.

Table 6. Assessment focus

Item	Mean	Std. Deviation
Focus1	4.30	.947
Focus4	4.30	.885
Focus3	4.20	.978
Focus2	4.12	.956
Overall averages	4.23	0.942

4.5 Competitiveness

From Table 7, it seems that UAEU students seek to get top grades in their studies to get the best job, see themselves as ambitious, and to prosper financially respectively. Interestingly, being ambitious came after attempting to get higher grades and jobs. Another interesting finding here is that financial incentives were not the main driver to obtain a university degree. These findings worth further investigation.

Table 7. Competitiveness

Item	Mean	Std. Deviation
Competi1	4.39	.889
Competi2	4.08	.953
Competi3	3.00	1.213
Overall averages	3.82	1.018

4.6 Listening

According to Table 8, he highest scores (Listen3,5) showed that students would understand better if the lecturer explains things rather than reading about them and prefer listening to the lecturer than reading textbooks (as highlighted above). This shows a strong propensity by UAEU students to rely on the lecturer's explanations as a learning vehicle than reading the textbook. The listening aspect is more effective if students hear explanatory rather than reading aspects of the taught material in textbooks. It is important to measure students' recollection of what they hear and learn in the classroom by any future research vis-à-vis literature on cognitive capability and the absorption capacity. Although listening is important to learning but this not sufficient to effectively learn and remembering the taught material. Given the above discussion about relying on the course-slides and less on the textbook for learning may suggest a weakness in learning in general and reading-capabilities more specifically of such students. This could be attributed to time-poorness above or to weakness in the English language e.g., a fear or discomfort in reading a large amount of English Text. These important assertions worth further investigations.

Table 8. Listening

Item	Mean	Std. Deviation
Listen5	4.47	.837
Listen3	3.96	1.054
Listen4	3.58	1.170
Listen1	3.46	.967
Listen2	3.45	.961
Overall averages	3.78	0.998

Finally, Table 9 shows the overall means of the different items in this research.

Table 9. Overall means of the different items

Item	Mean	Std. Deviation
Assessment Focus	4.23	0.942
Motivation	4.04	0.97
Agreeableness	3.97	0.94
Extraversion	3.87	0.95
Competitiveness	3.82	1.018
Openness	3.78	0.961
Listening	3.78	0.998
Conscientiousness	3.45	1.048
Mastery Effort	3.37	1.018
Time poorness (item worded negatively)	3.32	1.11
Neuroticism (item worded negatively)	2.73	1.196

It could be argued here that overall, assessment focus, motivation, agreeableness, extraversion, competitiveness, openness, listening and conscientiousness respectively were the most important strategies adopted by UAEU students. Time-poorness was not a big problem but mastery effort needed to be boosted amongst UAEU students.

Neuroticism scored the lowest mean average and hence, UAEU students negated being of a high neuroticism nature.

5. Discussion and conclusion

This research was developed with a focus to understand student learning strategies in UAEU. This research reviewed relevant literature in pedagogy and developed a framework that highlighted important learning strategies. The potential impact of each variable on student's learning strategies is examined using a survey questionnaire. This research has theoretical as well professional contributions and contentions. At the theoretical level, this research generated further insights pertaining to UAEU's students learning habits. Although it was not possible to elucidate the significance of the research factors on student's success as such, the BF personality traits and the remaining factors shed interesting insights and contrasts at the same time on students learning strategies.

Findings from the case study suggest that UAEU's student learning strategies were modest. The highlighted contrasting views and the dominance of most responses around the average further suggests this posture. This could be attributed to personal as well as to cultural reasons as hypothesized in this research. Many of the enhancements could be achieved by designing programs aiming at enhancing student's learning capabilities and strategies. However, it is the cultural aspects that are more difficult to unveil and address.

Cultural issues require the cooperation and collaboration of the overall community surrounding learning in general and the family more specifically.

It is worth investigating the possible overlap between the different factors in general and between Motivation and Mastery effort more specifically by any future research. For example, the possible interrelationships between Motivation, and Mastery effort is highlighted in this research.

The expected outcome of this research will be of importance to researchers, professionals and policymakers interested in addressing weak and strong learning strategies. This is an initial research in this area in UAE and indeed, other researchers and universities maybe interested to understand the learning strategies of their students. Researchers could further use the suggested factors or add to them and test their significance on their contexts. Professionals would capitalize on many of the implications in this research (Table 10) to design and offer training programs and workshops aimed at students and officials in universities and elsewhere. Policymakers could consider many of the suggestion made in this research to devise effective policies to enhance student learning strategies.

Reference list

1. Kinga, R., McInerneyb, D. & Watkinsa, D. (2012). Competitiveness is not that bad…at least in the East: Testing the hierarchical model of achievement motivation in the Asian setting, *International Journal of Intercultural Relations*, 36(6), pp 446–457.

2. Graham, S. (2006). Listening comprehension: The learners' perspective. System, 34(2), 165–182
3. Koçak, E. & Bayır, R. (2009). Project and group based learning and competition based evaluation in lesson of microcontroller applications. Procedia - Social and Behavioral Sciences, 1(1), 1513–1518
4. Lynn, J. (2009). Learning orientations: Diversity in higher education. Learning and Individual Differences, 19(2), 195–208 London: Sage Publications.
5. Michou, A., Mouratidis,A., Lens,W. & Vansteenkiste, M. (2013). Personal and contextual antecedents of achievement goals: Their direct and indirect relations to students' learning strategies, Learning and Individual Differences 23 (2013) 187–194
6. Mitrofana, N. & Iona, A. (2013). Predictors of Academic Performance. The Relation between the Big Five Factors and Academic Performance. Procedia - Social and Behavioral Sciences 78, 125 – 129
7. Premkumar, G., & Roberts, M. (1999). Adoption of New Information Technologies in Rural Small Businesses. The International Journal of Management Science (OMEGA), 27, 467-484.
8. Thong, J. (1999). An integrated model of information systems adoption in small business. Journal of Management Information Systems, 15(4), pp. 187-214.
9. Vedel, A. (2014).The Big Five and tertiary academic performance: A systematic review and meta-analysis. Personality and Individual Differences 71, 66–76
10. Weinstein, C. E. & Mayer, R. E. (1983). The teaching of learning strategies. Innovations Abstracts, 5(32), 1-4. http://files.eric.ed.gov/fulltext/ED237180.pdf
11. Wolters, C. (1999). Relation between high school students' motivational regulations and their use of learning strategies, Learning and Individual Differences, 11(3), 281-299
12. Zimmerman, B. J. (1994). Dimensions of academic self-regulation: A conceptual framework for education. In D. H. Schunk & B. J. Zimmerman (Eds.), Self-regulation of learning and performance: Issues and educational applications (pp. 3-21). Hillsdale, NJ: Lawrence Erlbaum Associates.

Appendix 1. The survey questions

A. Extraversion

1. like to do a great deal of activities
2. like to be with others
3. can easily say to others what I think
4. do something not to get bored
5. happy and lively

B. Agreeableness

1. behave correctly and honestly with others
2. understand when others need my help
3. like to give gifts
4. treat my peers with affection
5. If a classmate has some difficulty I help her/him
6. trust in others

C. Conscientiousness

1. do my job without carelessness and inattention
2. When I start to do something I have to finish it at all costs

3. like to keep all my university things in a great order
4. It is unlikely that I divert my attention

D. Neuroticism

1. usually in a depressed mood
2. argue with others with excitement
3. easily get angry
4. easily lose my calm
5. usually feel guilty even about silly things

E. Openness

1. know many things
2. have a great deal of imagination
3. easily learn what I study at class
4. able to create new games and entertainments
5. like to know and to learn new things
6. would like very much to travel and to know the habits of other countries

F. Motivation

1. make university work enjoyable by focusing on something about it that is fun
2. try to find ways that the material relates to my life
3. remind myself about how important it is to get good grades
4. push myself to see if I can do better than I have done before
5. persuade myself to work hard just for the sake of learning
6. challenge myself to complete the work and learn as much as possible
7. think about trying to become good at what we are learning or doing
8. try to study at a time when I can be more focused
9. try to get rid of any distractions that are around me

G. Mastery effort

1. try to be strict with myself in my study habits, so that I can do the very best I can
2. look at most of the additional readings suggested by the lecturer
3. limit my studying to the slides only
4. use the prescribed textbook in my study
5. make sure I clearly understand the assessment requirements early in the course
6. usually set out to understand thoroughly the meaning of what I am asked to read
7. usually put a lot of effort into trying to understand things that at first seem difficult

H. Time-poorness

1. don't have enough time to do as much study as I need to for my course
2. Other things such as work and family do not leave me enough time to think about the ideas from my studies
3. Often I don't have enough time to really understand the ideas I read about

I. Assessment focus

1. pay close attention to information the lecturer gives about exams

2. Lecturers sometimes indicate what is likely to be in the exams, so I look out for hints
3. take care to find as much information as possible on what will be in an exam
4. When working on an assignment, I try to keep in mind exactly what the particular lecturer seems to want

J. Competitiveness

1. want top grades in my studies so that I will be able to select from among the best jobs available
2. see myself as an ambitious person
3. The main benefit of a university education is that it will enable me to earn more money

K. Listening

1. remember best things that are spoken
2. remember best what I hear
3. prefer listening to the lecturer than reading textbooks
4. prefer listening to reading
5. understand better if the lecturer explains things rather than reading about them

IoT in Education: Integration of Objects with Virtual Academic Communities

Jack Marquez[1], Jhorman Villanueva[1], Zeida Solarte[1], Alexander Garcia[1],

[1] Universidad Autonoma de Occidente, Calle 25 No 115-85,
760030 Cali, Colombia.
{jdmarquez, javillanueva, zsolarte, agdavalos}@uao.edu.co

Abstract: Internet has changed the way people interact and education has not been immune to this change, which has created new forms of interaction between teachers and students that helps to improve the teaching and learning process, and expands the context in which students learn. Moreover, with the integration of objects to the Internet, new possibilities for applications and services in domains such as education are available, where its use can lead to innovations that could facilitate the teaching-learning process. In this paper a new model for integrating objects to Virtual Academic Communities (VAC) is proposed. Tests of the proposed model were performed by the implementation of a case study, and the outcomes show that using IoT provides a more engaging learning environment for students and more data about the learning process to help teachers to enhance their knowledge about the learning pace of their students and their learning difficulties.

Keywords: Virtual Academic Communities, IoT, Architecture, learning process, education.

1 Introduction

Technology is one of the elements that have strongly influenced education in recent years, particularly since the Internet boom. Today we live in an era where the amount of data, knowledge and technological devices are changing the mindset of institutions in their teaching and learning processes. Taking technology as one of its tools, education is changing from a model by which knowledge is only transmitted to one where it is presented in an active and collaborative manner, seeking to improve the processes of teaching and learning.

Students acquire knowledge more easily if they do so interactively, i.e. where the activities actually motivate them to learn. Technology presents this great feature to get the attention of people and can be a great help in the teaching and learning process.

The Internet of Things (IoT), is barely being integrated into the application domain of education. This integration of technology shows great potential to enhance the teaching-learning process, providing support to make real the premise "anytime

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_19

anywhere", not only in the common areas of education, taking advantage of the possibility of having a fully transparent and connected environment for the user.

The connection of objects in an educational environment can produce large amounts of data, such as when students are using educational resources, how they are using them, if they are really evolved and how many of them (through evaluation). Additionally, the integration of objects to the Internet or the Internet of Things opens new possibilities for applications in domains such as education, where its use can lead to innovations that enhance the teaching-learning process.

The inclusion of the IoT in the teaching-learning process enables the interaction between objects that are available in educational environments and students, and teachers. However, the integration of objects in the education domain is an issue that must be further researched because previous research works have focused primarily on aspects such as: network communications (protocols, technologies, etc.), objects identification, and architectures, among others.

This paper presents a new model for integrating objects that are available in educational environments with Virtual Academic Communities (VAC). One of the changes is that objects go from being passive elements in educational environments to becoming more active objects and more involved in supporting the teaching-learning process.

An adapted architecture is proposed for implementing this new integration model. This architecture is basically an adaptation of previous architectures for some IoT application domains, and it uses the paradigm of layered architectures and architectural styles such as REST architectures.

The rest of the paper is organized as follows. Section 2 reviews the background on the IoT in education; Section 3 proposes a new integration model of objects available in learning environments with Virtual Academic Communities (VAC). Section 4 presents an adapted architecture for implementing the new model. Section 5 presents a case study, which was proposed to test the new model. Section 6 discusses the outcomes of the test and Section 7 presents conclusions.

2 IoT in the Education Domain

Some research studies are looking to integrate the IoT in educational environments in order to improve the learning process and facilitate the teaching process, because according to these research studies the interaction of students with real-world objects promotes improved learning and understanding of a particular subject matter. Integrating IoT as a new actor in educational environments can facilitate the interaction of people (students and teachers) and (physical and virtual) objects in the academic environment. This interaction means that objects can communicate with each other and with the people who are in these educational environments.

Below are listed (see Table 1) some of the most relevant publications that were found in the literature on the application of the IoT in education through various works, researches and some case studies.

Table 1. Classification of publications on the application of IoT in education

Reference	Description	Differences
[1]	Interactive model based on IoT for English teaching.	This model is specific for English teaching and it use voice and visual sensors, which can correct English learners' shape of mouth and pronunciation.
[2]	IoT environment to teach elementary programming skills.	This research combines three concepts: IoT, Living Labs, and intelligent Campus (iCampus).
[3]	Lifelong learning environment using IoT and learning analytics.	The system use tagged objects and LMS for collecting data and performing the analysis of students' learning process using learning analytics techniques.
[4]	Ubiquitous learning environment using IoT.	Authors designed a technical framework and the system architecture of u-learning. Framework includes three layers: perception, network, and application layer.
[5]	Environments equipped with IoT devices to create new learning scenarios.	A system that allows students to interact with physical objects, which are virtualy associated with a subject of learning.

2.1 Objects in Educational Environments

Commonly in educational environments such as classrooms and laboratories, among others, there exist a number of physical objects (laboratory equipment, computers, books, collectibles, etc.) that are provided for the daily use of students and teachers to perform different teaching and learning activities. Integrating these objects to the VAC would allow additional types of activities that contribute to facilitating the teaching and learning processes.

Currently interaction with physical objects can be seen as static, since it implies that students perform processes manually requiring them to be in the same place as the object. While the integration of objects to the VAC could make this interaction more dynamic, because these may generate additional data to students and teachers, allowing interaction between them that is both virtual and autonomously, and supporting the teaching and learning activities in a more direct way.

The IoT has played an important role in the integration of the physical and virtual worlds. Integrating physical objects can help to improve services/applications, and thus processes, such as education, can be enriched with more data and new forms of interaction that help to generate more integrated educational environments and facilitate teaching-learning activities.

3 Integration Model of Objects to VAC

The Virtual Academic Community, VAC, is formed by one or more groups of individuals linked by common interests, committed to continuous learning processes, whose main objective is the shared construction of knowledge, using ICT as a means of expression, as a communication tool, as a teaching resource and even as a management tool [10]. These are the possibilities of communication and interaction that are generated in the VAC, the determinants that have facilitated its position as a resource of great demand for building knowledge and learning collaboratively.

The intention to integrate objects to the VAC is that they become active elements (physically and virtually) inside the VAC and allow supporting communication activities, teaching, learning, monitoring and management, among others. Having a characterization and differentiation of such objects, allows evaluating and understanding the level of intervention and involvement in space, time and forms of interaction that are foreseen.

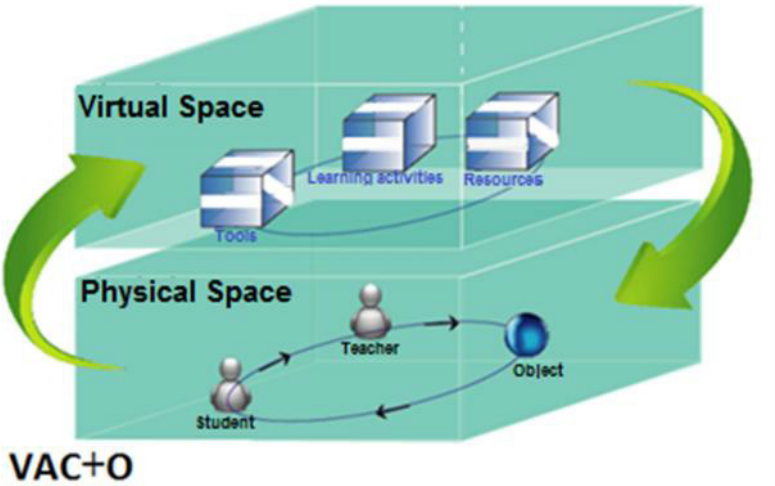


Fig 1. VAC spaces: virtual and physical

Differentiation of these spaces is related to the space, in which the objects exist, which may be physical or virtual (see Fig. 1). The first is the physical place where

actors that make up the VAC, such as the teacher (tutor) or teachers share and live. In this space are located physical objects belonging to the environment (classroom, laboratory, libraries, auditoriums, etc.).

A virtual space (see Fig. 1) is a non-physical space that is not tangible, for which the categories of time and position are not possible. It is specifically designed for the interaction of people and for the processing, storage, distribution and exchange of information. Some of the best known virtual spaces are social networks, chat rooms, discussion forums and email.

Regarding the VAC, it is clear that the elements that support it, are located in the virtual space, where tools like blogs, forums and chat rooms are found; the contents in different formats (text, image, audio/video) that are generated and consumed; and learning activities designed to be performed by students individually or collectively (see Fig. 1). The virtual object par excellence in the learning environment is the LMS (Learning Management System), which is a learning management platform where the services and tools such as authentication, administration, evaluation, communication, and collaboration, among others are integrated. Below are briefly described the actors and elements that compose these two spaces (physical and virtual):

a) Physical space: In this space coexist the physical actors that make up the VAC, they can generate content and interact with other actors, as follows:

- Teacher: is responsible for teaching a particular topic and designs the learning activities.
- Student: is responsible for participating in learning activities that can be collective or individual which may involve the use of and interaction with objects.
- Objects: are the physical objects that are found in different educational environments like laboratory equipment (e.g. measuring instruments, tools), books, textbooks, desks, and boards, and so on. These objects facilitate the work of students and teachers and allow them to carry out the activities of learning / teaching.

b) Virtual space: in this space are the elements that support the VAC, as follows:

- Tools: typically, tools such as blogs, forums, chat rooms, etc., which together with the contents (text, image, audio / video) are used by the actors (students, teachers, objects) to make and facilitate teaching-learning activities.
- Contents: are elements such as text, images, audio, and video that are generated and consumed by the actors.
- Learning Activities: are the activities performed by the students, which can be collective or individual, and among them are: workshops, homework, lab

work, etc. The objects come to play an important role in these activities, because what is sought by integrating them to the VAC is to help facilitate the learning process and improve interaction with them.

3.1 Objects Classification

With regard to the objects that can be integrated into the VAC it is understood that they are those, which through unique addressing schemes can interact with other objects in order to achieve objectives set by design. In this sense, the classification of these objects ranges through the performance of any of the following categories of analysis [6], [7], [8]: level of interaction, processing capability, and intelligence. The following objects classification is proposed:

- Tagged Objects: are objects that are tagged using technologies such as RFID or NFC that hold information about them (codes, identification, description, etc.). They are also known as "Non-IP Objects", since they do not support Internet protocols and do not have an IP address.
- Smart Objects: they are endowed with certain computing capabilities, storage, and communications, which allow them to perform data processing and communicate with other objects and software platforms (e.g. send data about their status).
- Social Objects: now taking a generational leap from objects with "some intelligence" to objects with a certain "social awareness", thus resulting in the so-called "social objects" [9]. This type of object inherits the capabilities of smart objects and thanks to them they may be part of a community of objects and are able to relate to each other independently to cooperate in certain activities.
- Virtual objects: they are digital elements that have a specific purpose, comprise a series of data and can perform different actions. They are characterized by a very flexible level of interaction that allows them to interact through interfaces with people, applications/services or other objects.

These different types of objects can be integrated to a VAC (see Fig. 2) and become an active part of it, thanks to the possibilities of interaction that they offer. Integrating physical objects to the VAC seeks to take advantage of their specific qualities (physical and technical) to support and strengthen services and processes in terms of individual and collaborative construction of knowledge and learning; for this purpose the exchange of data between physical objects is very important, including between physical and virtual objects and between objects and people.

This is considered as a positive advance in relation to the forms of interaction in a VAC, as there is a broadening of possibilities because it is no longer just about the teacher-student and student-student or student interaction with tools, resources,

content and learning activities; in short, the range is extended to integrate interaction with objects.

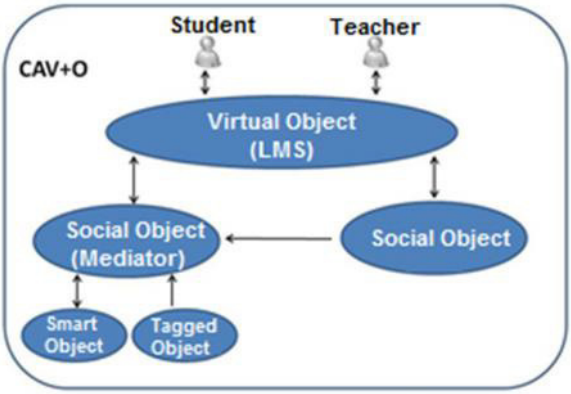


Fig 2. Objects integration and their relationship with VAC actors

4 Architecture for IoT in Education

To facilitate the implementation of the proposed model of integration an architecture that can be used to structure scenarios in educational settings was defined.

From the review of reference architectures for IoT [11], [12], [13], [14] and taking into account the principles of service-oriented architectures (SOA), an adaptation of an architecture that combines some previous architecture features was proposed.

IoT reference architecture allows real space objects to communicate and become part of the virtual space, while SOA can provide modularity and interoperability because it facilitates the implementation of services on different devices, and platforms, with the possibility that they interact.

The proposed architecture uses the paradigm of layered architectures and it consists of four layers, which are explained as follows:

- Hardware/Communications Layer: This layer has all the hardware components and communications that allow physical objects to be adapted or created so they can be part of the Internet.
- Messaging Layer: This layer is responsible for establishing communication between objects, more advanced than the hardware/communications layer, using a simple protocol of request-response, using the data that the hardware/communications layer makes available and turning it into messages.
- Services Layer: In this layer the services are offered, and they use the data captured by the objects to fulfil a specific purpose, only objects with IP

communication interfaces may offer services, so only those objects implement this layer. This layer works under a REST (REpresentational State Transfer) style, which uses HTTP protocol to make calls between machines instead of using complex mechanism such as SOAP (Simple Object Access Protocol).

- Application Layer: This layer is closest to the end user and consists of all applications that are implemented associated with specific scenarios. Each application must provide interfaces for user access to them. The applications are based on services offered by the service layer and the composition thereof.

5 Test of Proposed Integration Model

To test the integration model a digital electronics course for undergraduate engineering students was selected as a case study. In this course students have to implement a digital circuit and it is possible to collect data about lab work performed by the students.

In the proposed case study two objects have been implemented: a measuring instrument (smart object) and a Mediator (social object), and the LMS Moodle was adapted as a virtual object. Figure 3 shows a schematic diagram of the scenario with objects, the architecture layers which are implemented and interactions between the objects.

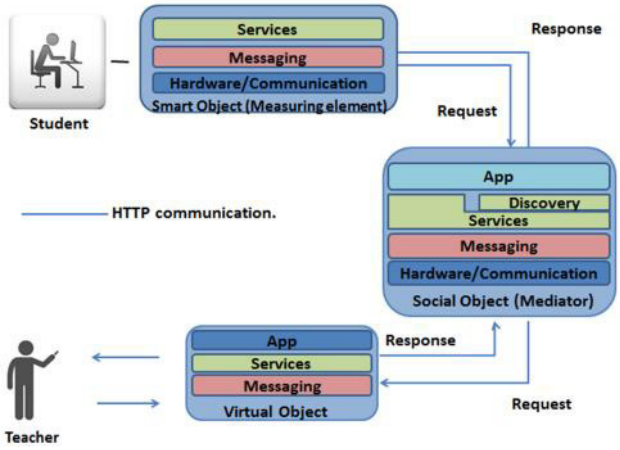


Fig 3. Testing scenario of the integration model.

The students interact with implemented objects (e.g. measuring element and mediator) at the lab for doing their tasks and the more relevant data of their activities

(e.g. measurements) are collected and stored in the LMS Moodle database. Then the teacher can track this data through LMS reports, which helps the teacher to monitor the work that students have done in the lab.

The teachers can also track and analyse other issues such as the information (web pages, papers, blogs, etc.) recommended by students to their peers, the time that students take to solve the exercises in the lab, and monitor the students that access to the lab class.

For implementing and adapting the objects for testing the proposed model Arduino and Raspberry Pi boards were used, because they are two of the most common prototyping boards due to their openness and support (documentation, user community options, etc.).

6 Discussion

Two surveys were conducted to evaluate the case study, which was used for testing the implementation of the integration model:

a. Survey 1: questions about the "technological profile" of students on the course were defined. The questions focused on showing whether students had previous experience using technology (e.g. use of e-learning platforms) in previous courses and their participation in VAC.
b. Survey 2: questions about the students' perceptions of practical experience in the laboratory during the test were defined. The questions focused on the students' perception about the objects deployed in the laboratory, the VAC services and interaction using the VAC tools.

Survey 1 was conducted before the test with 13 students on the digital electronics course, while survey 2 was conducted after the test. The answers to both surveys' questions that were collected from students have been analysed and some interesting findings from correlating the two surveys are evident:

- Previous experience in the use of technology was not relevant for the test implementation of the integration model. That is, even though new objects and some adapted objects were deployed in the test scenario with their respective services objects, the use of these objects and their services was relatively easy for students and in the students' opinion (see Table 2), they helped to facilitate the implementation of the lab work.

Table 2. Two questions related to technological elements

Question	Always	Almost always	Almost never	Never
Were the devices deployed to support	61.5%	30.8%	7.7%	0%

the laboratory classes helpful for performing lab work activities?				
Was it easier to perform the laboratory class activities with this form of work supported by technology?	46.2%	53.8%	0%	0%

- The VAC and its services was a new element for the students of this course and its use positively contributed to the development of the activities of the lab class (see Table 3). The fact that students have the facility to handle services such as forums and chat rooms, and interact virtually through these tools allows them to easily adapt to the environment of the VAC and its services.

Table 3. Two questions related to VAC topics

Question	Always	Almost always	Almost never	Never
Did the collaborative activities (forums and discussions) in the VAC help to build knowledge?	23.1%	53.8%	15.4%	7.7%
Do you think that the VAC is a reliable learning environment?	46,2%	46,2%	7,7%	0%

- According to the opinion of students (see Table 4), the expectations they had about lab work were fulfilled and adding objects and technological elements motivated them to perform the activities in the lab class more easily.

Table 4. Two of the questions about students' expectations

Question	Always	Almost always	Almost never	Never
Did using technological elements in the setting of the lab class and virtual elements motivate you to perform the activities in the lab more easily?	76.9%	23.1%	0%	0%
Do you consider that your expectations of the lab class using VAC support were fulfilled?	61.5%	38.5%	0%	0%

According to the previous arguments it is possible to say that the perception of students of the test course is positive and based on their answers to survey 2 the deployment of (new and adapted) objects and VAC services helped them to perform the lab work activities.

7 Conclusions

This paper proposes a new model for integrating objects to VAC and an adapted architecture for implementing and testing this new model. The integration of smart objects to the VAC enables the gathering of more data about activities in labs and new ways of interaction between actors in the VAC and objects. The objects go from being passive elements in labs to becoming more involved in supporting the teaching-learning process.

The data gathered could help teachers to understand the learning process in more detail, which means that they can see which parts of an assignment of the lab work were easy and which parts were so difficult that the students experienced difficulty and could not achieve the learning goals. Teachers could use this data to improve their feedback to students and to be more accurate in their advice to students.

IoT could help to improve teaching and learning experiences, especially for courses that involve working in labs. And using the IoT in the teaching-learning process enables an interaction between smart objects that are available in educational environments and students and teachers. However, the interaction between objects is an issue that should be further researched and our future work will focus on this topic, which is also relevant for other application domains.

Acknowledgements. This work is part of the research project "Integration Model of Virtual Academic Communities (VAC) with real world objects through the Internet of Things", which was supported by Colciencias (grant 334-2013), a Colombian national agency for fostering science, technology, and innovation.

References

1. Wang, Y.: English interactive teaching model which based upon Internet of Things. In: 2010 International Conference on Computer Application and System Modeling (ICCASM), vol. 13, pp. V13-587. IEEE Press, New York (2010).
2. Chin, J., Callaghan, V.: Educational Living Labs: A Novel Internet-of-Things Based Approach to Teaching and Research. In: 2013 9th International Conference on Intelligent Environments (IE), pp. 92-99. IEEE Press, New York (2013).
3. Cheng H, Liao W.: Establishing a lifelong learning environment using IoT and learning analytics. In: 14th International Conference on Advanced Communication Technology, ICACT (2012).
4. Xue, R., Wang, L., Chen, J.: Using the IoT to construct ubiquitous learning environment. In: 2011 Second International Conference on IEEE Mechanic Automation and Control Engineering (MACE), pp. 7878-7880, (2011).
5. González, G. R., Organero, M. M., Kloos, C. D.: Early Infrastructure of an Internet of Things in Spaces for Learning. In: 2008 IEEE 8th International Conference on IEEE Advanced Learning Technologies (ICALT), pp. 381-383, (2008).
6. Elkhodr, M.; Shahrestani, S.; Hon Cheung.: The Internet of Things: Vision & challenges. In: TENCON Spring Conference, 2013 IEEE, pp. 218-222, (2013).
7. González García, C. C., Pelayo G-Bustelo, B. C., Pascual Espada, J. J., & Cueva-Fernandez, G. G.: Midgar: Generation of heterogeneous objects interconnecting applications. In: A

Domain Specific Language proposal for Internet of Things scenarios. Computer Networks, 64143 - 158. (2014)
8. García, A.G., Alvarez, M.A., Espada, J.P., Martínez, O.S., Lovelle, J.M.C., García-Bustelo, B.C.P.: Introduction to Devices Orchestration in Internet of Things Using SBPMN. (2011)
9. Atzori, L., Iera, A., Morabito, G.: From "smart objects" to "social objects": The next evolutionary step of the Internet of things. IEEE Communications Magazine, 52(1), 97-105 (2014).
10. Campo, W, Chanchí, G, Arciniegas, J.: Arquitectura de Software para el Soporte de Comunidades Académicas Virtuales en Ambientes de Televisión Digital Interactiva. In: (Spanish)', Formación Universitaria, 6, 2, 3-14. (2013).
11. Lopes, N., Furtado, P., Silva, J., & Pinto, F.: IoT Architecture proposal for disabled people. In: International Conference On Wireless And Mobile Computing, Networking And Communications, pp. 152 - 158. (2014). doi:10.1109/WiMOB.2014.6962164.
12. Miao Wu; Ting-Jie Lu; Fei-Yang L Miao Wu; Ting-Jie Lu; Fei-Yang Ling; Jing Sun; Hui-Ying Du: Research on the architecture of Internet of Things, 2010 3rd International Conference on Advanced Computer Theory and Engineering (ICACTE), vol.5, pp.V5-484,V5-487. (2010).
13. Shanzhi, C., Hui, X., Dake, L., Bo, H., Hucheng, W.: A Vision of IoT: Applications, Challenges, and Opportunities with China Perspective. IEEE Internet of Things Journal, 1(4), 349 (2014)
14. ALMANAC, Reliable Smart Secure Internet of Things for Smart Cities, (2013) URL: http://www.in-jet.dk/en/articles.php?article_id=24.

The Use of Information Systems in the Context of Indigenous Cultures

Joselice Ferreira Lima[1], Dener Guedes Mendonça[1], Suzana Alves Escobar[1], Claudio Alexandre Gusmão[1], Gustavo Teixeira[1]

[1]Instituto Federal do Norte de Minas Gerais (IFNMG),
Campus Januária-MG, Brasil
{denerxy, joselice.f.lima, claudioagusmao, suza.escobar, lealtex}@gmail.com

Abstract: This paper, through a literature review analyzes the use of technology in the indigenous environment as a resource for the preservation of their culture / language. It focuses on information systems and information management as ways to ensure the storage of data on indigenous language. It also displays the results of a system in its first version - which catalogs the words of a language in text format, image and sound - in this case the indigenous words Xakriabá people. We concluded that the availability of the words in this format may support the cultural revival of a group of people. It is expected that making online vocabulary available may contribute to the preservation and transmission of language and culture for future generations.

Keywords: Indigenous peoples, information systems, information management, indigenous language.

1 Introduction

New technologies and the Internet have triggered changes in several portions of society, even in the indigenous environment. Among these changes there is a new way of looking at the use of information technology (IT), now with greater transparency and paramount importance for the transmission and preservation of human knowledge. Among the many abstract representation forms of a society, the language of a group represents the main portion of genuine knowledge that is responsible for the cultural stability of generations.

Globalization changed the world, also changing the vision and the forms of interaction of indigenous peoples in relation to technologies, allowing them to access new forms of information and increasing social interactions, but in the meantime their culture and language is being forgotten. So, for the maintenance and preservation of cultural remains of indigenous communities' electronic devices may provide efficiency and quality for storing and collecting data. "The disappearance of these languages would be a great loss to indigenous communities, as they are the traditional means of transmission of culture and thought and an important part of ethnic identity" [1]. Currently, the issue of availability and sharing of information is of great value as

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_20

means of access and proliferation are diverse, such as computers, tablets, smartphones and more.

In Lemos' view [2], Medias produce a sense of location, but so that physical barriers are not limiting. The "informational city" finds in the "culture of mobility" its fundamental principle: mobility of people, objects and information technologies without precedent. The value of intangible assets in a society is differential according to perpetuation and dissemination of knowledge. The more you use and apply existing technology to preserve a particular culture most knowledge is generated and reprocessed, then, culminating in knowledge management. This virtuous cycle is capable of transforming knowledge, an immeasurable value and an important asset that can be developed through information systems to be used in different situations.

The need to search for new knowledge generated to obtain recovered information, which can be used, stored, processed and made available. "The use produces or creates need for new information, this gives the start to the process in cycle or feedback" [3]. These data transformation processes in information and later generation of knowledge takes place within a community that interacts with each other and knowledge expand the limits beyond its borders, giving origin to important issues such as information management. The content production, registration and diffusion within the government, society and individuals will then reflect the cultural diversity as an example the language of the people.

Moore; Galucio and Gabas Júnior [1] point out that due to the concern about endangered languages new documentation methods have been developed. They are focused on the recording of language samples, scanning and annotation of the recordings and their use for language revitalization. These recordings and notes should be stored in digital form permanently. Documentation may be a solution for the preservation of a culture, not only historically, but for reproduction within communities and the consequent increase in affection with the language.

This article discusses the use of information systems as a means of registering the vocabulary of a community, in this case the Xakriabá indigenous community. After this introduction, in the following section we talk about the use of technology, information management and information systems in the indigenous environment. The third section shows the looks of the system for cataloging Words Indigenous (SISCAPI) and finally in the fourth session concluding remarks and perspectives for future work are presented.

2 Technology and Information Management

The term Information Technology according to Beal [4], is used to describe the set of technological and computing resources made for generation and use of information. IT according Rezende (2000) is based on the following components: Hardware, its devices, and peripherals; Software and its features; Telecommunications systems; Data management and information [4]. Within this environment "Information and Communication Technologies (ICT)", a term used by Silva [5], covers all participant elements of information technology and allows information to be produced dynamically; being disseminated and shared nearly in real time.

In this context technology management encompasses the set of activities and projects created with computing resources in order to preserve information as a patrimony of society that is linked to its preservation and coherence. Each community should use information management according to their specific needs. Individuals should then develop possible uses for such information technology, following its implementation and before its dissemination.

In this sense, the trilogy, data, information and knowledge can be understood as: any element identified in its raw form that alone does not lead to an understanding of a particular fact or situation [6], but allows the performing of calculations, operations and measurements. Information "is data that has been processed and stored in an understandable way for your recipient [...]" (Padoveze [7] cited Nakagawa). It can be understood as the contextualization of data in a syntax structure, producing sense, from associations and the establishment of relations between them. While knowledge "is a set of conceptual tools and categories used by humans to create, collect, store and share information" [8]. It covers the absorption of interpreted data according to the analysis of information. Human knowledge is expanded through social interaction between tacit and explicit knowledge what contributes to interaction and conversion of knowledge and expertise.

In indigenous communities such processes of acquisition and dissemination of knowledge are present in several ways. The "explicit" transmission of knowledge is performed directly via interaction among its members, as customs are passed through activities conducted in groups. Knowledge is part of the indigenous reality and the content is something very natural and part of the interaction in the villages [9].

These factors lead us to the processes of knowledge management, either directly or indirectly, since the main challenge now is the acquisition and transfer of tacit and declarative knowledge in an interactive and spiral transformation process, which leads to transmission and creation of knowledge in a dynamic and ongoing process. So, through information technology there is, in some ways, spiral of knowledge to be disseminated with knowledge being exchanged, converted, combined with other existing forms that create new ones for the society, then, building an information network.

2.1 Information System on Indigenous Environment

According to Stair [10] "an Information System (IS) is a set of interrelated components that collect, manipulate, store, disseminate data, information and provides a feedback mechanism to achieve a goal". In this context it is necessary in the planning and implementation of experimental environments to reflect on "what we want to make available" and try to make accessible information, which requires enhanced conditions of access and use of heterogeneous users on digital interfaces, which can both allow or limit human-computer interaction from the user-content-context intersection [3].

In the development of systems that are considered "sets of interacting and interdependent parts which together form a whole unit with certain goal and perform a particular function" [6] several tools are used to enable the integration of parts. Many of these tools are free, with no need to purchase licenses.

Currently we observe the increasing technological evolution that gradually reaches the indigenous environment, whether through electronic devices or digital inclusion, technology itself has been used as a tool for interaction and knowledge, as in the example mentioned by Gallois and Carelli [11]: "The project Video in the Villages" (Vídeo nas Aldeias) from the Center of Indigenous Labour / CTI, has made available to some indigenous communities, information and technology that allowed the manipulation of their own image, building a library network in villages, and encouraging exchange [...]. As they register and view, in the courtyard of the villages, their performances - either rituals or political negotiations - these communities, rebuild and strengthen cultural events as they wish to preserve their culture for future generations and, above all, they judge that is appropriate to compare themselves to non- Indians.

The internet is another factor of use and interest of the indigenous population when it comes to dealing with new technologies. A partial survey in 2010 counted a hundred and eleven internet points in indigenous villages. Aside from these internet points, some communities have internet at the headquarters of their association in the city or have access to existing connections in administrative offices situated in their territory, as the *Baníwa*, who bring their laptops to take advantage of the antennas of the army platoons in areas of the upper Rio Negro borders [12].

Miranda [13] points out that a characteristic of globalization is the accelerated exchange of information as an instrument of information exchange through new media and as a form to access information technology that reflects on distance and time, these tend to disappear with the use of technological resources, but rather to cause the homogenization of cultures, helps maintain cultural identities.

Taking into account indigenous issues and the contact with people before isolated[1] from the public eye and even the growth of the indigenous population if considered the demand for specific services, it highlighted the need to invest in technological innovations. The scanning and annotation of natural language samples recordings are in the early stages, but the demand for documentation on the part of indigenous groups is increasing rapidly. Literacy and revitalization programs are common, but the results are not collected and evaluated systematically [1].

Considering how each community lives, respecting their traditions and culture in the use of technology, there are now computer programs that are used in indigenous culture preservation. In the village *Suruí*, Sete de Setembro in Rondonia, Google Earth has been used to detect the presence of intruders. The initiative also proposed to add information maps on its territory and history (provided by the Indians themselves), so that this information should be public [12].

The indigenous language issue has also been raised and linked to the use of information systems. Google launched in 2012 a project to preserve and ensure the survival of indigenous dialects in the world "Endangered Languages", a site that brings together a catalog of cultures around the world, to promote indigenous cultural preservation [14]. In Brazil, Steven Bird, professor at the University of Melbourne,

[1] Until the 1988 Constitution, some indigenous peoples had to make use of several mechanisms of resistance, hiding and even denying their ethnic identity as a means of protection to continue surviving. "Emerging people" is the term used in anthropology to analyze the phenomenon of "resurrection" of communities as indigenous people (Escobar, 2012).

has created a system for cell called "*Aikuma*". After recording the ancient and traditional stories in the application, the content is shared with other phones in the network. With the audio available in all phones, it can then be adapted into Portuguese by anyone connected to the system [15].

Despite the popular belief that new technological devices end up with the traditional cultures, the use of technology as a means of preserving indigenous culture is a smart way to allow them both to coexist rather than being mutually exclusive.

3 System for Cataloging Indigenous Words

SISCAPI is a web system that seeks to meet a need perceived by the Xakriabá. The Indigenous Land Xakriabá is located in the municipality of São João das Missões in the northern Minas Gerais. One of the consequences of permanent contact with non-Indians is the absence of an indigenous language itself among Xakriabá, which speak portuguese in a specific variant. The Xakriabá are implementing the *Akwen* language revitalization process from contacts with the *Xerente*, but there are no linguistic studies on the Portuguese spoken and written by the Xakriabá nor about the revitalization process of considering their native language [9].

Visiting there we observed a lack of registration of their native language; only oral transmission of words; lack of similarity between the Portuguese and the indigenous; lack of a visual identity for indigenous words; difficult to identify existing indigenous languages; lack of written and online materials on the tongue. It was noticed that the available technology is not widely used in the indigenous language preservation.

Thus, the system was developed and directed also to any existing indigenous community in Brazil, as it was perceived through literature that the lack of registration of these indigenous languages is a problem present in other villages and not just among the Xakriabá.

Our system is in the public domain, collaborative, open source and available on the web. In the case studywe performes, we used the fragments Xakriabá language that is spoken among the Indians and reproduced in written and sporadic representations in this community based on the Portuguese language [16].

3.1 Review with Related Work

The conducted survey identified two foreign solutions ("Languages at Risk" and "Aikuma") in Brazil. As well as the systems observed the SISCAPI is concerned to ensure that part of the indigenous people's culture is preserved, in this case, oral background of Brazilian tribes.

On the website "Languages at Risk" geolocation is used for referencing of the world's indigenous cultures. It enables collaboration through articles, videos, photos, etc. There are few collaborations and files include several types of information and some data related to indigenous languages.

"Aikuma" is a translation mobile application that is controlled by voice. It records audio, but the physical material is a CD with stories and translations. It does not cover the graphics / Writing indigenous language. It is necessary to wait for the translation

of the whole story. The goal is to use the recordings in the future to decrypt and recover languages.

In SISCAPI we attempted to categorize such dialects according to the preservation of these cultures. The system records the indigenous word, the audio of its pronunciation and its meaning in Portuguese linked to a representative image. The system is designed to be lightweight, simple and intuitive; information is available for consultation and management via web with a print preview next to the language of information, offering a kind of dictionary.

3.2 A view of SISCAPI

Concerning the technology used in building the system we opted for the web platform that allows the circulation of the information network on any computer, anywhere in the world. The development and web hosting were decisive to ensure that the system data remains stored. Web servers may have increased their storage capacity if the system requires so. You can also choose new domains and have a system in place for each indigenous language or existing village. The image and sound files that could lead to larger database consumption have a file size limit (2 MB), considering that this value meets the needs of audiovisual systems [17].

As there are several communities and indigenous languages it is possible to bind them both in the system which would allow a comparison and integration among speakers concerning the vocabulary used, providing a uniform and centralized way to access. Image 01 presents the information and main ideas covered by SISCAPI.

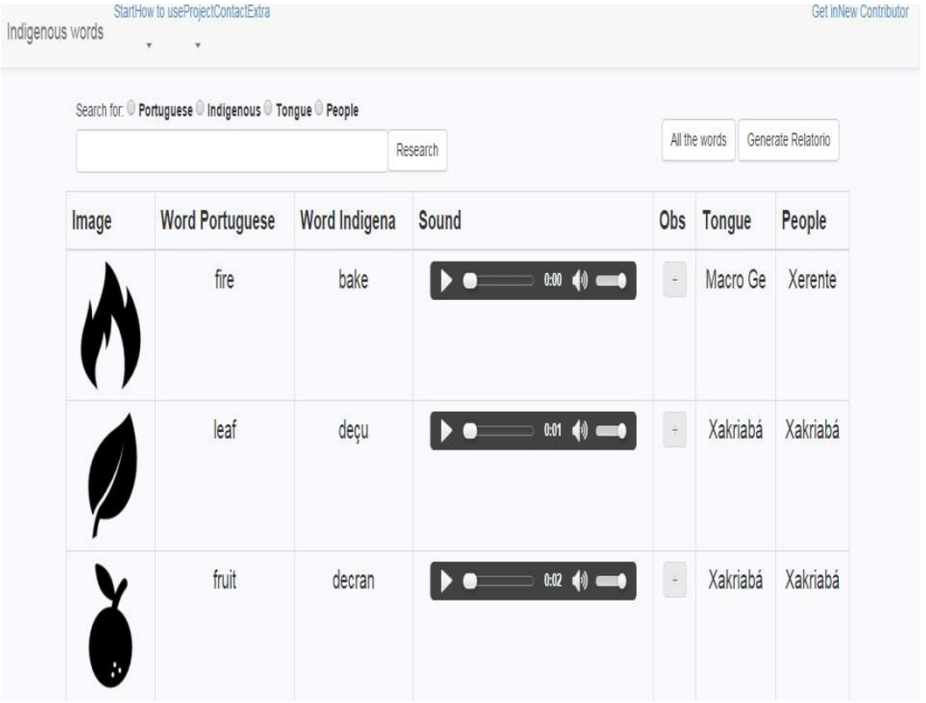


Image 1. Source:. The author. Home screen: contains the registered indigenous words (text, image and sound); It allows searching through pre-existing filters; PDF available for all registered words (text only); It provides a variety of information through existing menus; It presents the users login and register to participate in the system (new colaborator).

The system is online and available at the website www.palavrasindigenas.com.br to aid recovery and storage of indigenous dialects contributing in education and language learning through the cataloging of words, sounds and images used in these communities. The SISCAPI enables to catalog words of the indigenous vocabulary through word storage (writing), sound (pronunciation) and image (branding). Data was structured according to the standards of exchange of information on the web and was produced and stored so it can be found and reused. Thus enables data collection, storage, search and selection of the tribe's vocabulary. It serves as an instrument of organization and retrieval of information associated with indigenous vocabulary and practices related to its preservation, which can serve different purposes. The system was based on indigenous linguistic experience and on the scenario of the Xakriabá community.

4 Final Thoughts

The use of networked systems can enable the sharing of different information, leading communities to exchange knowledge. The provision of on-line vocabulary, for example, can be constituted as a significant contribution to the preservation and perpetuation of cultures at different levels, from written to oral representation. This kind of approach can provide enormous advances because a larger set of data is shared. In this context, information systems are presented as solutions for processes of storage and information production, from data transformation and through the application of human knowledge.

The process of knowledge building and transfer expresses information value, which is often not easy to measure as it depends on its users. Currently the transfer of customs and knowledge is conducted orally in the villages, however, there is a tendency for indigenous communities to communicate through social networks, and it may come to be regarded as an affordable alternative to increase their interaction and development.

Whereas one of the main problems perpetuated over the years is the lack of records of practices and cultural activities of people, it is understood that a system can significantly contribute to perpetuating their memory. Information systems are presented as good proposals to provide easier access to information, data collection, storage, search and selection.

The use of systems do not make people abandon their culture to the digital environment, on the contrary, it helps to preserve it, because with global information storage systems, knowledge will become wider, allowing communication to improve and preserve culture. The preservation of languages is essential to the maintenance of other cultural manifestations, such as songs and myths. In addition, languages are complex systems that, once studied and understood, can contribute to a better

understanding of the human language and serve as an instrument of self-assertion of identity and indigenous culture [1].

The formation of an online database is a viable alternative to be applied as it is a way to store the evolution of studies in this sense, the data collected by the community of users when stored can be viewed by other individuals. They can make new collections, adding new meanings. It is understood that the acquired knowledge is related to action, as opposed to information, "so it is specific to the context and relational" [3]. Relevant characteristics of words databases, sounds and images, can be used, interpreted and in the end, the information that is cataloged becomes data and experiences that can be shared and reused producing new data, information and knowledge.

SISCAPI seeks to foster discussion about the loss of indigenous languages which implies the risk of loss of culture, because any language as simple as it is involves several other aspects to be studied, resulting in adjustments and improvements to the system. It is hoped that this initiative creates subsidies for knowledge and storage of indigenous languages and based on data collected develop other studies focusing on the preservation of dialects, improvements and or creation of systems focusing indigenous peoples.

Thus, digital files are required for modern documentation as it stores recordings, notes and other information permanently and in an affordable way. However, the life of tapes, mini discs, CDs or other media is limited, so currently, servers as the Indian Museum and the Goeldi Museum are being built. Files of this type have as their main beneficiaries indigenous groups. In Australia 95% of consultations of files related to indigenous peoples are made by Aboriginal [1].

Thus, it is considered that the alternative of using a web system that enables data sharing, as well as its storage in different digital media. It is therefore a viable means to disseminate and communicate the language of a people. In this sense the continuity of this work is already underway, as the development of the second version of the system is on its way. We are trying to create a mobile app platform / site in the English version to meet other audiences, improving design, study field and other possibilities.

References

1. Moore, D. A.; Galucio, A. V.; Gabas Junior, N.: Desafio de documentar e preservar línguas. Scientific American Brasil, Brasília-DF (2006)
2. Lemos, A.: Cultura da Mobilidade. Revista Famecos. Nº 40, Porto Alegre-SC (2009)
3. Lima, J., F.: Arquitetura em Rede de Compartilhamento de Laboratórios On-line. Tese de Doutorado. Programa de Pós-Graduação em Engenharia Elétrica, Universidade de Brasília-DF (2013)
4. Beal, A.: Introdução a Gestão da Tecnologia da Informação, Brasília-DF (2007)
5. Silva, E.: GT4: Gestão da Informação e do Conhecimento nas Organizações, São Paulo-SP (2013)
6. Oliveira, D., de P., R. de.: Sistemas, organizações e métodos: uma abordagem gerencial". 13. ed.; Ed. Atlas, São Paulo-SP (2002)
7. Padoveze, C., L.: Sistemas de Informações Contábeis: fundamentos e análise. 2. ed., Atlas, São Paulo-SP (2002)

8. Laudon, K., C.; Laudon, J., P. Sistemas de informação gerenciais, São Paulo-SP (2011)
9. Escobar, S., A.: Os projetos sociais do povo indígena Xakriabá e a participação dos sujeitos: entre o desenho da mente, a tinta no papel e a mão na massa. Pós-Graduação em Educação: Conhecimento e Inclusão social. Belo Horizonte-MG, (2012)
10. Stair, R., M.; Reynolds, G., W.: GT4: Gestão Princípios de Sistemas de Informação, São Paulo-SP (2011)
11. Gallois, D. T.; Carelli, V.: Índios eletrônicos: uma rede indígena de comunicação, São Paulo-SP (1998)
12. Renesse, N.: O que pensam os índios sobre a presença da internet em suas comunidades?, São Paulo-SP (2010)
13. Miranda, A.: Sociedade da Informação: globalização, identidade cultural e conteúdos. Ci. Inf., v. 29, n. 2, p. 78-88, Brasília-DF (2000)
14. Kleina, N.: Google lança projeto para preservar idiomas em extinção (2012)
15. Neher, C.: Projeto usa smartphone para preservar línguas indígenas (2013)
16. Mendonça, D., G.; Lima, J., F.; Gusmão, C., A.: O uso da tecnologia no auxílio à preservação do idioma indígena: o caso Xakriabá. In Anais do XXXV Congresso da Sociedade Brasileira de Computação (CSBC). 4º DesafIE - Workshop de Desafios da Computação Aplicada à Educação, Recife-PE (2015, a)
17. _____.: O Uso da Tecnologia como Ferramenta de Compartilhamento e Preservação do Dialeto Indígena. In Anais do XXVI Simpósio Brasileiro de Informática na Educação (CBIE). X Conferência Latino-Americana de Objetos e Tecnologias de Aprendizagem (LACLO), Maceió-AL (2015, b) DOI: 10.5753/cbie.wcbie.2015.125

Graph colouring and branch and bound approaches for permutation code algorithms

Roberto Montemanni[1], János Barta[1], and Derek H. Smith[2]

[1] Dalle Molle Institute for Artificial Intelligence
University of Applied Sciences of Southern Switzerland
Galleria 2, 6928 Manno, Switzerland
{*roberto.montemanni, janos.barta*}*@supsi.ch*

[2] Division of Mathematics and Statistics
University of South Wales
Pontypridd, CF37 1DL, Wales, UK
derek.smith@southwales.ac.uk

Abstract. A considerable amount of research has been devoted to permutation codes in recent years. This has been motivated by some real-world applications. Permutation codes are important because of their robustness against transmission errors and noise. This study addresses the problem of the construction of the largest possible permutation codes with given parameters, namely a specified length and minimum Hamming distance. The problem is modelled in terms of maximum cliques and it is shown how a well-known upper bound based on colouring can be successfully embedded inside a branch and bound method. Experimental results are presented to evaluate the effectiveness of the new idea.

Keywords: Permutation codes, maximum clique algorithms, branch and bound, colouring bound.

1 Introduction

This paper discusses how a classic upper bound for the maximum clique problem based on graph colouring can be effectively employed for the construction of largest possible permutation codes. The problem is modelled as a maximum clique problem and a branch and bound algorithm (Carraghan and Pardalos [1]) is used to solve it.

Permutation codes (sometimes referred to as permutation arrays, see [2]) have received substantial attention in the literature [3–10, 12]. This interest is motivated by an application to powerline communications, when M-ary Frequency-Shift Keying (FSK) modulation is used [6, 11, 13–16]. In this context, permutations are used to ensure that power output remains as constant as possible while combating impulsive noise, and permanent narrow band noise from electrical equipment or magnetic fields, as well as the more common white Gaussian noise [12]. Other uses of permutation codes can be found in the design of block ciphers [17] and in multilevel flash memories [18, 19].

A permutation code is a set of permutations in the symmetric group $\mathscr{S}_n$ of all permutations on n symbols. The permutations will be referred to as *codewords* and n is the *code length*. The *minimum Hamming distance* measures the error-correcting capability of the code. The Hamming distance δ between two codewords is the number of positions that differ in the two permutations. In other words, two permutations σ_1 and σ_2

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_21

are at distance δ if $\sigma_1\sigma_2^{-1}$ has exactly $n-\delta$ fixed points. The minimum distance d is then the minimum δ taken over all pairs of distinct permutations. Such a code is then denoted an (n,d) permutation code.

If the number of codewords of a code is as large as possible, redundancy in an encoding is minimized. Thus if $M(n,d)$ denotes the maximum number of codewords in an (n,d) permutation code it is important to determine $M(n,d)$. The most complete contributions to lower bounds for $M(n,d)$ can be found in [6, 20]. Some studies considering upper bounds have appeared in [5, 10, 21–23, 26], while in [24, 25] studies on the structure of optimal codes have been presented. Results on a similar problem using a metric different from the one treated in this paper can be found in [27].

The permutation code design problem can be represented in terms of a maximum clique problem: each permutation of $\mathscr{S}_n$ is associated with a vertex of the graph, and an edge exists between two vertices if and only if the corresponding permutations are at Hamming distance greater than or equal to d. This means that if the maximum clique problem on such a graph can be solved, an optimal (n,d) permutation code is obtained, while heuristic solutions will provide lower bounds for $M(n,d)$.

The specialized branch and bound algorithm originally introduced in [26] is considered in this work. It is shown how an upper bound previously introduced for this algorithm in [23] can be made substantially tighter by involving graph colouring concepts. Computational results to support the new ideas and conclusions are presented.

2 Problem description

A permutation of the n-tuple $x_0 = [0,1,...,n-1] \in \mathbf{N}^n$ is a *codeword* of length n and the set of all codewords of length n is denoted by Ω_n. From an algebraic point of view the set Ω_n is the single orbit of the symmetric group of permutations $\mathscr{S}_n$, i.e. $\Omega_n = \{x \in \mathbf{N}^n | x = gx_0,\ g \in \mathscr{S}_n\}$. Any subset Γ of Ω_n is a *permutation code* of length n. The main problem can now be stated as:

Definition 1 *Given a code length n and a Hamming distance d, the* Maximum Permutation Code Problem *(MPCP) consists of the determination of a code $\Gamma \subseteq \Omega_n$ with minimum distance d and the maximum possible number of codewords.*

Example 1 *The problem $(5,4)$ is to determine a maximal code of length $n = 5$ with minimum distance $d = 4$. As reported in [6] the optimal solution of this problem is $M(5,4) = 20$. An optimal $(5,4)$ code is shown in Figure 1.*

$$\Gamma = \{[01234],[02143],[03421],[04312],[10324],[12430],[13042],[14203],[20413],[21340],$$
$$[23104],[24031],[30241],[31402],[32014],[34120],[40132],[41023],[42301],[43210]\}.$$

Fig. 1. An optimal (5, 4) code.

Formally, the MPCP can be modelled as a *Maximum Clique Problem* (MCP, [1]) on a graph $G = \{V,E\}$ where there exists a bijection $\Omega_n \mapsto V$ such that for any pair of codewords $p,q \in \Omega_n$ mapping into vertices $v_p, v_q \in V$ respectively, $(v_p, v_q) \in E$ if and only if the Hamming distance between codewords p and q is greater than or equal to d.

3 A branch and bound approach

The original MCP method proposed in [1] has been specialized to permutation codes in [26]. The idea behind the specialized method is to inject knowledge from the permutation code problem into the generic MCP graphs. In such a way some regions of the search space can be avoided since it can be shown that they are not relevant. This desirable result is achieved through a decomposition approach.

The generic MCP algorithm originally described in [1] considers the vertices of V in a given order $\{v_1, v_2, ..., v_{|V|}\}$. If no pruning is applied, the algorithm would produce at most n cliques of increasing size. In a first stage, the method is able to retrieve the largest clique C_1 that contains the vertex v_1. Then a further stage is entered, where C_2, the largest clique in $G\backslash\{v_1\}$ that contains v_2 is retrieved, and so on. This provides an exhaustive search of the solution space.

Applying heuristics and pruning techniques, the search space can, however, be reduced by orders of magnitude.

The notion of the *depth D* is important for the algorithm. Suppose vertex v_1 is the vertex leading the search at a given stage. At depth 2, all vertices adjacent to v_1 are considered as *potential expansions*. At depth 3, all vertices already present at depth 2, and that are also adjacent to the vertex selected at depth 2 are considered and so on. When no more vertices are present at a certain depth, a maximal clique has been identified, and backtracking can be safely activated.

In the original algorithm, a very simple (and extremely fast) pruning rule, based on the number of vertices left at each level is adopted to achieve early backtracking. The rule can be summarized in the following proposition.

Proposition 1 (Carraghan and Pardalos [1]) *At depth D, with M_D representing the set of potential expansion nodes and LB a lower bound on the size of the optimal clique, if $D+|M_D| \leq LB$, then the current solution cannot be expanded into an improved clique, and the backtracking mechanism can be activated.*

The rule described in Proposition 1 proved to be dramatically effective.

When the entire search-tree created by the method has been visited or declared dominated, the computation can be stopped and an optimal maximum clique (equivalent to a permutation code in the current context) has been found.

The modifications to the original method introduced in [26] divide the whole search tree into different smaller subtrees, each one covering a portion of the relevant search-space. The underlying idea is that such a decomposition contributes strongly to successful pruning in the general branch and bound framework.

The following definitions are required to formalize the idea of what we will refer to as Algorithm 1 (see next page).

Definition 2 *$R(i, j)$ is the number of codewords with symbol j in position i required in any feasible solution.*

Definition 3 *$F(i, j)$ is the set of vertices of G associated with codewords with symbol j in position i in the current partial solution during the execution of Algorithm 1.*

Definition 4 *$S(i,j)$ is the set of vertices of G associated with codewords with symbol j in position i in the residual codewords compatible with the current partial solution during the execution of Algorithm 1.*

When approaching a permutation code with parameters n,d, the definitions above are used to subdivide the global search space into relevant regions of it, by setting appropriate values of $R(i,j)$. It is trivial to derive all the relevant combinations that can happen in a real problem, given a target solution value, and eventually knowledge of a valid upper bound for $M(n-1,d)$. The remainder of this section will therefore focus on a generic subproblem, arising once a set of valid values for the $R(i,j)$s is instantiated.

The pruning rules for Algorithm 1 are based on the following results:

Proposition 2 (Montemanni et al. [26]) *Given a set of requirements R specifying values for $R(i,j)$ as defined in Definition 2, if during the execution of Algorithm 1 $\exists\, i,j \in \{0,\ 1,\ \ldots,\ n-1\}$ and $R(i,j) \in R : R(i,j) < |F(i,j)|$ then backtracking can be activated since the current partial solution does not fulfill the requirements in R.*

Proposition 3 (Montemanni et al. [26]) *Given a set of requirements R specifying values for $R(i,j)$ as defined in Definition 2, if during the execution of Algorithm 1 $\exists\, i,j \in \{0,\ 1,\ \ldots,\ n-1\}$ and $R(i,j) \in R : R(i,j) > |F(i,j)| + |S(i,j)|$ then backtracking can be activated since any solution contained in the current search-subtree does not fulfill the requirements in R.*

As previously observed, it is important to stress that multiple runs of the specialized algorithm, with different sets of requirements, can be combined together to cover all possible configurations and guarantee therefore a proof of optimality. In [26] it is experimentally shown that the cumulative running time of the subproblems is far shorter than that of the original algorithm without any decomposition.

4 Colouring bounds

It is well-known (see, for example [28]) that an upper bound for the size of the maximum clique of a graph can be obtained from a vertex colouring of the graph.

In the graph colouring problem, two adjacent vertices cannot be assigned the same colour and the aim is to colour all the vertices of the graph with the minimum possible number of colours. It is straightforward to see that if a graph can be coloured with s colours, then it cannot contain a clique of size larger than s, therefore a natural upper bound for $M(n,d)$ can be obtained by solving a colouring problem on the graph representing the problem.

Unfortunately, calculating a good quality colouring is normally time consuming, and so it is not possible to calculate the bound at each node of the search-tree of the algorithm described in Section 3. For this reason, a common strategy is to compute one or more colouring solutions for the global graph *before* entering the branch and bound tree, and to use the pre-computed colouring solutions later inside the branch and bound search-tree to precipitate pruning. More formally, define *Col* as a feasible colouring of

Algorithm 1 A maximum clique algorithm

Require: a set of selected nodes $F \subseteq V$ and a set of potential expansion nodes $S \subseteq V$. The best clique retrieved so far is contained in the external set *Best*. A set R of requirements specifies the form of values for certain $R(i,j)$. The recursive algorithm is normally invoked with the following values for the parameters: $F := \emptyset$, $S := V$ and $Best := \emptyset$.

CarraghanPardalos(F, S)

```
1: while S ≠ ∅ do
2:     select s ∈ S;
3:     S := S\{s};
4:     S' := S;
5:     for z ∈ S' do
6:         if (z,s) ∉ E then
7:             S' := S'\{z};
8:         end if
9:     end for
10:    F' := F ∪ {s};
11:    if S' = ∅ and |F'| > |Best| then
12:        Best := F';
13:    else
14:        if |F'| + |S'| > |Best| then
15:            if ∄i, j ∈ N and R(i,j) ∈ R : (R(i,j) < |F(i,j)| or R(i,j) > |F(i,j)| + |S(i,j)|) then
16:                CarraghanPardalos(F', S');
17:            end if
18:        end if
19:    end if
20: end while
```

the graph G, Col_i as the colour associated with vertex i in such a colouring and Col_M as the set of colours associated with $M \subseteq V$ in such a solution.

Proposition 1 can be then improved according to the following result:

Proposition 4 *At depth D, with M_D representing the set of potential expansion nodes and LB a lower bound on the size of the optimal clique, if $D + |Col_{M_D}| \leq LB$, then the current solution cannot be expanded into an improved clique, and the backtracking mechanism can be activated.*

Analogous improvements can be applied to Propositions 2 and 3. Before formalizing this, it is however important to observe that these latter results apply locally only on the codewords with a given symbol j in a given position i. For this reason, it might be intuitively more effective to reason on a local colouring solution calculated for the subgraph of G containing only the vertices associated with these codewords. Such a *local colouring* might clearly turn out to be far from optimal once propagated to the rest of the vertices of the graph, but potentially produces better results in the context of these propositions.

Remark 1 *Once a local colouring has been found for a subgraph associated with a (position i, value j) pair, by exploiting the symmetry of the graph, a solution can be automatically propagated to all the other pairs (k,l) in the rest of the graph in a trivial way. This is done in the implementation used here. It improves the total computation time spent on local colouring substantially.*

Proposition 2 cannot be directly improved by the colouring bound, since any partial solution F, and consequently its subsets $F(i,j)$, will be valid cliques, and therefore they will be coloured with $|F|$ (respectively $|F(i,j)|$) colours by definition.

The situation is different for Proposition 3. It can be improved, as described in the following result:

Proposition 5 *Given a set of requirements R specifying values for $R(i, j)$ as defined in Definition 2, if during the execution of Algorithm 1 $\exists i, j \in \{0, 1, \ldots, n-1\}$ and $R(i, j) \in R : R(i, j) > |Col_{F(i,j)}| + |Col_{S(i,j)}|$ then backtracking can be activated since any solution contained in the current search-subtree does not fulfill the requirements in R.*

The pseudocode of Algorithm 1 can be easily modified to incorporate the new ideas. Namely, it is sufficient to use $|Col_{S'}|$ in place of $|S|$ in line 14 and $|Col_{S(i,j)}|$ instead of $|S(i, j)|$ in line 15.

Notice that the theory has been developed referring to one colouring solution, but considering multiple colouring solutions is likely to improve the pruning. In terms of Algorithm 1, this would imply the addition of a loop ranging through all the colouring solutions considered and covering lines 14-18. There is however a trade-off to consider: handling multiple colourings might end up increasing the overall computation time of the method, since time has to be invested to find the initial colouring solutions, and for the loop mentioned above. The experimental results of Section 5 will empirically measure this trade-off, and will also prove the effectiveness of the ideas introduced in this section.

5 Experimental results

The permutation code with parameters (6,5) is used in this paper as a benchmark. This choice is common in the literature (see, for example [24–26]), motivated by the fact that it is one of the largest fully treatable problems with the technology currently available. In particular, attention will be focused on one position of the code. By considering all the meaningful combinations of values of $R(0, j)$ it can be proved that $M(6,5) = 18$, although this is outside the scope of the present work. The aim here is to show how colouring-based bounds can effectively speed up the computation by forcing early pruning while visiting the search-tree. In this context, the traversal of each search-tree will be completed even when an optimal solution (according to [26]) has been retrieved already.

In the experiments the exact version of the DSATUR algorithm described in [29] is used to solve colouring problems. This is an exact method, but the execution is truncated after a maximum computation time of 4 seconds (for each run) and the best (heuristic) solution retrieved is returned in case optimality has not been proved in such a computation time. The characteristics of the solutions provided by the algorithm normally depend strongly on the order in which the vertices of the graph are presented. For this reason, in this study the following six different orderings are considered in order to test the impact of multiple colouring solutions on the pruning capabilities of Proposition 4 and Proposition 5:

1. Initial ordering: the algorithm is applied with vertices ordered according to the lexicographic order of the associated codewords (this is the default ordering);

2. Largest degree first: the vertices are sorted in non increasing order of their degrees before the algorithm is applied;
3. Largest degree first with updates: this is the same as the previous one, but now the vertices of largest degree are successively removed from the graph and added to the list of sorted vertices. So this time the degree calculation excludes vertices that have already been removed from the graph;
4. Smallest degree first: the vertices are sorted in non decreasing order of their degrees before the algorithm is applied;
5. Smallest degree first with updates: this is the same as the previous one, but now the vertices of smallest degree are successively removed from the graph and added to the list of sorted vertices. So this time the degree calculation excludes vertices that have already been removed from the graph;
6. Random ordering: the algorithm is applied with vertices ordered randomly.

Following the theory described in Section 4 when the graph colouring algorithm is applied to the whole graph the colourings (and the orderings) will be referred to as *global*. Similarly, when the colouring algorithm is applied only on a subgraph containing all vertices associated with words with a specific value j in a given position i the colourings (and orderings) will be referred to as *local*.

Results are presented in Tables 1-6, where all the relevant optimal combinations of $R(0, j)$ are considered. For each experiment an initial lower bound $LB = 17$ and an initial upper bound $UB = 30$ are considered, since a solution with 17 codewords is straightforward to retrieve, and 30 is a trivial upper bound (see for example [24]). In each table columns 1 and 2 denote the number of global and local orderings used respectively. If the number is 1 it is the initial ordering (the default ordering) that is used. In columns 3 and 4 the time in seconds required to visit the search-tree and the total number of nodes visited are reported, for each combination of local and global ordering (colouring) considered.

Table 1. Problem (6,5) with $R(0, j) = \{5, 4, 3, \leq 3, \leq 3, \leq 3\}$

No. of Global orderings	No. of Local orderings	Sec	Nodes
0	0	61.01	31,413,402
1	0	58.65	30,727,933
6	0	84.80	14,648,696
0	1	13.89	8,426,888
0	6	7.20	2,169,303
1	1	19.21	8,647,932
1	6	10.55	2,187,116
6	6	38.98	2,168,643

The experiments indicate that using colouring solutions as described in Section 4 can drastically improve the computation times and the number of search-tree nodes visited by the branch and bound algorithm described in Section 3. Both the factors considered are decreased by up to one order of magnitude by just deploying graph colouring concepts into the original branch and bound framework.

A finer study of Tables 1-6 also indicates that global colouring solutions (based on global orderings) are useful but considering one colouring solution only is more con-

Table 2. Problem (6,5) with $R(0, j) = \{5, 3, 3, \leq 3, \leq 3, \leq 3\}$

No. of Global orderings	No. of Local orderings	Sec	Nodes
0	0	750.01	436,641,040
1	0	371.48	274,769,522
6	0	379.76	120,431,371
0	1	79.75	67,537,223
0	6	26.51	8,721,718
1	1	106.70	84,168,801
1	6	24.75	11,383,553
6	6	62.44	10,469,924

Table 3. Problem (6,5) with $R(0, j) = \{4, 4, 4, \leq 4, \leq 4, \leq 4\}$

No. of Global orderings	No. of Local orderings	Sec	Nodes
0	0	1,280.57	490,775,395
1	0	759.96	354,853,741
6	0	1,015.86	212,344,086
0	1	355.79	141,547,328
0	6	195.79	42,967,165
1	1	375.01	141,940,942
1	6	122.56	43,117,217
6	6	213.11	43,060,959

Table 4. Problem (6,5) with $R(0, j) = \{4, 4, 3, 3, \leq 3, \leq 3\}$

No. of Global orderings	No. of Local orderings	Sec	Nodes
0	0	1,743.12	632,567,082
1	0	1,082.01	459,840,891
6	0	1,392.17	280,873,741
0	1	440.77	204,363,106
0	6	187.88	57,797,614
1	1	521.17	207,136,275
1	6	220.14	59,128,806
6	6	341.62	58,887,360

Table 5. Problem (6,5) with $R(0, j) = \{4, 3, 3, 3, 3, 2\}$

No. of Global orderings	No. of Local orderings	Sec	Nodes
0	0	27,686.11	10,854,388,364
1	0	14,680.94	7,820,127,181
6	0	18,409.08	4,644,227,820
0	1	6,195.89	3,739,897,610
0	6	2,461.58	822,109,820
1	1	7,081.68	3,827,416,965
1	6	2,693.68	850,768,132
6	6	3,514.47	849,151,258

venient than using more in terms of running time. This intuitively happens because the gain associated with the other colouring solutions is typically marginal, and anyway the time spent to calculate the multiple colouring solutions does not pay off in terms of global time reduction for the overall algorithm. The situation is different when local colouring solutions (orderings) are used. In this case considering six orderings (and consequently six distinct colouring solutions) clearly pays off. This intuitively happens because the time spent to calculate local colouring solutions is much shorter than that necessary to obtain good quality global colouring solutions (the optimal solution is nor-

Table 6. Problem (6,5) with $R(0, j) = \{3,3,3,3,3,3\}$

No. of Global orderings	No. of Local orderings	Sec	Nodes
0	0	144,487.71	59,807,792,221
1	0	82,420.77	48,402,461,745
6	0	121,905.58	35,460,056,076
0	1	47,325.84	28,820,694,336
0	6	36,227.05	12,209,812,158
1	1	56,944.20	30,028,334,435
1	6	41,814.69	12,714,963,664
6	6	54,703.97	12,701,225,827

mally found much more quickly on the subgraphs associated with local colouring) and at the same time Proposition 5 seems to benefit substantially from multiple colourings, leading to overall shorter global computation times for the algorithms. The conclusions drawn for computation times can be transferred directly to the number of search-tree nodes visited to close the problem by the different methods considered.

6 Conclusion

In this paper, the design problem for permutation codes has been modelled as a maximum clique problem. It has been shown from a theoretical point of view how graph colouring upper bounds can be employed to improve the performance of a specialized branch and bound algorithm recently presented. Experimental results confirm the effectiveness of such theoretical results. In particular, they show how the computation time and the number of search-tree nodes visited by the branch and bound algorithm are drastically reduced when colouring bounds are used. The study also helps to evaluate the contribution of the different theoretical results, and provides indications about good design choices when considering multiple colouring solutions at the same time.

References

1. Carraghan, R., Pardalos, P.M.: An exact algorithm for the maximum clique problem. Operations Research Letters, 9 375–382 (1990)
2. Montemanni, R.: Combinatorial optimization algorithms for the design of codes: a survey. Journal of Applied Operations Research 7(1):36–41 (2015)
3. Deza, M., Vanstone, S.A.: Bounds for permutation arrays. Journal of Statistical Planning and Inference 2 197–209 (1978)
4. Blake, I.F.: Permutation codes for discrete channels. IEEE Transactions on Information Theory 20(1) 138–140 (1974)
5. Bogaerts, M.: New upper bounds for the size of permutation codes via linear programming. The Electronic Journal of Combinatorics 17(#R135) (2010)
6. Chu, W., Colbourn, C.J., Dukes, P.: Constructions for permutation codes in powerline communications. Designs, Codes and Cryptography 32, 51–64 (2004)
7. Dukes, P., Sawchuck, N.: Bounds on permutation codes of distance four. Journal of Algebraic Combinatorics 31 143–158 (2010)
8. Frankl, P., Deza, M.: On maximal numbers of permutations with given maximal or minimal distance. Journal of Combinatorial Theory Series A 22, 352–260 (1977)

9. Janiszczak, I., Staszewski, R.: An improved bound for permutation arrays of length 10, http://www.iem.uni-due.de/preprints/IJRS.pdf (downloaded 9^{th} November 2015)
10. Tarnanen, H.: Upper bounds on permutation codes via linear programming. European Journal of Combinatorics 20 101–114 (1999)
11. Colbourn, C.J., Kløve, T., Ling, A.C.H.: Permutation arrays for powerline communication and mutually orthogonal latin squares. IEEE Transactions on Information Theory 50, 1289–1291 (2004)
12. Gao, F., Yang, Y., Ge, G.: An improvement on the Gilbert-Varshamov bound for permutation codes. IEEE Transactions on Information Theory 59(5), 3059–3063 (2013)
13. Han Vinck, A.J.: Coded modulation for power line communications. A.E.Ü. International Journal Electronics and Communications 54(1), 45–49 (2000)
14. Ferreira, H.C., Han Vinck, A.J.: Inference cancellation with permutation trellis arrays. Proceedings of the IEEE Vehicular Technology Conference, 2401–2407 (2000)
15. Huczynska, S.: Powerline communications and the 36 officers problem. Philosophical Transactions of the Royal Socicety A. 364, 3199–3214 (2006)
16. Pavlidou, N., Han Vinck, A.J., Yazdani, J., Honary, B.: Power line communications: state of the art and future trends. IEEE Communications Magazine 41(4), 34–40 (2003)
17. de la Torre, D.R., Colbourn, C.J., Ling, A.C.H.: An application of permutation arrays to block ciphers. Proceedings of the 31^{st} Southeastern International Conference on Combinatorics, Graph Theory and Computing 145, 5–7 (2000)
18. Jiang, A., Mateescu, R., Schwartz, M., Bruck, J.: Rank modulation for flash memories. Proceedings of the IEEE International Symposium on Information Theory, 1731–1735 (2008)
19. Jiang, A., Schwartz, M., Bruck, J.: Error-correcting codes for rank modulation. Proceedings of the IEEE International Symposium on Information Theory, 1736–1740 (2008)
20. Smith, D.H., Montemanni, R.: A new table of permutation codes. Designs, Codes and Cryptography 63(2), 241–253 (2012)
21. Janiszczak, I., Lempken, W., Östergård, P.R.J., Staszewski, R.: Permutation codes invariant under isometries. Designs, Codes and Cryptography 75, 497–507 (2015)
22. Montemanni, R., Barta, J., Smith, D.H.: Permutation codes: a new upper bound for M(7,5). Proceedings of the International Conference on Pure Mathematics, Applied Mathematics, Computional Methods, 86–90 (2014)
23. Montemanni, R., Barta, J., Smith, D.H.: Permutation Codes: a branch and bound approach. Proceedings of the International Conference on Informatics and Advanced Computing, 1–3 (2014)
24. Barta, J., Montemanni, R., Smith, D.H.: A branch and bound approach to permutation codes. Proceedings of the IEEE 2^{nd} International Conference of Information and Communication Technology, 187–192 (2014)
25. Barta, J., Montemanni, R., Smith, D.H.: Permutation Codes via Fragmentation of Group Orbits. Proceedings of the IEEE 3^{rd} International Conference of Information and Communication Technology, 39–44 (2015)
26. Montemanni, R., Barta, J., Smith, D.H.: The design of permutation codes via a specialized maximum clique algorithm. Proceedings of the IEEE 2rd International Conference on Mathematics and Computers in Science and Industry (to appear)
27. Smith, D.H., Montemanni, R.: Permutation codes with specified packing radius. Designs, Codes and Cryptography 69, 95–106 (2013)
28. Östergård, P.R.J.: A fast algorithm for the maximum clique problem. Discrete Applied Mathematics 120, 197–207 (2002)
29. Mehrotra, A., Trick, M.A.: A column generation approach for graph coloring. INFORMS Journal on Computing 8, 344–354 (1996)

Clustering Binary Signature applied in Content-Based Image Retrieval

Thanh The Van[1,3,⋆] and Thanh Manh Le [2]

[1]Faculty of Information Technology, Hue University of Sciences, Viet Nam
[2]Hue University, Viet Nam
[3]HCMC University of Food Industry, Viet Nam
vanthethanh@gmail.com,lmthanh@hueuni.edu.vn

Abstract. Image retrieval is an important problem on the multimedia systems. It is time-consuming to query directly on a large image database. So, the paper approaches to build an image retrieval system CBIR (*Content-Based Image Retrieval*) based on binary signature to retrieve effectively on the large data of images. Firstly, the paper presents the segmentation method based on low-level visual features including color and texture of image. On the basis of segmented image, the paper creates binary signature to describe location, color and shape of interest objects. In order to match similar images, the paper presents a similarity measure between the images based on binary signatures. On the basis of the similarity measure, the paper proposes the clustering binary signature method to quickly query similar images. At the same time it describes the splitting and group method to apply for clusters of binary signatures. From there, the paper gives the CBIR model to describe the process of similar image retrieval. To demonstrate the proposed method, the paper builds application and assesses experimental results on image databases including Corel, Corel Wang and ImageCLEF.

Keywords: Image Retrieval; Binary Signature; Similarity Measure

1 Introduction

Nowadays, image data is applied widely in many fields such as digital library, geographic information system, satellite observation system, criminal investigation system, astronomical researches, bio-medical application, etc [6], [8], [15]. On the other hand, image is a non-structured data because their content has intuitive nature [1], so the problem of image mining has many challenges in looking for utility information from large image database. Moreover, image retrieval is an important problem in the field of visual computer and image processing [1].

The image retrieval problem is divided into two main classifications [1], [6], [8], [15] including (1) Image retrieval based on key word TBIR (*text-based image retrieval*), i.e. image's index on the base of description in form of text is defined by user, therefore it is time-consuming to describe image's content and there are

⋆ Center for Information Technology, HCMC University of Food Industry, Viet Nam

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_22

particular limitations because of subjectivity of people; (2) Image retrieval based on content CBIR (*content-based image retrieval*) is presented in 1980; The CBIR finds a set of similar images with query image based on automatic extraction about content of image [15] . So, the CBIR overcomes the restriction of TBIR. However, it has many difficult matters such as extracting feature, creating multi-dimension indexes and giving the similar image retrieval method.

CBIR architectural includes two parts: (1) Extracting feature to create index for the image; (2) Implementing the similar image retrieval based on index. The result of image retrieval returns the most similar images in the given measure.

The paper approaches the CBIR and uses binary signature to create index for image object. The binary signature of image has length n as a vector in space $\sum^n$ (with n as the number of dimensions and $\sum = \{0, 1\}$ as a set of basis symbols) to describe visual interest of image [7]. Therefore, the paper approaches the method of image segmentation for creating binary signature based on CIE L*a*b* color space and Wavelet transform in order to extract color and texture of image. This binary signature describes location, color and shape of interest object. From there, the paper proposes the similarity measure and performs clustering binary signature to quickly query similar images.

2 Related Work

There are many works related to content-based image retrieval are published such as extracting object on image based on histogram value [16], similar image retrieval based on matching interest regions [2],[16], color image retrieval based on bit plane and color space L*a*b* [17], converting color space and building hashing in order to retrieve content of color images [11], etc.

According to [1], Tamura proposed the method of approximate of texture based on human visual system. Wavelet transform is applied in analyzing texture and classifying images based on decomposition of multi-resolution of images.

According to [5], Kumar proposed automatic segmentation method based on Wavelet transform in order to create segmentation quickly and easily.

According to [7], Yannis Manolopoulos described the binary signature to query similar images based on S-Tree. Besides that, Nascimento and Timothy Chappell [3],[9],[10] approached the similar image retrieval method based on binary signature. The experiment shows the effectiveness when querying on large image databases.

Recently, many works of similar image retrieval based on binary signature have been published such as image retrieval based on index and S-Tree [10], image retrieval based on EMD measure and S-Tree [12], image retrieval based on binary signature [7], image retrieval based on signature graph [13],[14], etc.

Related works show that the method of image retrieval based on binary signature is very effective. So, the paper approaches the method which creates binary signature based on interest object of segmented image. The binary signature describes shape, color and location of interest object, from there we cluster binary signatures to query quickly for similar images.

3 Creating Binary Signature of Image

3.1 Image Segmentation

To recognize the texture vector of neighboring pixels, we use the DWF transform (*Discrete Wavelet Frames*) [18] to convert the intensity into sub-samples. The DWT is executed by the low-pass filter $H(z)$ to decompose the intensity. The high-pass filter $G(z) = zH(-z^{-1})$ is defined rely on $H(z)$. The bank filter $H_V(z)$, $G_i(z)$, $i = 1, ..., V$ is created by $H(z)$, $G(z)$, with $H_{k+1}(z) = H(z^{2^k})H_k(z)$, $G_{k+1}(z) = G(z^{2^k})H_k(z)$, with $k = 0, ..., V-1$, $H_0(z) = 1$.

The standard deviation value reflects entropy around the expectation value and this entropy describes the texture of discrete signals. So, the standard deviation of all detailed components on DWF transform is used as the feature texture. For this reason, the texture vector corresponding to pixel p is $T(p) = [\sigma_1(p), \sigma_2(p), ..., \sigma_{9\times V}(p)]$ which is calculated on neighboring square.

The color vector $I(p) = (I_L(p), I_a(p), I_b(p))$ is created by the color space $CIEL^*a^*b^*$ which is endorsed as international standard in 1970 and uniform perception of human [1].

After extracting the texture and color of image, we implement the process of cluster of all pixels on the image by K-Means method. In the first step one chooses the center cluster rely on the contrast C of the image. To quickly execute, the image I is divided into non-overlap blocks which are called supper pixels. Therefore, the texture vector $T^b(b_l)$ and color vector $I^b(b_l)$ of the block b_l are average values of texture vectors and color vectors of all pixels on the block.

Definition 1. *Given the two arbitrary blocks b_l, b_n, the contrast of image is $C = \max\{d = \alpha||I^b(b_l) - I^b(b_n)|| + \beta||T^b(b_l) - T^b(b_n)||\}$ (the experiment uses $\alpha = \beta = 0.5$). The background and the foreground of image corresponding to the blocks which have low energy and high energy, respectively.*

Fig. 1. A sample image is divided into 7×11 blocks

On the next step, we find the set of complement center O (i.e. we search the nearest blocks with foreground rely on the measure d). In the experiment, we find the centers which have $d > \mu C$ (with $\mu = 0.4$).

Algorithm 1. Segmentation

Input: The color image I

Output: The mask M

Step 1: Extract texture vector $T(p)$ and intensity vector $I(p)$ for each pixel on image I.

Step 2: Compute the center of blocks by calculating the average of texture vectors and color vectors of all pixels in each block.
Step 3: Calculate the contrast C to form background and foreground.
Step 4: Find the set of complement center O based on the contrast C.
Step 5: Cluster all the pixels on the image I rely on the set of center O.
Step 6: Create the mask M with clustered pixels.
Step 7: Remove the regions have small area rely on the mask M.

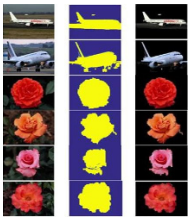


Fig. 2. Some results of segmented images

3.2 Creating Binary Signature of Image

Definition 2. *The binary signature of the interest region O of image I is a bit-string $Sig_I(O) = b_1 b_2 ... b_N$ where $b_i = 1$ if the i^{th} cell of image I has overlap with the interest region O, otherwise $b_i = 0$, with $N = n \times n$ be the number of cells of image.*

Definition 3. *Let $c_1, c_2, ..., c_m$ be indexes of dominance colors of interest region $O_1, O_2, ..., O_m$ with $c_i \in \{1, 2, ..., M\}$. Then, the binary signature describes colors of image I based on interest regions $O_1, O_2, ..., O_m$ is a bit-string $Sig_C^I = b_1 b_2 ... b_M$ where $b_i = 1$ if $i \in \{c_1, c_2, ..., c_m\}$, otherwise $b_i = 0$.*

Definition 4. *Giving image I, let $Sig_O^I = b_1^O ... b_N^O$ and $Sig_C^I = b_1^C ... b_M^C$ be the binary signature of interest regions and the ones of dominance colors of image I, respectively. Then, the binary signature of image I is defined as $Sig(I) = Sig_O^I \oplus Sig_C^I = b_1^O ... b_N^O b_1^C ... b_M^C$.*

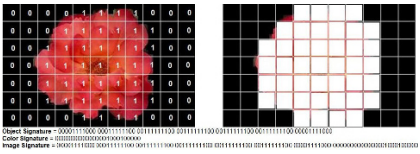


Fig. 3. An example about binary signature of image

3.3 The Similarity Measure

Definition 5. *Let* $Sig(I) = Sig_O^I \oplus Sig_C^I$ *and* $Sig(J) = Sig_O^J \oplus Sig_C^J$ *be binary signatures of image* I *and* J*. The dissimilarity measure based on interest regions and color in turn* $\mu_O(sig_O^I, sig_O^J)$ *and* $\mu_C(sig_C^I, sig_C^J)$ *are defined as follows:*

$$\mu_O(sig_O^I, sig_O^J) = \frac{|(sig_O^I XOR sig_O^J)|}{N} = \frac{\sum_{i=1}^{N}(sig_O^I[i] XOR sig_O^J[i])}{N} \in [0,1]$$

$$\mu_C(sig_C^I, sig_C^J) = \frac{|(sig_C^I XOR sig_C^J)|}{M} = \frac{\sum_{i=1}^{N}(sig_C^I[i] XOR sig_C^J[i])}{M} \in [0,1]$$

Definition 6. *(The dissimilarity measure between two images) Let* $Sig(I) = Sig_O^I \oplus Sig_C^I$ *and* $Sig(J) = Sig_O^J \oplus Sig_C^J$ *be binary signatures of image* I *and* J*. Then, the dissimilarity measure between two images* I *and* J *is* $\phi(I,J) = \alpha \times (\mu_O(sig_O^I, sig_O^J)) + \beta \times (\mu_C(sig_C^I, sig_C^J))$*.*

Theorem 1. *The function of dissimilarity measure* μ_α *is a metric because of properties as follows:*

(1) Non-negative: $\mu_\alpha(sig_\alpha^I, sig_\alpha^J) \geq 0$ *and* $\mu_\alpha = 0 \Leftrightarrow sig_\alpha^I = sig_\alpha^J$

(2) Symmetry: $\mu_\alpha(sig_\alpha^I, sig_\alpha^J) = \mu_\alpha(sig_\alpha^J, sig_\alpha^I)$

(3) Triangle inequality: $\mu_\alpha(sig_\alpha^I, sig_\alpha^J) + \mu_\alpha(sig_\alpha^J, sig_\alpha^K) \geq \mu_\alpha(sig_\alpha^I, sig_\alpha^K)$

Proof. This theorem is proved easily.

The paper uses the dissimilarity measure ϕ to assess the similar level between two images. So, the dissimilarity measure ϕ is used as the similarity measure.

4 Clustering Binary Signature

Definition 7. *A cluster* V_i *has center* I_i *with* $k_i\theta$ *is a radius, be defined as* $V_i = V_i(I_i) = \{J | \phi(I_i, J) \leq k_i\theta, J \in \Im, i = 1, ..., n\}$*,* $k_i \in N^*$*.*

Definition 8. *(The Rules of Distribution of Images) Giving set* $\Omega = \{V_i | i = 1, ..., n\}$ *is a set of clusters, with* $V_i \cap V_j = \emptyset, i \neq j$*, let* I_0 *be an image needs to distribute in a set of clusters* Ω*, let* I_m *be a center of cluster* V_m*, so that* $(\phi(I_0, I_m) - k_m\theta) = \min\{(\phi(I_0, I_i) - k_i\theta), i = 1, ..., n\}$*, with* I_i *is a center of cluster* V_i*. There are three cases as follows:*

(1) If $\phi(I_0, I_m) \leq k_m\theta$ *then the image* I_0 *is distributed in cluster* V_m*.*

(2) If $\phi(I_0, I_m) > k_m\theta$ *then setting* $k_0 = [(\phi(I_0, I_m) - k_m\theta)/\theta]$*, at that time:*

(2.1) If $k_0 > 0$ *then creating cluster* V_0 *with center* I_0 *and radius is* $k_0\theta$*, at that time* $\Omega = \Omega \cup \{V_0\}$*.*

(2.2) Otherwise (i.e. $k_0 = 0$*), the image* I_0 *is distributed in cluster* V_m *and* $\phi(I_0, I_m) = k_m\theta$*.*

On the base of the similarity measure ϕ and the rules of distribution of image are shown in ***Definition 8***, the paper proposes the algorithm to create clusters of binary signatures. With the input image database $\Im$ and the threshold $k\theta$, the algorithm returns the set of clusters $CLUSTER$.

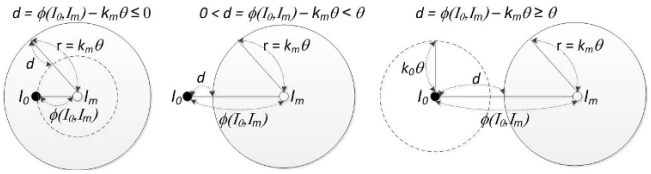


Fig. 4. An illustration of the distribution rules of images

Algorithm 3. Clustering binary signature
Input: Image database $\Im$ and threshold $k\theta$
Output: A set of clusters $CLUSTER = \{V_1, V_2, ..., V_n\}$

$CLUSTER = \emptyset$; $k_I = 1$; $n = 1$;
for $\forall I \in \Im$ **do**
  if $CLUSTER = \emptyset$ **then**
    $I_0^n = I$; $r = k_I\theta$; Initialize cluster $V_n = \langle I_0^n, r, \phi = 0\rangle$;
    $CLUSTER = CLUSTER \cup V_n$;
  else $(\phi(I, I_0^m) - k_m\theta) = \min\{(\phi(I, I_0^i) - k_i\theta), i = 1, ..., n\}$
    if $\phi(I, I_0^m) \le k_m\theta$ **then** $V_m = V_m \cup \langle I, k_m\theta, \phi(I, I_0^m)\rangle$;
    else $k_I = [(\phi(I, I_0^m) - k_m\theta)/\theta]$;
      if $k_I > 0$ **then**
        $I_0^{n+1} = I$; $r = k_I\theta$; Initialize cluster $V_{n+1} = \langle I_0^{n+1}, r, \phi = 0\rangle$;
        $CLUSTER = CLUSTER \cup V_{n+1}$; $n = n + 1$;
      else $\phi(I, I_0^m) = k_m\theta$; $V_m = V_m \cup \langle I, k_m\theta, \phi(I, I_0^m)\rangle$;
      end if
    end if
  end if
end for

The process of clustering can lead to unequal distribution about the number of images in each cluster. So, we need to split the cluster which has a large radius. Let $\zeta = \{\zeta_1, \zeta_2, ..., \zeta_m | \zeta_i \in [0, 1]\}$ be a scale sequence which is ordered descending. The split algorithm of a cluster $V = \{I | \phi(I_0, J_i) \le k\theta, J_i \in \Im, i = 1, ..., n, k \in N^*\}$ is done as follows:

Algorithm 4. Splitting cluster
Input: $\zeta = \{\zeta_1, ..., \zeta_m | \zeta_i \in [0, 1]\}$, $V = \{I | \phi(I_0, J_i) \le k\theta, J_i \in \Im, k \in N^*\}$
Output: A set of cluster C

Step 1: Initializing $C = \emptyset$
Step 2: Setting $\zeta_{\max} = \max\{\zeta_i \in \zeta\}$;
Step 3: Choosing $I_M \in V \backslash C$ so that $d = k\theta - \phi(I_0, I_M) \ge k\zeta_{\max}\theta$ and $\phi(I_M, I_m) > k\zeta_{\max}\theta$, where I_m is a center of cluster of C $(m = 1, ..., M - 1)$
if exist I_M **then** $V_M = \{I | \phi(I_M, I) \le k\zeta_{\max}\theta\}$; $C = C \cup V_M$; go to Step 3;
else $\zeta = \zeta \backslash \zeta_{\max}$; go to Step 2;
end if
Step 4: : Each $J \in V$ is not distributed yet, we cluster it into C based on the rules of distribution by ***Definition 8***.

Theorem 2. *Let* $C = \{V_1, V_2, ..., V_M\}$ *be a set of clusters which is split from* $V = \{I | \phi(I_0, J_i) \leq k\theta, J_i \in \Im, i = 1, ..., n\}$. *We have the results as follows:*

(1) The set of clusters of C *include the items of* V *and this set non-overlapping, i.e.,* $V_i \cap V_j = \emptyset$, *with* $i \neq j$ *and* $i, j \in \{1, 2, ..., M\}$.

(2) Each item of V *belongs to a unique cluster of* C

(3) All of the items in V *are distributed into* C.

Proof. This theorem is proved easily.

Giving the set of cluster $C = \{V_1, V_2, ..., V_M\}$, so that each V_i has a center I_i. The group algorithm is done as follows:

Algorithm 5. Group the set of clusters

Input: $C = \{V_1, V_2, ..., V_M\}$, threshold δ, a scale ζ

Output: A set of centers of clusters V and the group of clusters G

Step 1: Initializing $G = \emptyset$; $V = \emptyset$

Step 2: Choosing $V_\alpha, V_\beta \in C$: $\phi(I_\alpha, I_\beta) = \max\{\phi(I_i, I_j) | i \neq j \wedge i, j \in \{1, ..., M\}\}$

if $\phi(I_\alpha, I_\beta) < \delta$ **then** $G = C$; return;

else $V = \{V_\alpha, V_\beta\}$; $C = C \backslash V$;

end if

for $V_i \in C$ **do**

  if $d = \min\{\phi(I_i, J_j)\} \geq \zeta\phi(I_\alpha, I_\beta)$ **then** $V = V \cup V_i$; $C = C \backslash V_i$;

  end if

end for

$G = \{G_i = V_i | V_i \in V, i = 1, ..., |V|\}$;

for $V_j \in C$ **do** $\phi(I_j, I_m) = \min\{\phi(I_j, I_k)\}$, with $V_k \in V$; $G_m = G_m \cup V_j$;

end for

5 Image Retrieval

5.1 Image Retrieval Algorithm

The image retrieval algorithm finds out the set of images are corresponding to the query image I_Q. On the base of cluster groups $G = \{G_1, ..., G_n\}$, the algorithm determines the group G_m which stores images with most similarity, after that it gives out the result including images of group G_m.

Algorithm 6. Image Retrieval

Input: Query image I_Q, A set of center cluster V and the group of clusters G

Output: A set of images IMG

Step 1: Initializing $IMG = \emptyset$;

Step 2: $\phi(I_Q, I_m) = \min\{\phi(I_Q, I_i) | I_i$ as a center of $V_i \in V\}$;

for $I \in G_m$ **do** $IMG = IMG \cup \{I\}$;

end for

5.2 Experiment Model

The process of experiment is implemented including two phases. The first phase is pre-processing to create the input data. The second phase executes the process

of image retrieval with the query image. The steps of pre-processing include: (1) Segment images on image database; (2) Create the binary signature of each segmented image; (3) Build the clusters including the binary signatures of similar images. The steps of image retrieval includes: (1) Segment the query image; (2) Create the binary signature of query image; (3) Find the nearest cluster based on group of clusters; (4) Sort the similar image's signatures by similarity measure; (5) Retrieve the similar images.

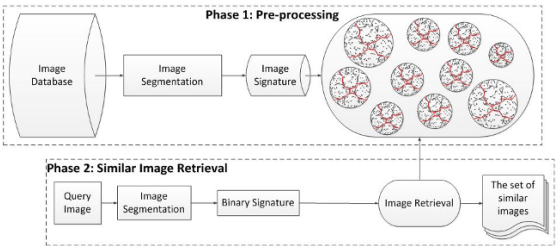


Fig. 5. The model of image retrieval

5.3 Experiment Results

The paper implements the process of similar image retrieval on image databases including COREL, COREL Wang and ImageCLEF which are classified to another subjects. Each query image, we find out the set of similar images on these image database.

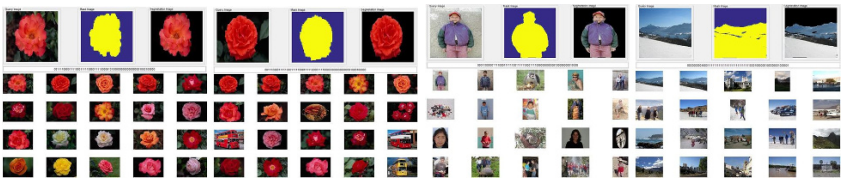


Fig. 6. Some results of the process of image retrieval

In the application, we use IPT (*Image Processing Toolbox*) of Matlab 2015. The experiment is executed on the computer which has the processor as Intel(R) CoreTM i7-2620M, CPU 2.70GHz, RAM 4GB and Windows 7 Professional operating system.

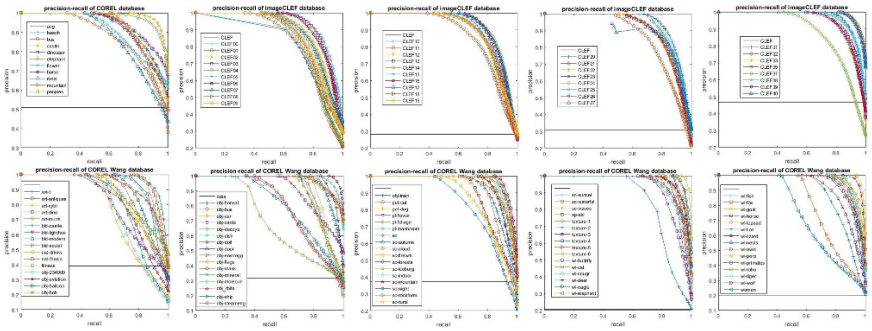


Fig. 7. Recall-Precision graph

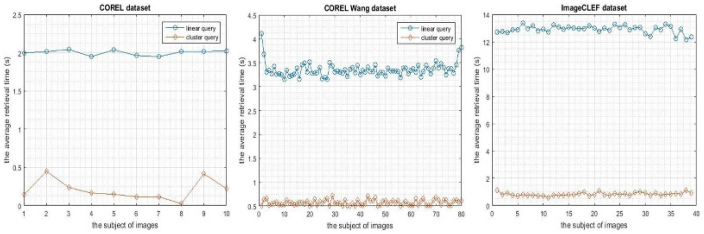


Fig. 8. The time (s) of image retrieval process (COREL, COREL Wang, ImageCLEF)

Table 1. Comparison of the average retrieval performance with COREL images

methods	Interest points	Color histogram	Fuzzy color histogram	S-Tree	Our approach
Average precision	0.657	0.488	0.509	0.549	0.760
Average recall	0.705	0.607	0.612	0.542	0.755
F-measure	0.680	0.541	0.556	0.545	0.757

Table 2. Comparison the size of storage volume

Image dataset	COREL	COREL Wang	ImageCLEF
Size of image dataset	59,691,434 bytes	41,854,565 bytes	1,723,000,375 bytes
Size of signature dataset	5,715,22 bytes	5,126,408 bytes	9,169,805 bytes
Reduced rate (%)	99.04253934	87.75185455	99.46780017

Table 3. The average of query time (s)

	Linear query	S-tree	Our approach
COREL	2.000	0.981	0.203
COREL Wang	3.353	1.143	0.571
ImageCLEF	12.905	3.349	2.837

6 Conclusion and Future Work

The paper build the binary signature of image to apply for matching similar images. It also presented the process of segmentation based on $CIEL^*a^*b^*$ and

Wavelet transform. According to the experiment, the image retrieval problem rely on binary signature very effectively at the same time help to quickly query and significantly reduced the query storage. In order to improve the accuracy, the future work of the paper will extract a set of interest objects of image and describe them based on basis objects for creating binary signature. From that, the paper builds a data structure to store and classify similar images and gives an automatic classification algorithm for a set of images.

References

1. Tinku Acharya, Ajoy K. Ray, Image Processing: Principles and Applications, John Wiley & Sons Inc. Publishers, Hoboken, New Jersey, 2005.
2. I. Bartolini et al., Query Processing Issues in Region-Based Image Databases, Springer-Verlag, Knowl. Inf. Syst, 25, pp.389–420, 2010.
3. Chappell et al., Efficient Top-K Retrieval with Signatures, ADCS, pp. 10–17, 2013.
4. P. W. Huang, Indexing Pictures by Key Objects for Large-scale Image Database, Pattern Recognition, 30 (7), pp. 1229-1237, 1997.
5. H. C. S. Kumar et al., Automatic Image Segmentation using Wavelets, JCSNS, 9(2), pp. 305–313, 2009.
6. Oge Marques, Borko Furht, Content-Based Image and Video Retrieval, Springer Science + Business Media New York, 2002.
7. Y. Manolopoulos, et al., Advanced Signature Indexing for Multimedia and Web Applications, Springer Science New York, 2003.
8. P. Muneesawang et al., Multimedia Database Retrieval: Technology and Applications, Springer Cham Heidelberg New York Dordrecht London, 2014.
9. M. A. Nascimento, V Chitkara, Color-Based Image Retrieval Using Binary Signatures, SAC 2002, Madrid, pp. 687–692, 2002.
10. M. A. Nascimento et al., Image indexing and retrieval using signature trees, Data Knowl. Engineering, 43, pp. 57–77, 2002.
11. Z. Tang et al., Robust Image Hash Function Using Local Color Features. Int. J. Electron. Commun., 67, pp. 717–722, 2013.
12. Thanh M.L, Thanh T.V, Image Retrieval System Based on EMD Similarity Measure and S-Tree, ICITES-2012, Springer Verlag, LNEE 234, pp. 139-146, 2013.
13. Thanh T.V., Thanh M. Le, Image retrieval Based on Binary signature and S-kGraph, Jour. of Annales Univ. Sci. Budapest., Sect. Comp., 43, pp.105–122, 2014.
14. Thanh The Van, Thanh Manh Le, RBIR Based on Signature Graph, ICCCI-2014, IEEE Xplore, pp.1-4, Coimbatore, India, 2014.
15. James Z. Wang, Integrated Region-Based Image Retrieval, Springer Science Business Media New York, 2001.
16. X.-Y. Wang et al., Robust Image Retrieval Based on Color Histogram of Local Feature Regions, Springer Science, Multimed Tools Appl, 49, pp. 323-345, 2010.
17. X.-Y. Wang et al., Robust color image retrieval using visual interest point feature of signicant bit-planes, DSP23(4), pp.1136–1153, 2013.
18. M. Unser, Texture classication and segmentation using wavelet frames, IEEE Trans. on Im. Processing, 4(11), pp. 1549-1560, 1995.

Tridimensional Scenes Management and Optimization for Virtual Reality simulators

Juan P. D'Amato[1,2], Cristian García Bauza[1,2], Marcos Lazo[1,2], Virginia Cifuentes[1,3],

[1]Instituto PLADEMA, Universidad Nacional del Centro de la Provincia de Buenos Aires, Campus Universitario S/N, 7000 Tandil, Argentina
[2]Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Argentina
[3]Comisión Nacional de Investigaciones Científicas de la Provincia de Buenos Aires (CICPBA), Argentina

{jpdamato, crgarcia, mlazo, cifuente}@exa.unicen.edu.ar

Abstract. Virtual Reality (VR) simulation offers a new paradigm for realistic control and operation training, employing 3D digital objects and environments to create immersive experiences. The virtual scenarios should be as similar to the real ones as possible, to improve training. Furthermore, obtaining a digital version of these scenarios is a complex process that involves several tasks including mathematical modeling and 3D detailed geometry generation, among others. This paper presents some novel software tools that easier the development of a 3D virtual subterranean simulator. By providing tight integration between traditional CAD software and visualization engines, these tools are successfully applied to the construction of several virtual scenarios. Moreover, some strategies to optimize digital resources to allow loading and visualizing large maneuver exercises along realistic train trajectories in desktop computers are presented.

Keywords: Graphics Computing, Geometry, Computational Optimization, Resource Administration, Training Simulators.

1 Introduction

Virtual Reality (VR) environments along with simulation techniques are valuable tools to practice and learn and can be applied to different disciplines and trainees. Being a trustworthy human-machine interface, these tools reduce the gap between the operation model and the real environment. The advantages of immersive based simulators for operators training are: the visual stimulation produced by the recreation of situations of the real world in a fully interactive fashion, the opportunity to develop knowledge and to practice skills and interact with other students protecting them from unnecessary risks. Many works show the advantages of VR for education [1, 3, 5, 6, 10, 11].

The training experience requires realistic and interactive operational environment visualization. For this purpose, high performance personal computers, and joint work

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_23

of different disciplinary groups are necessary to model the problem in a computational way [4]. A fundamental part of this team is the graphic design work. The designers model the scenarios with tridimensional geometry elements coming from CADs, blueprints, elevation maps or others. Generating these scenarios generally takes a long time. Therefore, they need various tools to ease the geometry organization [14].

In particular, a subway simulator is being developed by a group of designers. The scenario, composed by the stations and the tunnels, is represented by tridimensional models which contain hundreds of thousands of polygons and hundreds of high quality textures. Additionally, a complete scenario also includes animated objects (such as people, vehicles, among others) to get a realistic rendering. These scenarios consume plenty of memory that should be optimized in order to guarantee that an operator could work in real time without compromising the visual quality. Finally, the optimized scenarios are visualized in a rendering engine like Ogre3D [2].

In this paper, some techniques that reduce hardware requirements are presented. Particularly, it is described an image and geometry analysis algorithm that eliminates object redundancies and reduces images size. Furthermore, a dynamic scenarios load algorithm specially adapted to use during a subway driving training process is described. These tools were successfully applied in the creation of several virtual environments related to Argentinean train companies.

This article is organized in the following way: the materials and methods are described, then the result of the strategy proposed is presented and, finally, the conclusions.

2 Materials and Methods

The main purpose of working with Virtual Reality is to present to operators, who are being trained, multiple real world operational situations. Under this paradigm, trainees can face operators with abnormal functioning or risky situations, and evaluate how they react, as presented in [13, 15].

The VR method is only effective if the whole situation is greatly recreated, using both hardware controls and computational methods. The sensation of immersion is only achieved recreating in a digital and precise way a normal operational environment. It is well established that the coherence of a combination of simultaneous stimulus and the immersion sensation are key factors for training [7, 12].

The realistic 3D scenarios can be modeled using design software, photo sets, and detailed views, among others; generating sets of meshes and textures. When the 3D scenarios are very large, for example when modeling 10 kilometers tunnels, the designer's team may find it difficult to handle them and, thus, they need extra customized tools.

Following, we describe the methodology followed by our group for constructing a digital scene for VR using an automatic mesh building tool. The case of subway trains simulators is taken as an example.

2.1 Building 3D Scenes

The operator must recognize the environment to achieve an efficient and secure manipulation of the machinery. For this reason, the representation must consider all the particularities and elements that help subway drivers.

To create scenarios, first, in situ images are taken to capture the surrounding scenery elements. Then, exact positions are registered where the relevant objects are placed.The stations scenarios are completely different from each other, so they must be created by designers, paying special attention to indicators and representative paintings. As it can be observed in Figure 1, each station is different.

Fig.1. Two photographs of subway stations in Buenos Aires, Argentina.

On the other hand, tunnels have a repeated shape; consequently, they could be built automatically. Such geometry is constructed from real CADs that have altimetry, curves, tunnels shapes and other relevant information. Such data are filtered and validated, and then, using geometry extruding techniques, a first 3D model is generated. This model is stored in a standard 3D format that is shared between the designer and the programming group.

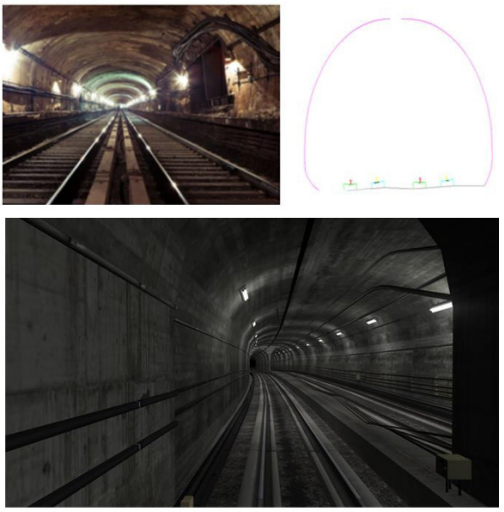


Fig.2.A real tunnel photograph (up-left), the CAD tunnel profile used (up-right) and a render of the extruded profile (down).

Finally, designers take these models, combine them with the stations, and add some relevant details, as brake indicators, lights, and other visual features. Then, using computer graphics techniques, illumination is customized and applied (see Figure 2). Figure 3 shows a final result of the generation, rendered in a commercial tool.

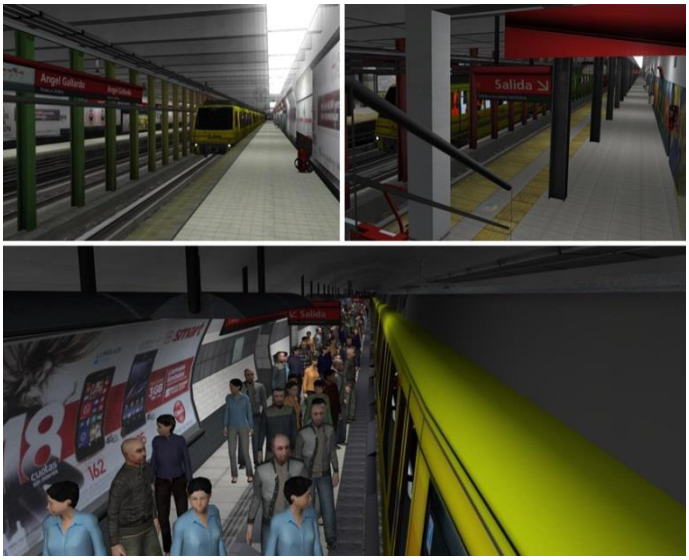


Fig.3. Different renders of a virtual station.

3 Method for Scenes Optimization

The 3D scenarios should be shown in real time, as far as the operators move along a virtual railway. As the scenarios are generally extensive, the resources (geometry and images) should be prepared and optimized carefully, not to affect the final 3D visualization.

To optimize the overall scenarios, three approaches are considered in this work: texture optimization, replicative mesh geometry elimination and dynamic loading. The first two strategies are applied before the simulator starts. The third one, as its name states, is applied in real time.

3.1 Optimization of Textures Sizes

The textures describe the surface of tridimensional objects. They are also used to apply visual effects as shadows or rugosity. The textures come from a material catalog or photographs assigned by designers to 3D objects. A typical scenario has thousands of images.

In general, designers use standard image resolutions for each image; however, in practice, countless images are either homogeneous (with few colors or repetitive patterns) or have a high detail that could not be appreciated when they are applied to little objects. Therefore, an ideal texture size is defined by the analysis of two features, homogeneity and 3D size.

The entropy [16] is considered the measure of texture homogeneity. It is the average quantity of information that an image contains. When all the pixels are equally probable (plain probability distribution), the entropy is maximum. When entropy is lower, information is higher. Therefore, the entropy of an image$X$ is denoted by $H(X)$.

Regarding the resolution, little objects, such as a drop tin or a small label could have a highly detailed texture which is not appreciated during simulation. It is possible to measure how much 3D space a texture occupies considering the 3D object dimension that utilizes them. We called M to each scenario object being $T(X)$ the normalized texture size in 3D space.

To combine both indicators, a linear combination was applied:

$$P(X) = \alpha\, H(X)\, T(M0) \quad \textbf{(1)}$$

Being α a normalization factor, $T(M_0)$ classifies objects sizes in three categories {1, 2, 3} regarding the surface S of the texture calculated in m^2, being:

1. if $S < 1\ m^2$
2. if $1\ m^2 \leq S < 5\ m^2$
3. in other case

According to $P(X)$, the texture is dimensioned in a smaller scale, preserving a minimum pixels resolution and maintaining the original aspect ratio.

3.2 Repetitive Objects Elimination

The designers usually reuse many objects when they create a complex scene: lights, signs, furniture, doors, among many others. When working with several scenarios, they clone objects and move them from one position to another, renaming them, increasing the overall memory size. To easier designer's task, it is desirable to automatically identify objects which are geometrically identical (clones) and eliminate them.

A metric to detect clones is proposed. Two objects are similar when they have the same material (same colors and textures) being the amount of the elements (vertex and triangles) and their geometrical arrangement is equal. Therefore, the classification criterion is reduced to the calculation of the minimum distance between the vertexes of two meshes M_X and M_Y as present in [9]. The formulation to calculate it is:

$$D(M_X, M_Y) = \sum_{x \in X} d(x, M_Y) + \sum_{y \in Y} d(y, M_X) \quad (2)$$

where x is a vertex of the mesh M_X, y is a vertex of mesh M_Y, $d(x, M_Y)$ is the minimum distance from x to M_Y, and $d(y, M_X)$ is the minimum distance from y to M_X.

This process is applied to each pair of objects that have the same amount of vertexes. If $D(M_X, M_Y)$ is close to 0, it is considered that the objects are clones and a unique geometry instance is kept.

3.3 Dynamic Scene Loading Method

The train scenarios have an important difference in reference to the flight or driving simulators. While those simulators demand extensive open fields where the vehicles move in any direction, the movement of the train is restricted to the railway, like moving along a line. Therefore, it is possible to know in advance the next position of the observer inside the train and thus, organize the scene to be rendered.

Particularly, a subway line is defined as a section sequence. Each section can be a "tunnel" or a "station" having an associated 3D representation. As the entire scenario could not be kept in memory, the scenes are loaded in a dynamic way, considering only the coming section.

To know how many sections must be visualized, the observer's movement and the distance to the coming section are considered. For each update, the remaining time to the next scenes is computed based on the current speed. If it is smaller than a threshold (15 seconds), the corresponding scene starts to be loaded. In order to keep the refresh rate, the load is concurrent to the simulation, and it does not block the visualization. Given that the scene is composed by hundreds of objects and textures, and that it is a process that requires the use of a graphic card, a limited quantity of objects is created for each frame. After a frame is rendered, the objects are pumped to the GPU memory, assuring that the time is smaller than 10 milliseconds. Simultaneously, objects and materials that are no longer visible or needed are removed, and memory is freed.

Figure 4 shows the uploading and downloading scenes mechanics for two instants of execution time. This way, the memory and resources consumed by the visualizer are maintained almost constant, allowing subway representation of any length.

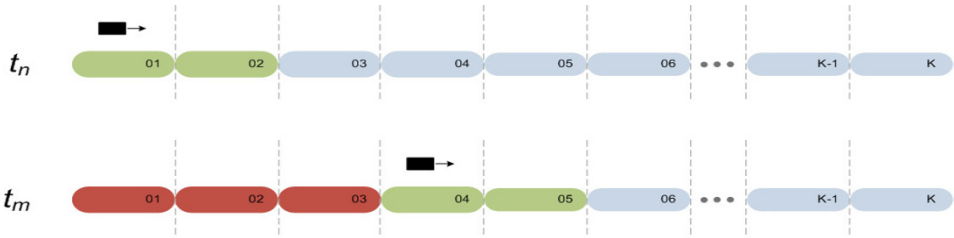


Fig.4. Uploading and downloading scenes mechanism in two time instants t_n and t_m: loaded scenes (green), unloaded scenes (light blue) and eliminated scenes (red).

4 Results

In this section, we present the results obtained by the application of the proposed methods. For this purpose, we used a scenario where a train goes through 3 stations over a 2 kilometers tour, at a constant speed of 50 kilometers per hour. This scenario is composed of 630 3D meshes and about 300 image textures; however, in some cases, the scenarios could be bigger than this.

For each method, we carried out a different experiment, as they are described below. For the tests, we employed an Intel i7 CPU, with 12 GB of RAM and a NVIDIA 980 GTX GPU with 3GB of RAM.

4.1 Texture Size Change Analysis

The GPU memory space required for the whole textures reaches 1850 MB, without considering the auxiliary textures created by the graphic engine.

Employing the texture analysis method, we detect four possible texture combinations:

- textures with a repetitive pattern (low entropy) mapped to small or large objects
- textures with a non-repetitive pattern (high entropy) mapped to small or large objects

Empirically, it was observed that low entropy textures could be reduced more without affecting visual perception. In the other case, the object size determines the optimization rate. Table 1 shows these cases with the estimated reduction percentage.

Table 1. Examples of textures used in the simulator.

Texture 1	Texture 2	Texture 3
		
High Entropy **Little Size** 50% reduction	**LowEntropy** **Intermediate/High Size** 25% reduction	**High Entropy** **Intermediate/High Size** 75 % reduction

After evaluating the whole textures dataset, we found that about 80% of textures could be reduced to half of their original size. In this case, the GPU' memory requirement falls below 654 MB.

In Figure 5 it can be appreciated how image quality is affected. For simulation purpose, the result is more than acceptable, thought.

Fig.5. Scene captured **(**above**)**.Original image (below, left) and 50% reduced (below, right).

4.2 Repetitive Object Elimination Analysis

In this experiment, we registered the amount of memory necessary to store vertex and triangles information of the whole scene. After applying the object duplication detection method, we found the amount of replicated objects that fulfill the condition described in ec.2. Table 2 resumes the quantity of objects discovered for each scene and the memory that can be free.

Table 2. Duplicated object and unnecessary memory proportion visualization.

	#Objects	#Repeated Objects	Memory use (%) Repeatedobjects
Scene 1	161	59(36%)	17%
Scene 2	154	75 (48%)	8%
Scene 3	315	207 (65%)	30%

We found that between 36% and 65% of the objects were redundant. In general, these were low-poly objects (like boxes or artifacts), As a result, the amount of memory that can be freed is not so significant. In the case of more complex geometry objects, for example, an escalator or a platform, we found only one instance.

4.3 Dynamic Scene Loading Evaluation

Finally, we evaluate the dynamic scene loader. To carry out this experiment, we evaluated the method while the simulator is running, using the already optimized scenarios. In this scenario, the train moved from the first station to the final one, at a constant speed. We explicitly load objects and remove them when they are no longer needed.

We compared both cases; one when the whole scenario is loaded at the beginning and then, loading each part while the train is moving forward. In the first case, Figure 6 shows that the simulation needs about 2 GB of RAM. Once it starts, the memory allocation keeps constant. The first part (named common) corresponds to graphics engine textures and objects. Then, the dynamic loader is evaluated. As it was expected, the simulator requires less memory, about 1.2 GB of RAM. Even more, as loading part of scene is faster, the simulator is ready to run before the other case.

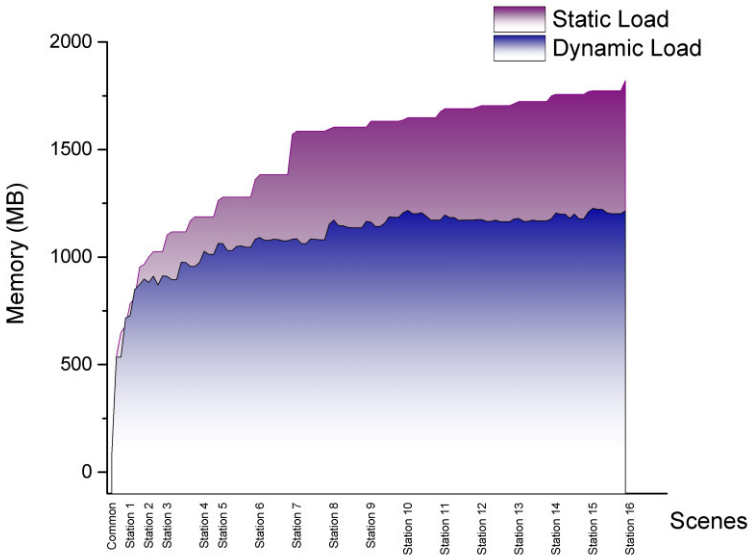


Fig.6. Resources used for the simulation initiation along 16 stations.

5 Conclusions

In this paper, some generic techniques to optimize large immersive simulator scenarios which achieve a high frame-rate with less hardware requirements are presented.

The texture optimization and the replicative mesh geometry elimination techniques are efficient and simple to implement, and they really easier the design team task. Both could be applied to optimize any tridimensional scenario.

On the other hand, the dynamic loading technique is more specific, because it depends on how the spectator/camera moves inside the scenario. Moreover, this technique relies on the graphics engine implementation and its performance could vary according to how the engine manages media resources.

In future versions, we will include some other techniques, like dynamic geometry and texture generation in order to reduce the memory requirement even more.

References

1. MartínezDurá R., ArevalilloHerráez M., GarcíaFernández I., GamónGiménez M., Rodríguez Cerro A.: Serious Games for Health and Safety Training. Serious Games and Edutainment Applications, Chapter 7, 107-124, Springer-Verlag London Limited, doi:10.1007/978-1-4471-2161- 9_7 (2011)
2. Ogre Open Source 3D Graphics Engine. http://www.ogre3d.org/ (2015)
3. Vénere, M., Cifuentes, M. V., D'Amato, J., y García Bauza, C.: Editor de escenarios para aplicaciones de Realidad Virtual. 34º Jornadas Argentinas de Informática e Investigación Operativa, ISSN 1666-1095 (2005)
4. Ferrington, G., Loge, K.: Virtual reality: A new learningenvironment. Comput. Teach. 19 (7), 16–19 (1992)
5. Li, G.C., Ding, L.Y., Wang, J.T.: Construction project control in virtual reality: A case study. J. Applied Sci. 6, 2724-2732 (2006)
6. Boroni, G., Garcia Bauza, C., D'Amato, J., Lazo, M.: Siper-Virtual Reality Simulator of Periscope. World Applied Sciences Journal, 813-817 (2012)
7. Sims, E.M.: Reusable, lifelike virtual humans for mentoring and role-playing, Comput. Educ. 49 (1), 75–92 (2007)
8. 3D Max Studio Modelling. http://www.autodesk.es/products/3ds-max/overview (2015)
9. Cignoni, P., Rocchini, C., Metro, R.: Measuring error on simplified surfaces, Computer Graphics Forum 17 (2), 167–174 (1998)
10. Schwebel, D., Combs, T., Rodriguez, D., Severson, J., Sisiopiku, V.: Community-based pedestrian safety training in virtual reality: A pragmatic trial. Accident Analysis & Prevention 86, 9-15, January 2016 (2016)
11. Grabowski, A., Jankowski, J.: Virtual Reality-based pilot training for underground coal miners. Safety Science 72, 310-314, February (2015)
12. Borsci, S., Lawson, G., Broome, S. Empirical evidence, evaluation criteria and challenges for the effectiveness of virtual and mixed reality tools for training operators of car service maintenance. Computers in Industry 67, 17-26, February (2015)
13. Takeda, J., Kikuchi, I., Kono, A., Ozaki, R., Kumakiri, J., Takeda, S. Efficacy of short-term training for acquisition of basic laparoscopic skills. Gynecology and Minimally Invasive Therapy, in press, available online 26 June (2015)
14. Mattioli, L., Cardoso, A., Lamounier, E.A., do Prado, P.: Semi-automatic Generation of Virtual Reality Environments for Electric Power Substations. Springer International Publishing Switzerland, Rocha et al (eds.). Advances in Intelligent Systems and Computing 353, 833-842, doi: 10.1007/978-3-319-16486-1_83 (2015)
15. Novak-Marcincin, J., Janak, M. Barna, J., Novakova-Marcincinova, L.: Application of Virtual and Augmented Reality Technology in Education of Manufacturing Engineers. Springer International Publishing Switzerland, Rocha et al (eds.). Advances in Intelligent Systems and Computing 276, 439-446, doi: 10.1007/978-3-319-05948-8_42 (2014)
16. Balian, R.: Entropy, a Protean concept. In Dalibard, Jean.Poincaré Seminar 2003: Bose-Einstein condensation - entropy. Basel: Birkhäuse, 119–144, ISBN 9783764371166 (2004).

A Survey on Open Source Data Mining Tools for SMEs

Pedro Almeida[1], Jorge Bernardino[1,2]

[1] ISEC – Superior Institute of Engineering of Coimbra
Polytechnic of Coimbra, 3030-190 Coimbra,
[2] CISUC – Centre of Informatics and Systems of the University of Coimbra
3030-290 Coimbra, Portugal
a21180299@isec.pt, jorge@isec.pt

Abstract. Data Mining is a software tool dedicated to scan data repositories, generate information, and discover knowledge. Currently, the traditional data processing tools and its applications are not capable of managing the massive amounts of data available inside SMEs environments. Therefore, it is critical to use effective and efficient Data Mining tools which represent a valuable support for SMEs decision-making. In this paper we describe and analyze seven popular open source data mining tools – KEEL, KNIME, Orange, RapidMiner, R Project, Tanagra and WEKA.

Keywords: Data Mining, Open Source Tools, Small and Medium Enterprises

1 Introduction

Making a business thrive in the global market is becoming a though task specially for Small and Medium Enterprises (SMEs). With the growth of the global market new problems for enterprises also arise. These problems can be divided into three different areas - operating problems, social concerns and economic issues. Innovative ways to address such problems must be created for enterprises to get the upper hand. Any advantage, no matter how small it is, can make the difference between success or failure. Extracting knowledge from the significant amounts of data available to an enterprise (whether it is data generated inside or outside) has been recognized as one of the most valuable ways to obtain a competitive advantage. For a long time it has been clear that manual analysis of data is not possible, and a small enterprise can easily generate data volumes in the Gigabyte range and higher. To analyze such data collections is necessary high processing power. Only Data Mining Tools and their computational power can provide such requirements along with the necessary robustness for the generation of reliable results and the necessary scalability to stay in line with the constant growth of data. The recognition of the importance of Data Mining allowed this research area to be among the fields of computer science that has produced the biggest amount of research and development in recent years. In research, extraction of valuable information from data is known as Knowledge Discovery in Databases (KDD). KDD is a process used to identify understandable, valid and potentially useful patterns in data [1]. KDD is a process commonly defined as having five different stages – selection, pre-processing, transformation, data mining and interpretation/evaluation [1].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_24

In this paper we focus on the Data Mining phase and the ways it can help Small and Medium Enterprises obtain success. Data Mining Tools have many applications in business environments. There are many use cases for Data Mining Tools but the most common consists of extracting patterns and trends stored in data and use these patterns to discover previously unknown information to be used in strategic management decisions [2]. This information comes in many forms and has a lot of characteristics that differentiate it from one another. Some of these characteristics are - uncertainty, high frequency and labelling as either organizational or behavioural. The patterns contained inside data can be used to perform diverse tasks such as - market analysis on products and clients, identification of potential product bundles, prevention of costumer loss, costumer acquisition and more accurate profiling of existing clients [3]. Patterns are not just useful for services but can also be used in industry for tasks such as finding the causes of manufacturing problems in industrial units. To aid SMEs cope with the complexity pattern mining ads to the whole data management cycle, a lot of tools have been developed and are constantly being renewed. In this paper we choose to analyze only Open Source tools because they require no acquisition costs, have a bigger flexibility and a faster renovation due to their extensive development community and are robust enough for SME's needs [4]. We explore seven popular open source data mining tools, describe them individually, compare their relevant characteristics and find out if they have the necessary features to follow new trends such as cloud support, social media support and Big Data.
The remainder of this paper is structured as follows. Section 2 gives some background on the Data Mining topic. Section 3 describes the seven analyzed tools. Section 4 compares the tools and provides information on what are the best choices. Finally Section 5 provides final conclusions and refers some future work.

2 Data Mining Explained

The KDD process has been the base to the build of many variations of itself. One of those variations is the Cross Industry Standard Process for Data Mining (CISP-DM) that divides the KDD process into six areas – business understanding, data understanding, data preparation, modelling, evaluation, and deployment [5]. This standard process is although complex for people in enterprise management to understand because they are not familiar with the details of Data Mining operations. With that in mind the process was shrunk into a simpler model with only three steps:
• Pre-Processing – The process of preparing data to feed the Data Mining tools. This step consists of assembling a data set large enough to contain relevant information that needs to be mined but small enough to be processed in an acceptable amount of time. This step also includes the cleaning of data through removal of noise and missing data nodes that add no value and thus do not need to be analyzed.
• Data Mining – Data Mining is a process developed from the intersection of techniques coming from various areas such as artificial intelligence, machine learning, statistics and databases.
• Results Validation – Results validation is the analysis that is made over the outputs given by the Data Mining step. This is a human task realized by analysts and the process is highly variable depending on the specific interests of the entity that is extracting the value from data.

In this paper we study only the Data Mining step. Data Mining is the core step in the Knowledge Discovery in Databases (KDD) process. Data Mining is an interdisciplinary field of computer science that pursues to find out data patterns, organize information of hidden relationships, structure association rules, estimate unknown items values to classify objects, compose clusters of homogenous objects, and unveil many kinds of findings that are not easily produced by a classic system. These findings should compose a model to be interpreted by analysts working on the Interpretation/Evaluation step of KDD process. The core feature of Data Mining is the ability to cross data that is retrieved from different sources such as databases, data warehouses, the World Wide Web or data streamed into the tool dynamically [6]. It must not be confused with the process of data extraction which is a step that happens before Data Mining. As we previously mentioned, the Data Mining process is a combination of techniques generated from many different areas of computer science.
The evolution of technology and the incorporation of computation in many aspects of the daily routine have created a deluge of data. Technology such as processing speed, storage capacity and transmission rate have been doubling every eighteen months since the late 90's creating the conditions for all this data to be used in benefit of the society [7]. The more data scientists look into data the more challenges they find and the more they understood that Data Mining Tools are necessary. In the next section we will look into some popular Open Source Data Mining Tools and the features they have to offer for Small and Medium Enterprises environments.

3 Open Source Data Mining Tools

We select the following Data Mining Tools - KEEL, KNIME, Orange, RapidMiner, R Project, Tanagra and WEKA, based on the work of [2], [4], [8] and [9].

3.1 KEEL

Knowledge Extraction based on Evolutionary Learning (KEEL) [10] is a tool that provides capabilities to perform a vast number of tasks related to knowledge discovery in datasets. It is the first open source tool written in Java with a library of evolutionary algorithms. Evolutionary algorithms are computer applications that are designed to evolve and improve with each new input they receive and work on. By providing a simple GUI based on data flows it allows the user to experiment with multiple datasets and algorithms. It is a very useful tool as it facilitates the understanding and ranking of the behaviour and performance of algorithms. It main focus is evolutionary algorithms (both for pre and post processing) for the Data Mining areas of regression, classification, clustering, pattern mining and others. Designed to provide both high research and educational value, KEEL contains data pre-processing techniques, classic data extraction techniques, computational intelligence algorithms, hybrid models and statistical methods for result evaluation. It is divided in seven function blocks that sort the user experience by areas of research and experience level of the user. Those blocks are - Data Management, Design of Experiments, Design of Imbalanced Experiments, Experimentation with Multiple Instance Learning Algorithms, Experimentation with Semi-supervised Learning Algorithms, Statistical Tests and Educational Experiments [10]. The latest stable release is 3.0. It is licensed under the GNU General Public License. KEEL's strong points are:

- Simple GUI based on the concept of data flows.
- Function blocks division to sort the user experience.

3.2 KNIME

KNIME [11] is an enterprise level data analytics platform aiming to help organizations stay one step ahead of change through the use of data knowledge. With a high level of customization it provides an adaptive learning curve accordingly to the time and effort each user wants to spend with the tool. It is completely visual and free of code so that the user can focus on working with the data and not waste time with implementation details. Based on the Eclipse IDE, it has a modular and extensible API that is ideal to use at both commercial, research and educational settings. By providing hundreds of different processing nodes it offers powerful capabilities for tasks such as pre-processing, cleansing, modelling, analysis and mining. One of its strong points is the high level or integration with other Data Mining tools such as Weka and R. Licensed under the GNU General Public License version 3, KNIME Analytics Platform can be extended with the KNIME Commercial Software (that has to be paid for) for additional professional support. KNIME strong points are:

- High level of customization that adapts the learning curve to the user.
- Based on the Eclipse IDE that is familiar to a lot of programmers.
- Easy integration with other Data Mining Tools.

3.3 Orange

Orange [12] is an open source tool for data analysis and visualization developed at the Bioinformatics Laboratory of University of Ljubljana. It provides tools for the performing Data Mining tasks in a graphical interface but also through the use of Python script coding. Packed with lots of features for analytics and components for machine learning, its main feature is essentially the high level of possible expansion through the use of add-ons that give the core bundle extra possibilities for tasks such as text mining, bioinformatics among others. The visual interface, known as Orange Canvas is very easy to use as it provides an understandable division of functionalities through nine different groups – data, visualization, classification, regression, evaluation, unsupervised learning, association, bioinformatics and prototypes. An illustration of the Orange Canvas Interface can be seen in Figure 1. To further increase such ease of use were introduced widgets as representation of the functionalities that can be placed and connected between them in the visualization area in the most intuitive way. The downside of Orange is that it is not as complete as other existing tools. Its latest stable version is 2.7., licensed under the GNU General Public License version 3. Orange main features are:

- Contains both GUI and Command-Line for Python script coding.
- Easy to understand division of functionalities through nine different groups.

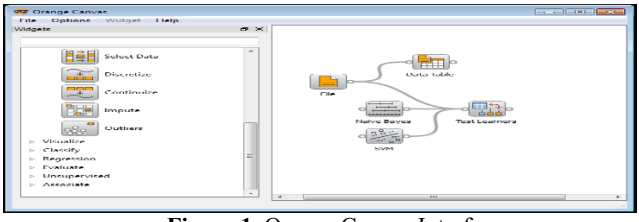


Figure 1. Orange Canvas Interface

3.4 RapidMiner

RapidMiner [13] is a tool for data analytics built not just for data scientists but also for business managers, developers and anyone with interest in this area. RapidMiner Studio (the open source version) has an easy to use visual environment that takes the user directly to the execution of data management tasks without requiring any coding. It is intuitive to use and also grants access to the help of a huge community of about 250,000 users. This community brings advantages such as speedy renovation of the tool but also fast and quality assistance for new users. The aforementioned qualities make RapidMiner very appealing for people who cannot use much time going through the learning curve. RapidMiner provides hundreds of existing methods for data transformation, modelling and visualization. But it also gives the user a powerful and extensible API that can be used to upgrade the tool to include their own algorithms. It is highly versatile in terms of configurations and sizes of datasets since all its methods can run in-memory, in-database or in clusters that work with Hadoop [13]. Other strong points are - different visualization outputs such as 3D graphs, scattered matrices or maps, the multiple interfaces such as the GUI or the batch processing unit, the accuracy of pre-processing methods and the complete toolbox with over 1500 operations available. An illustration of an example workflow can be seen in Figure 2. Developed in Java, it runs in every major platform and operating system. The open source version is very complete applying limits only on the size of memory that can be allocated (1GB) and in types of accepted data sources (.csv and Excel only). To sum up, RapidMiner main advantages are:

- It supports all computer environments.
- Visual interface that abstracts the user from implementation details.
- API that provides extension capabilities and versatility of configuration.
- Supports in-memory, in-database and cluster processing.
- Variety of visualization outputs.

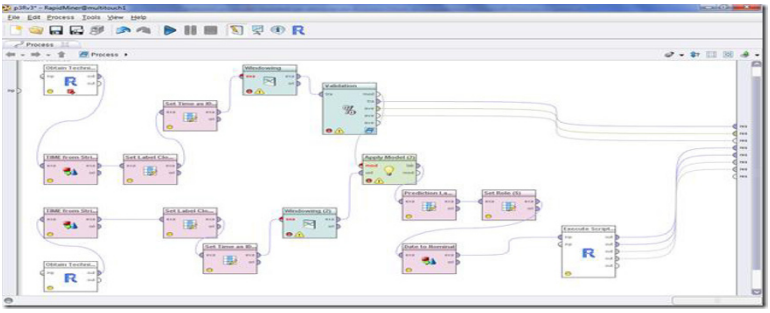


Figure 2. RapidMiner Workflow

3.5 R Project

The R Project [14] is the combination of a programming language and an environment for statistical and graphics computing. It has been designed with influence taken from the programming languages S and Scheme but unlike these it is completely open-source [15]. R Project provides a variety of graphical and statistical techniques that include linear and non-linear modelling, classic statistic tests, time-series analysis and more traditional features such as classification and clustering. It intends to be a fully planned ahead system built with coherency rather than a basic suite where different tools are simply added for extension of functionalities [16].

Among its strengths are the high extensibility through the use of packages for addition of new models, easy integration with code made in C, C++ or Fortran for the execution of intensive tasks and the ability to produce robust statistic plots for publication. Because R is in itself a programming language it allows users who are comfortable with coding to add features by adding new functions to the suite. It is an integrated suite of software that allows performing a full circle of data treatment including manipulation, calculation and display. Besides including effective methods for data storing and handling it includes a group of operators that provide methods for calculation with arrays and matrices. Other features include an integrated collection of tools for intermediate data analysis and graphical facilities to help visualization of such analysis. The R programming language also provides a simple way to develop functions with inclusion of conditionals, loops, input and output facilities that as we mentioned before can be integrated with functions written in other languages that perform better at computationally intensive tasks. The R Project has so much popularity among the community working with statistical data analysis that it has led to the creation of several tools to make it more user-friendly and appealing. One of them is RStudio [17]. RStudio Desktop is an IDE specifically aimed at working with R and developed by the company of the same name. It is licensed under the terms of the GNU License and can be run in a variety of UNIX distributions but also Windows and Mac OS. The latest stable version is 3.2.2. R Project strong points are:

- Provides extension capabilities through the use of packages.
- Users who are comfortable with coding new features with R language can easily configure and extend the platform to meet their requirements.
- Easy integration with other coding languages.

3.6 Tanagra

Tanagra [18] is a Data Mining tool developed for academic and research purposes containing methods that are applicable in the areas of data analysis, statistics, machine learning and databases. Tanagra has three main purposes - the first one is to provide researchers, teachers and students an easy access to data mining software. Second is to provide researchers with a buildable architecture where they can add their own experimental algorithms and compare them with existing solutions while saving them the time required to deal with implementation details and allowing them to focus on the data management. Last but not the least being open source helps providing users with a general idea of what a DM tool is like so they can build their own if that is of their interest. It is not a powerful tool to perform real Data Mining tasks as it does not support many types of data sources, doesn't have data cleansing tools and is not very interactive. More so the latest version is dated from 2008. This means the tool is not used as much as others available abandoned possibly for being considered inferior to other solutions that were deployed since then. In resume Tanagra's strong points are:

- It is a good tool for starters on academic and research areas because it's limited to the basics of Data Mining.
- Simple model for developers to use as an example to make their own tools.

3.7 WEKA

The Waikato Environment for Knowledge Analysis (WEKA) [19] is a workbench that integrates several common techniques of machine learning (ML). It is directed at all

people with interest in the area of ML from research, education, business or industry. For all of them, WEKA serves as a tool to extract useful knowledge from datasets that are too large to be analyzed manually. Other goals of WEKA include increasing the availability of existing ML algorithms and developing more efficient ones. For WEKA developers it is important to contribute for the creation of a framework for Data Mining that is easy to use and allows as many people as possible to make research. Written in Java and released under the GNU General Public License, WEKA contains tools for almost all basic Data Mining tasks such as pre-processing, classification, regression, clustering, association rules, and visualization. Additionally it features a robust framework for the development of new ML schemes. The framework is divided in four core areas – the Command Line Interface (CLI), the Explorer, the Experimenter and the Knowledge Flow. CLI and Explorer provide the same functions although in different ways (commands or graphic interface). An illustration of the Explorer panel can be seen on Figure 3. These functions are such as - define the data sources, prepare the data, apply the algorithms and visualize the results. The Experimenter is mainly a tool to compare the performance of different algorithms applied to the same dataset. The Knowledge Flow is a tool that allows the building of a dataflow through visually connected components. The latest stable version is 3.6 and supports working with datasets of considerable size and version 3.7 (still in developer stage) already provides access to new Java packages that allow performing Data Mining tasks with parallel processing. In resume, WEKA's strong points are:

- Easy to use for users with different levels of experience.
- Contains both Command-Line Interface and a Graphical User Interface.

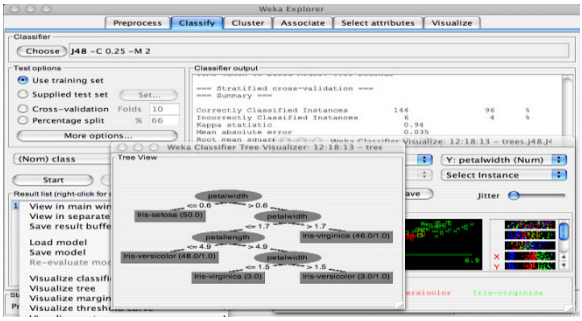


Figure 3. Example of the WEKA Explorer Panel

4 Open Source Data Mining Tools Comparison

To compare the Data Mining Tools - KEEL, KNIME, Orange, RapidMiner, R Project, Tanagra and WEKA - we chose seven characteristics that have been mentioned in previous works [2], [4], [8] and [9]. They are - programming languages used, operating systems, user interfaces, supported data types, social media features, cloud services support and support for Big Data. A tool may be more or less restrictive depending on what operating systems it works on. Although most tools are supported by the main operating systems it is still important to compare this characteristic. Business managers want to find a programmer to work with their data mining tools inside their company or hire one easily. A tool that uses more mainstream

programming languages will make this job easier and this is why this is feature is important for analysis. Tools with Graphical User Interface (GUI) are not only easier to use but have a less steep learning curve even for users unfamiliar with the tool. It is important to study the user interfaces available because tools with GUI will be more appealing than tools with Command Line Interface (CLI) only. Data comes from many sources and in many forms: databases, Excel files and URLs are just some of those many forms. It is also recommended that tools are up to date with new requirements and trends that have recently risen and are expected to remain of great importance in the near future. We study if tools are updated to such trends by analyzing three different types of features. One very important source of data for business is social media and social networks. In social media we can find user interactions, content sharing, influences, observations, feelings, opinions among many other types of potentially useful data. If a tool has the technical features to extract data from such source and analyze it this may be a considerable benefit for the company [20]. Cloud services while not free are a good alternative to the expensive acquisition of your own hardware infrastructure. Cloud services offer effective computational and data storage support for your data intensive applications. They do this by offering many different packages and services that allow to scale our contracted services up and down as needed thus making the best optimization of our resources and costs [21]. Even small enterprises with small revenue and small number of workers can generate a considerable amount of data. The business world is becoming more and more digital with the embracing of data generating technologies such as sensors, mobile devices, video streams and software logs just to name a few. It is important to analyze if the tools have the necessary features to handle Big Data such as scalability, flexibility, computational power and ability to store and preserve very large quantities of data [22]. From the results in Table 1 we can make the following decisions:

• KNIME is the most flexible tool since it is code free. After it, Weka, RapidMiner, Keel and Orange are the most recommended ones because they use Java language and has plenty of coders available for hire.

• All tools but Tanagra are supported by the major operating systems such as Windows, Linux or Mac OS X. Tanagra is only supported by Windows.

• When it comes to user interfaces, tools with GUI are always better than tools with CLI because they are more intuitive to use and have a less steep learning curve. All tools but KEEL provide GUI so this is not a really distinctive factor.

• About Data Types supported RapidMiner and R are the most complete tools. KEEL keeps up because it provides all types but only with the use of add-ons. KNIME, Weka, Orange and Tanagra are inferior on this area because they lack such even basic data type such as Excel files.

• When it comes to social media features, support for cloud services and support for Big Data, Keel, Orange and Tanagra do not provide any of these. Weka, R and KNIME do but again at the cost of extensions and RapidMiner only has Cloud and Big Data Support in the commercial versions.

The first conclusion we can make from our analysis is that there is not one tool that is absolutely superior to the others. Any choice a business manager makes will have to take in account the specific needs of the organization. With that in mind we can still make the following statements:

• RapidMiner is the most complete tool if support for Cloud and Big Data is not required. Next to it, KNIME and Weka are the best but only if the organization can generate data in other formats than not Excel supported files.

• R Project is also a good tool with support for all the new trending technologies. It has the problem of having an uncommon language with an inherent learning curve.

• Neither Keel, Orange nor Tanagra are good tools for SMEs environments. They are mostly academic and research tools for experimentation with Data Mining and do not support the features that are required for use in real scenarios.

Table 1. Open Source Data Mining Tools Comparison

	KEEL	KNIME	Orange	Rapid Miner	R Project	Tanagra	WEKA
Prog. Lang.	Java	Code Free	Java, C++, Python	Java	R, C, Fortran	C++	Java
OS	Win, Linux, Mac OS X	Win, Linux, Mac OS X	Win, Linux, Mac OS X	Win, Linux, Mac OS X	Win, Linux, Mac OS X	Win	Win, Linux, Mac OS X
Interfaces	CLI	GUI	CLI, GUI	GUI	CLI, GUI	GUI	CLI, GUI
Data Types	All (with add-ons)	All but Excel	All but Excel & URL data	All	All	Few	All
Social Media Feat.	No	Yes	No	Yes	Yes	No	Yes
Cloud Services Support	No	Yes	No	Only on Com. versions	Yes	No	Yes
Big Data Support	No	Yes (with add-ons)	No	Only on Comercial versions	Yes (with add-ons)	No	From version 3.7

5 Conclusions and Future Work

We can conclude that Open Source Data Mining Tools have already reached a level of robustness that makes them ready to be used in various fields such as business, industry, research or education. RapidMiner, KNIME, R Project and Weka are complete for use in SMEs environments and KEEL, Orange and Tanagra are good for academia and researching. New challenges such as the growth of data and the rising of new technologies will require the update of these tools. Not only will existing tools be upgraded but new tools will also be developed as everyone will try to create a tool that works as close as possible to her/his needs. This constant progress will make it

harder every day for SMEs to choose the perfect tool for their use case without wasting a vast amount of time and effort.
As future work we aim to further evaluate these seven popular tools in a real SME environment, but also explore others and provide business managers with easily understandable comparisons that allow them to make the better choice.

References

1. Fayyad, M. U., Piatetsky-Shapiro, G., Smyth, P.. Advances in knowledge discovery and data mining, pp. 1—34. American Association for Artificial Intelligence, Menlo Park, CA (1996)
2. Borges, C. L., Marques, M. V., Bernardino, J.. Comparison of data mining techniques and tools for data classification. C3S2E '13 Proceedings of the International C* Conference on Computer Science and Software Engineering. pp 113--116 (2013)
3. Witten, H. I., Frank, E., Hall, A. M.. Data Mining: Practical Machine Learning Tools and Techniques, 3rd Edition. Morgan Kaufmann, Massachusetts (2011)
4. Hasim, N., Haris, A. N. A study of open-source data mining tools for forecasting. IMCOM - Proc. of 9th Int. Conf, on Ubiquitous Information Management and Communication. (2015)
5. Shearer, C.: The CRISP-DM Model: The New Blueprint for Data Mining. Journal of Data Warehousing. 5, 13—23 (2000)
6. Han, J., Kamber, M., Pei, J.: Data Mining: Concepts and Techniques, 3rd Edition. Morgan Kaufmann, Massachusetts (2012)
7. Bell, G., Gray, N. J.: The revolution yet to happen. Beyond calculation. Copernicus, New York (1997)
8. Jovic, A., Brkic, K., Bogunovic, N.. An overview of free software tools for general data mining. 37th International Convention on Information and Communication Technology, Electronics and Microelectronics (MIPRO). pp 1112 -– 1117 (2014)
9. Fernández, A., Río, S., López, V., Bawakid, A., Jesus, M. J., Benítez, J. M., & Herrera, F. Big Data with Cloud Computing: an insight on the computing environment, MapReduce, and programming frameworks. WIREs Data Mining Knowl Discov, 4: 380–409. (2014)
10. Alcalá-Fdez, J., Fernandez, A., Luengo, J., Derrac, J., García, S., Sánchez, L., Herrera, F.. KEEL Data-Mining Software Tool: Data Set Repository, Integration of Algorithms and Experimental Analysis Framework. Journal of Soft Computing 17:2-3 pp. 255—287 (2011)
11. KNIME, http://www.knime.org
12. Demšar, J., Curk, T., Erjavec, A. Orange: Data Mining Toolbox in Python; Journal of Machine Learning Research, vol. 14, pp. 2349−2353, (2013)
13. Rapid Miner, http://rapidminer.com
14. R Project, http://www.r-project.org/
15. Hornik, K. The R FAQ. http://cran.r-project.org/doc/FAQ/R-FAQ (2015)
16. Morandat F., Hill, B., Osvald, L., Vitek, J. Evaluating the design of the R language: objects and functions for data analysis. ECOOP'12 Proceedings of the 26th European conference on Object-Oriented Programming, pp 104--131 (2012)
17. RStudio, http://www.rstudio.com/products/rstudio
18. Rakotomalala, R. TANAGRA : un logiciel gratuit pour l'enseignement et la recherché. Actes de EGC'2005, RNTI-E-3, vol. 2, pp.697--702, (2005)
19. Hall, M., Frank, E., Holmes, G., Pfahringer, B., Reutemann, P., Witten, H. I.. The WEKA Data Mining Software: An Update. SIGKDD Explorations, vol. 11 (1), pp. 10--18 (2009)
20. Olowe-Adedoyin, M., Gabet, M., Stahl, F. A Survey of Data Mining Techniques for Social Network Analysis. Journal of Data Mining & Digital Humanities, vol. 2014 (2014)
21. Talia, D. 2nd IEEE International Conference on Spatial Data Mining and Geographical Knowledge Services (ICSDM), pp 1-4 (2015)
22. Woerner, S., Wixom, B. Big data: extending the business strategy toolbox. Journal of Information Technology, vol. 30, pp 60-62 (2015)

Functionalities as superior predictor of applications privacy threats

Alessio De Santo[1], Brice Quiquerez[1] and Cédric Gaspoz[1],

[1] Information Systems and Management Institute, HES-SO // University of Applied Sciences Western Switzerland, HEG Arc, Neuchâtel, Switzerland
{alessio.desanto, brice.quiquerez, cedric.gaspoz}@he-arc.ch

Abstract. Applications are invading our devices whether in our phones, computers and TVs or in our cars, appliances and cameras. Providing great benefits in terms of added functionalities and customization, these applications also put a lot of pressure on our privacy. In order to offer their services, these applications needs access to data stored on the devices or captured by various sensors. Currently all systems have implemented a permissions based framework for granting access to various data, based on the requests made by the applications. However, it is difficult for most users to make informed decisions when they are asked to grant these accesses. In this paper, we present a paradigm shift from a permissions to a functionalities framework. We show that users are consistent in understanding functionalities offered by applications and we propose an ontology for bridging the gap between understandable functionalities and technical permissions.

Keywords: threatening application, privacy, malware, user privacy concerns

1 Introduction

In the last few years, application markets have rapidly become widely popular [22]. Listed in dedicated markets, the user can browse and choose applications from thousands of alternatives. To choose an application, users can mainly rely on the name, the editor, the description, the screenshots and eventually the users' reviews. Application developers must request permission to access device resources. This resources could also include some sensitive personal information. A permission list is presented to the user who has no other choice but to accept them in exchange for the application's functionalities. The permissions are listed with the implicit assumption that the user is able to determine whether the listed permissions are appropriate [23]. In our opinion, access to some features and data of the user's device should be justified by the functionalities offered by the application. However, when the user has to accept a permission without knowing the functionalities involved, it is non-trivial to classify an application as privacy invasive. Previous researchers have identified here a potential issue for user privacy [2, 8, 10].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_25

2 State of the art

Detection of potential malware, including viruses, worms, spyware and Trojans, has become a big issue in literature today. Malware or malicious software, can be defined as "any software that does something that causes harm to user, computer or network" [25]. With the advent of applications markets, an easy meeting point between consumers and developers has been created. Unfortunately, these markets also provide an easy distribution mechanism for developers with malicious intent to distribute malware [23]. Furthermore, due to the nature of mobile devices, users are exposed to new threats [3]. While being mainly based on existing kernels, the mobile nature of applications makes conventional techniques no longer adapted for detecting and reacting to malware [3]. Several researchers have tried to find a way in protecting the users [2, 7], but it's actually hard to know when an application could be privacy threatening. In fact, we should make a distinction between malicious applications and privacy threatening applications. In our opinion, a malicious application aims to bypass the platform securities to access your personal data. On the other hand, a privacy threatening application could collect data without bypassing any security system, but simply by requiring access to personal information stored on the device.

To address these market-security issues, the various operating system platforms use different approaches. A manual inspection can be run before the application is published on the market. This manual intervention involves teams of experts who are responsible for identifying violations of developer policies or malicious scripting contained in the source code of the application. This first practice allows us to recognize malicious patterns and protect the market from potential malware, but it doesn't necessarily help to determine whether the different information and resources used by the application are appropriate. Therefore, the privacy and consequently the security of the users relies on the user's decision to install an application by accepting a list of permissions. The implicit assumption is made that user is able to determine whether the listed permissions are appropriate or not. This permission list is presented to the user at the time of installation or at the first use of the application, depending of the platform. Through this permission list, the user is asked to grant access to specific smartphone functions such as network access, GPS location, stored personal information, etc. Thus, when accepting a permission, the user will grant, consciously or unconsciously, access to the personal information stored on the device. Once this is granted, the application can access and collect the personal information it needs unnoticed.

While most of previous work has focused on the code [7, 13, 14, 30], and runtime behavior [3, 9, 16, 28], to detect behavioral anomalies and therefore malware, only a few researchers have considered the potential privacy threat of an application through permissions [4, 23, 29]. Pandita et al. [23] summarize the caveat of this work as: *what does the user expect?* Through their research, they have managed to bridge the semantic gap between what users expects an application to do and what it actually does, by analyzing through Natural Language Processing (NLP) whether the application description provides any indication of why the application needs a permission. Nevertheless, a potential privacy threat exists. An application can totally justify the required permissions by furnishing corresponding functionalities, but in counterpart massively sales some confidential personal data. Moreover, not everyone places the same value on the information, as privacy concerns are not the same for every user's profile. Through this research, we would like to suggest a three-level scale (Table 1) to

categorize a potential privacy threatening application with respect to a given user profile. This categorization emerges by contrasting applications descriptions, applications permissions and user privacy concerns. Applications descriptions represent the human perceptible text which will in part influence the installation of the application. By contrast, the application's permissions represent the not-so-human perceptible list of resources accessed by the application. Ideally the application description and therefore the functionalities should be strongly linked to the permissions requested. Although, as we will see through this research, this is not always true. The potential privacy threatening application categorization (Table 1) that we are suggesting brings out the different possible situations.

Table 1. Potential privacy threatening application categorization

Category	*Description*
Red	The application description doesn't provide any indication for why the application needs a permission.
Green	The application description provides indication for why the application needs a permission
Orange	Red + user's non-privacy concerning permissions. Green + user's privacy concerning permissions.

This categorization introduces a new component in the determination of whether an application has to be considered as potentially privacy threatening: the user's privacy concerns. This component represents the sensitivity of each individual user regarding their personal data. This sensitivity may be measured using the De Santo and Gaspoz seven mutually exclusive permission threatening categories [24]. In Table 2, the seven categories are associated with the corresponding Android permissions. These categories of permissions represent all the potentially threatening permissions that could be requested from an application user.

Table 2. User's privacy risk sensibility measurement

Category	Android Permissions
Location	access_coarse_location, access_fine_location, access_location_extra_command, access_mock_location,
System settings and status	access_wifi_state, battery_stats get_tasks, read_phone_state, read_sync_settings, read_sync_stats
Profile and contacts	get_accounts, read_contacts, read_call_log,
Messages and social	read_sms, read_social_stream, read_user_dictionary
User profile and interests	read_profile, subscribed_feeds_read, read_history_bookmarks,
Calendar	read_calendar
Audio, photo and video	record_audio, camera, read_external_storage

By answering a Likert five-scale survey on the users' concerns about each one of these categories, users provide a profile of their privacy concerns. Matching the user profile with the permissions required by an application allows us to categorize applications in a unique and personal way.

3 Functionalities

Recent studies have explored the understanding of smartphone users regarding the permissions that they are required to grant while installing a new application, as well as the resulting privacy concerns [5, 8, 11]. To respond to the users' lack of understanding of the effects of these permissions on their privacy, researchers proposed several options. Kelley et al. [20] showed that when users are presented with a list of permissions before selecting a given application in the store, they tend to choose the application requesting fewer permissions. Other studies found that fine grain controls over the permissions can improve the user's ability to reduce privacy threats by limiting access to permissions providing a real value for the user [2]. However, after developing a permission map to gain a complete understanding of the permission infrastructure, Felt et al. [10] found that many applications are requesting permissions that are not even being used in their codebase. They attribute these to "developer confusion over the permission system (confusion over permission names, related methods, deputies, and deprecated permissions)" [10]. In another study [12] they found that common cases of over-privilege are due to the developer's lack of attention during the release process, leaving permission requests from copied snippets or development testing as well as the fact that they are incentivized to ask for more permissions upfront due to the fact that a change in the permissions requested will trigger a manual update of the application on the user's smartphone. Finally, Kelley et al. "found that participants continued to report that other characteristics of applications are as important as or more important than permissions, including: cost, functionality, design, simplicity, rating, number of ratings, reviews, downloads, size, and others" [20].

Therefore, we have chosen to switch our focus from the permissions to the expected functionalities. Drawing on Christensen et al. [6] "jobs to be done" approach where products should be "hired" by the customers in order to solve a specific problem that they find themselves with, we postulate that users are able to understand the job that they will be able to do with a given application. Thus, instead of forcing users to understand the permissions framework and the consequences for their privacy of choosing one permission, we ask users to identify which functionalities are provided by an application.

Each application comes with a description written by the developer which presents, in plain text, the benefits of the application in order to attract potential users. Besides this description, the application also comes with a list of requested permissions. Whereas users can understand a plain text, we have seen that they have problems understanding the meaning and scope of the permissions. Thus, using functionalities, we can bridge the gap between the intelligible descriptions and the less intelligible permissions. In order to be able to provide a list a functionalities to the users, we first had to identify potential functionalities based on the applications' descriptions and then create an ontology of these functionalities and their relationships with the underlying permissions.

Various techniques were explored for establishing a list of functionalities that would cover a maximum of applications. Two main approaches were retained to deduce the functionalities. The first one, starting from the descriptions, to derive a list of functionalities and the second one, starting from the permissions, to achieve the same. Both approaches were used by selecting samples of applications having a common permission and applying a text mining algorithm to their corresponding descriptions. The result is a concept card by threatening permission representing the more frequently used words. Figure 1 illustrates the concept cards issued for the text mining of 30,000 descriptions using the Android permission "p_read_calendar".

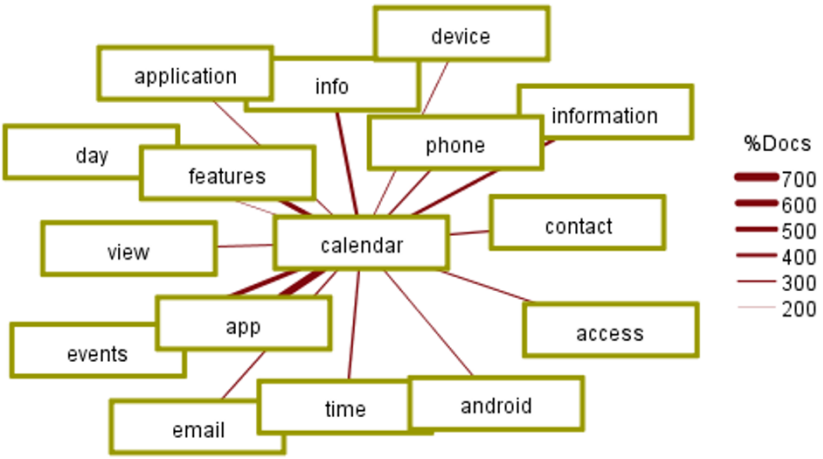


Figure 1. Concept cards

By contrasting the results obtained with each sample of distinct threatening permission (Table 2), we removed common concepts and noise, resulting in a list of the most characteristic concepts for each given permission. This allowed us to achieve a first list of 56 functionalities matching threatening permissions.

The second step was the creation of an ontology comprising applications, functionalities and permissions in order to enlighten the relations between each of them. We use the term ontology not in its philosophical sense as "an explicit, partial account of the intended models of a logical language" [15] but as an explicit representation of concepts and their relationships [27]. Moreover, using an ontology of the domain will allows us to draw inferences in order to make assertions about applications and their permissions. This is due to the fact that "when a number of modalities are specified as being appropriately related, either positively or negatively, to a variable, a rule can be implemented to infer a complementary relationship between the modalities themselves" [1]. Our ontology is based on three concepts: application, functionality and permission. Whereas permissions are already presented in Table 2, Table 3 presents the functionalities associated with the permissions p_localisation and p_camera.

Table 3. Functionalities associated with the permissions p_localisation and p_camera

Functionality	*Definition*
Augmented reality	Displaying information overlays and digital content tied to

	physical objects and locations by means of the camera.
Take a picture	Taking photographs.
Record a movie	Recording movies.
Face recognition	Identifying a person using the device's camera.
Localisation/navigation	Determining the place where you are or your way to a given location or POI.
QR/barcode scanner	Reading printed codes and triggering specific actions based on the content of the code.
Tourism Information/bookings	Providing touristic information (POI, reviews, ...) and/or allowing travel bookings related activities (hotel, transport, ...).
Weather forecast	Providing weather forecasts based on the current location or any location in the world.
Flashlight	Transforming the flash and/or display in a small portable lamp.
Photos and videos Editor	Editing photos and/or videos stored on the device.
Upload/share/view personal photos/videos	Sharing, uploading or viewing photos and/or videos stored on the device.

We defined four types of relations: application *provides* a functionality, functionality *builds on* another functionality, functionality *needs* a permission and application *requests* a permission. These relations provide two links between a given application and the permissions. The first link is the technical link as defined by the developer of the application. An application *requests* some permissions that are technically necessary in order to guarantee its operation. The second link is the functional link. An application *provides* some functionalities that in turn *need* permissions. In contrast to the technical link, the relation between an application and some permissions is not the fact of the developer, but the result of the perception of the usefulness of the application to support the jobs to be done by the user. Therefore, given that the second link is technically independent of the first link, we are able to identify applications that request more permissions that are needed in order to provide the announced functionalities (Figure 2).

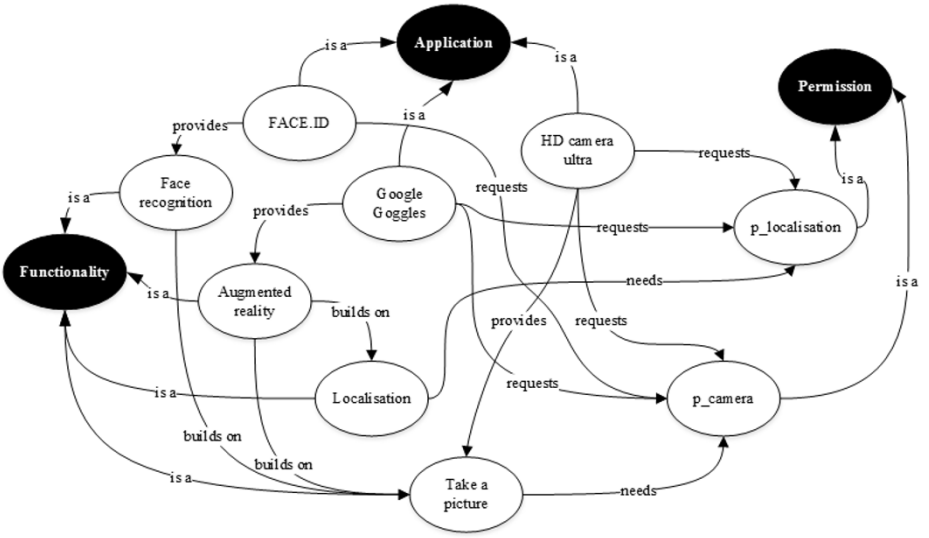


Figure 2. Excerpt of the ontology

Using the provided ontology, given an application providing the functionality of taking pictures and requesting the p_camera and p_localisation permissions, we can deduce that the permission p_localisation is not necessary to support the user in fulfilling its job. At that time, we make no judgement regarding the fact that p_localisation can be useful to add geographical information to the pictures. We only state that it is not needed for fulfilling the job of capturing a scene for future viewing.

Given that we were able to create an ontology of functionalities and their relations with applications and permissions, we should be able to identify applications that request more permissions than are theoretically necessary in order to fulfill their announced functionalities. However, the final missing link to establish is the link between an application and its functionalities. As we have seen, Pandita et al. [23] used NLP in order to extract information about functionalities offered by applications from their description text. This proved to be quite effective, but this approach does not support our main assumption that the user should be able to understand the functionalities provided by an application from its presentation. Therefore, we need to assess if a user is able to correctly assign one or more functionalities to an application, simply by reading its description.

4 Functionalities attribution

Functionalities being elaborated to bridge the gap between applications' descriptions and permissions, it is necessary to assess the comprehension and equivocality of each functionality. In order to avoid attribution errors due to the large amount of possibilities, we focused on smaller subsets of functionalities. However, this research focuses on the 11 functionalities issued from device camera permission (p_camera) and user localisation permission (p_localisation). Before assessment by the general public the comprehension and equivocality of functionalities, we processed a three-step refinement. The result of this process was the ontology presented in chapter 3. This three-step refinement process is based on a sample of 225 applications: 75 applications requiring p_camera permission, 75 requiring p_localisation permission and 75 other applications weren't requiring either of these two permissions.

In the first part of this process we humanized as many as possible of the functionalities issued from the concepts cards. For instance, functionalities such as "compass", "localisation" and "maps" were refined into a less technical one, "navigation".

In the second part of the process, two experts assessed the functionalities through the 225 application sample. However, the entire sample was manually processed to associate each application description with the considered corresponding functionalities. The two experts distinctively conducted the attribution to avoid any mutual influence. Nevertheless, experts commonly refined the functionalities as they were progressing with their assignment, in order to have the same comprehension of the functionalities. The functionalities that required a discussion were refined in order to reach an expert consensus about unequivocal functionalities. In the end, the two experts reached an Iota

coefficient of 0.67, indicating a substantial agreement. After commonly reviewing their attributions the experts agreed on a sample of 211 applications with an Iota coefficient of 0.99 and they excluded applications with poor descriptions or poor clarity. The experts agreed almost perfectly on functionality attribution of this 211 application sample. Within this sample, the functionalities could be attributed in an unequivocal manner according to the experts.

The third step of the process consisted of expanding the functionalities' attribution assessment to any potential applications user. However, we used a crowd platform to manually associate the same 211 applications sample with the same 11 functionalities. When the crowd had a high agreement between the contributors, that would mean that the functionalities were unequivocal to anyone and could therefore be used to universally bridge the gap between the application's descriptions and permissions. A first assessment on 100 applications with 12 contributors allowed us to further refine the functionalities and description of the task, for instance, by renaming the functionality "navigation" as "localization/navigation". The localization of points of interest in the proximity of the user was omitted by some users in the functionality "navigation". The initial "Document Scanner" was also replaced by "QR/Barcode Scanner", and "Tourism Reviews" and "Tourism Bookings" becoming "Tourism Information/Bookings". This kind of incomprehension resulted from contributors' feedback. Full-sized functionality attribution was run on the 211 applications that were completed through 828 trusted judgments by 47 contributors. The results are presented in the next section.

5 Results

The attribution of functionalities relies to some degree on subjective interpretation. Studies measuring the agreement between two or more participants should include a statistic that takes into account the fact that observers will sometimes agree or disagree simply by chance. Janson and Olson's Iota coefficient was used to calculate inter-rater reliability [17, 18]. This Iota coefficient examines chance-corrected agreement and is an extension of Cohen's kappa, as it can be used not only with interval level data but also with multivariate data and with several coders. The interpretation of Iota coefficient is similar to that of the Kappa coefficient, the Iota coefficient being the multivariate version of the Kappa coefficient. An Iota of 1 indicates perfect agreement, whereas an Iota of 0 indicates agreement equivalent to chance. Taking into account that participants had to categorize descriptions using 11 different functionalities, which means that there are 2048 (2^{11}) different categorizations, the Landis and Koch [21] classification could be fairly used to interpret our results.

The results of our experiment on the crowd showed agreement on functionalities going from slight (Take a Picture, Record a Movie) to almost perfect (QR/Barcode Scanner). The multivariate agreement being of 0.54, the overall agreement is moderate on the functionalities perspective.

Table 4. Iota coefficients on functionalities attribution

Functionality	*Iota coefficient*
Augmented reality	0.52
Take a picture	0.17

Record a movie	0.02
Face recognition	0.13
Localization/navigation	0.52
QR/barcode scanner	0.84
Tourism information/bookings	0.48
Weather forecast	0.63
Flashlight	0.74
Photos and videos editor	0.53
Upload/share/view personal photos/videos	0.22
	0.54

It is interesting to notice that the functionalities with the lower rates of agreement are the ones related to the use of the camera and the gallery. We could admit a confusion between those functionalities from the participants. Merging this three categories (Take a picture, Record a movie and Upload/share/view personal photos/videos) which represent in the end the same permission (p_camera) we could increase the agreement rate to a more acceptable level (0.25) which is considered as fair. Further iterations of the assessment could re-label or make further precise this functionality.

Table 5. Iota coefficients on merged functionalities

Functionality	*Iota coefficient*
Augmented reality	0.52
Face recognition	0.13
Localization/navigation	0.52
QR/barcode scanner	0.84
Tourism information/bookings	0.48
Weather forecast	0.63
Flashlight	0.74
Photos and videos editor	0.53
Merged photos/videos functionalities	0.25
	0.55

Using our ontology, we could also determine the corresponding permissions behind our functionalities, resulting in a logically even higher agreement rate of 0.62 which is considered as substantial.

Table 6. Iota coefficients on functionalities attribution

Functionality	*Iota coefficient*
p_camera	0.59
p_localisation	0.64
	0.62

6 Discussion

Assessing the ability of smartphone users to correctly assign functionalities to applications, showed that (1) our functionalities are unequivocal for most users and (2) users are able to derive functionalities from application descriptions. The first result is a confirmation of the quality of the extraction process used in order to create our ontology. Each functionality is specific enough to avoid misattributions but is also comprehensible enough that random individuals are able to understand its meaning. With this validation, we can now extend our ontology to whole application stores. The second result is a confirmation of our hypothesis that users are able to correctly identify functionalities of applications in contrast to their poor understanding of the permissions framework [11]. This is an important contribution as it could potentially establish a new mindset on how to design permissions frameworks in order to increase the understanding of users. It is particularly important in a time where applications are included everywhere, and stores are booming. Applications are now included in smartphones, computers and ebook readers as well as in televisions, kitchen appliances, cars, cameras, sport devices and more to come. They are part of our lives and it will be more and more difficult to ignore them. While it is possible to shut down a smartphone in order to protect our privacy by not registering our location in some circumstances, it is difficult to prevent our car registering and transmitting our location while in use. Therefore this research laid the foundation for a shift from technical to human centered design of permissions frameworks.

Building on these results, we now have to find a way to assign these functionalities to a corpus of more than a million applications. In fact, the very large number of applications precludes a fully manual treatment. To solve this task, we consider a solution using semi-supervised learning algorithms. Semi-supervised learning algorithms are able to learn a classification task using an already classified sample, thereafter applying the learned algorithm to solve new cases. Furthermore, SVM algorithms (support vector machines) usually give good results for classification tasks and are especially well adapted to the specific textual data, including their very high dimensionality [19]. We propose to explore the use of semi-supervised algorithms to apply functionalities to very large corpuses of applications. By carefully leveraging crowdsourcing to prepare sets of labelled applications, we should be able to reliably attribute functionalities to applications across whole stores. Once done, this would allow us to determine the privacy threatening potential (Table 1) of each application in the store based on the users' sensibility to their privacy.

7 Conclusion

This research presents a paradigm shift in how to design permission frameworks that bridge the gap between easily understandable functionalities that are provided by applications and the less understandable technical permissions that are required in order to run the application. As editors are trying to increase their benefits in monetizing their users' profiles through the use of various ads platforms the danger is also increasing for users to see their data going in the wild [26]. Therefore, a comprehensible and efficient

permissions framework is required in order to protect the privacy of the users of these applications.

After designing the first ontology of a permissions framework, we designed an experiment to ask subjects to assign functionalities based on their understanding of the applications descriptions. With an Iota coefficient of 0.62, the subjects had a substantial agreement on the attribution of permissions according to Landis and Koch [21]. This result validated our hypothesis that presenting functionalities instead of permissions to the users could achieve a high level of agreement among subjects regarding permissions requested by applications.

Acknowledgments

This paper is partly based upon work supported by the RCSO ISnet under Award No. 37075.

References

1. Adams, W.A.: A transdisciplinary ontology of innovation governance. Artif. Intell. Law. 16, 2, 147–174 (2007).
2. Beresford, A.R. et al.: MockDroid. Proceedings of the 12th Workshop on Mobile Computing Systems and Applications – HotMobile '11. pp. 49–54 ACM Press, Phoenix, AZ, USA (2011).
3. Bläsing, T. et al.: An android application sandbox system for suspicious software detection. Proc. 5th IEEE Int. Conf. Malicious Unwanted Software, Malware 2010. 55–62 (2010).
4. Chakradeo, S. et al.: MAST: Triage for Market-scale Mobile Malware Analysis. ACM Conf. Secur. Priv. Wirel. Mob. Networks. 13–24 (2013).
5. Chin, E. et al.: Measuring user confidence in smartphone security and privacy. Proceedings of the Eighth Symposium on Usable Privacy and Security – SOUPS '12. p. 1 , Washington, DC, USA (2012).
6. Christensen, C.M. et al.: Finding the Right Job for Your Product. MIT Sloan Manag. Rev. 48, 3, 38–47 (2007).
7. Egele, M., Kruegel, C., Kirda, E., Vigna, G.: PiOS Detecting privacy leaks in iOS applications. Proc. 18th Annu. Netw. Distrib. Syst. Secur. Symp. NDSS 2011. 11 (2011).
8. Egelman, S. et al.: Choice Architecture and Smartphone Privacy: There's a Price for That. The Economics of Information Security and Privacy. pp. 211–236 Springer Berlin Heidelberg, Berlin, Heidelberg (2013).
9. Enck, W. et al.: TaintDroid: An Information-Flow Tracking System for Realtime Privacy Monitoring on Smartphones. Osdi '10. 49, 1–6 (2010).
10. Felt, A.P. et al.: Android permissions demystified. Proceedings of the 18th ACM conference on Computer and communications security - CCS '11. pp. 627–637 ACM Press, Chicago, Illinois, USA (2011).
11. Felt, A.P. et al.: I've got 99 problems, but vibration ain't one. Proceedings of the second ACM workshop on Security and privacy in smartphones and mobile devices - SPSM '12. p. 33 ACM Press, Raleigh, North Carolina, USA (2012).
12. Felt, A.P. et al.: The effectiveness of application permissions. Proceedings of the 2nd USENIX conference on Web application development. p. 12 USENIX Association, Berkeley, CA, USA (2011).
13. Gibler, C. et al.: AndroidLeaks: Automatically detecting potential privacy leaks in Android applications on a large scale. Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics). 7344 LNCS, 291–307 (2012).

14. Grace, M. et al.: RiskRanker : Scalable and Accurate Zero-day Android Malware Detection Categories and Subject Descriptors. Proc. 10th Int. Conf. Mob. Syst. Appl. Serv. 281–293 (2011).
15. Guarino, N.: Understanding, building and using ontologies. Int. J. Hum. Comput. Stud. 46, 2-3, 293–310 (1997).
16. Hornyack, P. et al.: These Aren't the Droids You're Looking for: Retrofitting Android to Protect Data from Imperious Applications. Proc. 18th ACM Conf. Comput. Commun. Secur. 639–652 (2011).
17. Janson, H.: Calculating and Reporting Rorschach Intercoder Agreement. March, (2008).
18. Janson, H., Olsson, U.: A Measure of Agreement for Interval or Nominal Multivariate Observations by Different Sets of Judges. Educ. Psychol. Meas. 64, 1, 62–70 (2004).
19. Joachims, T.: Text Categorization with Support Vector Machines: Learning with Many Relevant Features. Proc. 10th Eur. Conf. Mach. Learn. ECML '98. 137–142 (1998).
20. Kelley, P.G. et al.: Privacy as part of the app decision-making process. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems – CHI '13. pp. 3393–3402 ACM Press, Paris, France (2013).
21. Landis, J.R., Koch, G.G.: The measurement of observer agreement for categorical data. Biometrics. 33, 1, 159–174 (1977).
22. McDaniel, P., Smith, S.W.: Not so great expectations: Why Application Markets Haven't Failed Security. Secur. Privacy, IEEE. 8, 5, 76 – 78 (2010).
23. Pandita, R. et al.: WHYPER : Towards Automating Risk Assessment of Mobile Applications W HYPER : Towards Automating Risk Assessment of Mobile Applications. USENIX Secur. Symp. 527–542 (2013).
24. De Santo, A., Gaspoz, C.: Influence of Users' Privacy Risks Literacy on the Intention to Install a Mobile Application. In: Rocha, A. et al. (eds.) New Contributions in Information Systems and Technologies. pp. 329–341 Springer International Publishing, Cham (2015).
25. Sikorski, M., Honig, A.: Practical Malware Analysis: The Hands-On Guide to Dissecting Malicious Software. (2012).
26. Stevens, R. et al.: Investigating User Privacy in Android Ad Libraries. Workshop on Mobile Security Technologies (MoST). p. 10 , San Francisco, California, USA (2012).
27. Uschold, M., Gruninger, M.: Ontologies: principles, methods and applications. Knowl. Eng. Rev. 11, 2, 93–136 (1996).
28. Yan, L., Yin, H.: Droidscope: seamlessly reconstructing the os and dalvik semantic views for dynamic android malware analysis. Proc. 21st USENIX Secur. Symp. 29 (2012).
29. Zhou, Y. et al.: Hey, You, Get Off of My Market: Detecting Malicious Apps in Official and Alternative Android Markets. Proc. 19th Annu. Netw. Distrib. Syst. Secur. Symp. 2, 5–8 (2012).
30. Zhou, Y., Jiang, X.: Dissecting Android Malware: Characterization and Evolution. 2012 IEEE Symp. Secur. Priv. 4, 95–109 (2012).

Technologies and information systems: a contribution to the sustainability of the agri-food sector

José Luís Reis

ISMAI, Maia University Institute, research unit CEDTUR/CETRAD, Maia, Portugal
Comission Viticulture of the Vinho Verde Region, Porto, Portugal

Abstract. Companies producing goods and services, in the food industry, need to have product, processes and marketing technologies, integrated with information systems supported by Information and Communication Technologies (ICT) to enable to plan, monitor, control and integrate all activities associated with the production, promotion and distribution. As the man evolves, he is creating new ways of communicating information to survive and to improve his quality of life. With globalization there is a reduction in transport and communication costs, as well as global logistics and distribution systems, which allows to be distributed products, including agri-food, where it comes from, to reach all the world. Regardless of other technologies, ICT are leading to the globalization, and one of the sectors affected by globalization, is the food industry. This article develop a set of data elements, which are constituted as a body of knowledge about technologies aspects, including technological developments, the main types of technologies and information systems, technological trends and some marketing aspects in the agri-food sector that contribute to its sustainability.

Keywords: Agri-food Technologies, Information Systems, Marketing Technologies, Sustainability, Food Supply Chain Network.

1 Introduction

It is fundamental to the development of the different sectors to organize a set of data elements related with technologies that support different management processes. To make a contribution to the sustainability of the agri-food sector, it is important to create a body of knowledge about some aspects of the technologies, including technological developments, the main types of technologies and information systems, and some technological trends in the agri-food sector. Generically food supply chain network have four different actors: farmers/producers, industrial companies, distributors and the retailers, each of them have different levels of organizational management, and to help the management support, the managers have the need of back office and front office information systems. In this article, the body of knowledge is constituted with the ways of integration of the main information systems and technologies that make possible to produce and distribute, in a sustainable way, products in the agri-food sector.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_26

2 Technologies in the agri-food sector

As the man evolves, he is creating new ways of communicating information to survive and to improve his quality of life. With globalization there is an ever closer integration of the countries and people of the world, a reduction in transport and communication costs, and the elimination of artificial barriers to the flows of goods, services, capital, knowledge and (to a lesser extent) of people across borders [1], as well as global logistics and distribution systems, sometimes multimodal, that make the products (goods and services), including agri-food, coming from where they are produced to all parts of the world. Regardless of other technologies, ICT are leading to the globalization, and one of the sectors affected by globalization, for good and for bad, it is the food industry.

2.1 Communicating, technologies and information systems

The technologies are the backbone for communication, allowing today, millions of people not to be hungry because either ICT or other technologies, that are vital to the achievement production levels that meet the amount of product required by the markets, with quality and above the expected food security, reaching also at the best time to the market. The technologies can be of three types; product, process and marketing technologies [2], and play a key role in our daily life as well as with regard to the vegetable or animal foods (cereals, vegetables and fruit products, dairy products, wine, olive growing, sheep, pigs, goats or poultry). Since the production, quality control, packaging, transportation to distribution, there are different types of technologies in the various activities associated with the production of products of agri-food sector.

Product technologies have the knowledge about the physical properties, characteristics of the components and the ability to incorporate this knowledge in the production of goods and services, providing a value for a company or an individual (for example, to know what are the right products and the best nutrients to produce certain drinks). Process technologies incorporate the knowledge on how to produce the goods or services, and the ability of designing, creating value for others (eg, have the best production line, and the best bottling line that allows to pack drinks). Marketing technology are designed to ensure the knowledge of technology products and processes for a specific application and capacity to deliver. These, due to their complexity, involve skills on market analysis, brand, packaging, communication and logistics (for example, the company which has the world's best drink, solved the problems of product and process technologies, but intends to sell it in a new market and for this it should hire a company specializing in market research) [2].

Data about food products are recorded in databases in a proper way that allows their traceability, because, unlike other products, with the exception of the pharmaceutical industry, the agri-food is to be taken, what requires greater care with hygiene, safety and quality. Shannon's theory of information has created a bridge between information and uncertainty, between information and entropy and the information and chaos [3], and as Marshall McLuhan rightly said, in 1967, the first computer dawn and cyberspace, man has evolved and went from a "food collector incongruous reappearing as a collector of information" [4]. Since the 60s, the information can be

collected and registered in the Transaction Processing Systems, all sales of products made in a canteen from the point of sale systems, and since the 80s, with the Management Information Systems the sales of cafeteria products can be registered, the analysis can be done to proceed to the optimization of stocks, as well as to define which products are selling less at a certain time of year, and the Decision Support System, assist the manager to take the decision to buy less products of this type [5, 6]. Only considering the technology as part of the strategic business plans, managers can make the investments that allow companies to provide farmers with the products according to the needs, a customized/personalized (with food components suitable for each farmer) and strict costs while maintaining margins, contributing to the business sustainability [2].

2.2 The food chain network and the main types of information systems

The network of agri-food supply chain, known for Food Supply Chain Network (FSCN), consists of a set of actors who collaborate so that the product reaches the consumer, from the farmer/producer, through the company that processes the product (can or cannot a processed product that requires raw materials), by the distributor, to the retailer [7]. The automation of production processes in the control of industrial products such as biscuits, sliced bread or toast, involving technology related to automated production lines, machinery, through robotics, with less and less human intervention because the production lines are composed of electronic and mechanical equipment controlled by computer systems that allow define the optimal amounts of raw materials (flour, eggs, sugar, salt, chocolate, vitamins, etc.) to produce a given product, with energy and protein values advisable for good nutrition.

On the grounds of a factory of food products, machines or robots are responsible for the manufacturing processes of food, such as cutting machines, mixing, heating, sorting, etc., that have incorporated information technology that includes sensors, actuators (running some mechanical actions such as start or stop a machine, making adjustments to the settings, etc.) and a programmable logic controller by which the machine is controlled. The machine can incorporate a DCS - Digital Control System, which will allow human operators to manually interact with the DCS and get reports. The DCS can be attached to a SCADA - Supervisory Control and Data Acquisition, whereby a number of different machines (and thus a production line) can be monitored and controlled. In turn the SCADA system can be connected and integrated with ERP - Enterprise Resource Planning , which will have the oversight of the entire company on production and related activities. In a production agri-food system (food or drink), the ERP system has to ensure the quality, hygiene traceability, recording data that let you know the product components and the dates on which the product was produced, and this information is disseminated to the different departments of the organization who need it. This information is then communicated to business partners upstream and downstream (upstream and downstream), and to the regulatory and certification entities [8, 9]. For example, in the case of an apparatus for producing crackers or cookies, the equipment must have characteristics which enable it to rolling, combination, size and cutting, peeling, as well as an oven, cooling the stack and packaging [10].

The industrial production equipment is controlled by information systems. These systems sometimes use information and communication technologies to integrate with other systems, including:
- BackOffice Systems (Enterprise Resource Planning - ERP) optimize the administrative, financial and in some cases production control.
- FrontOffice systems (Customer Relationship Management - CRM) that enable the management of customer relationships.
- Suppliers management systems (Supply Chain Management - SCM) to help value chain management between companies and their suppliers.
- Production planning systems (Material Resource Planning - MRP II) are the control and planning the production and managing stocks used for manufacturing processes. With the evolution of BackOffice systems, the functionalities of MRP II came to be in the ERP systems.

Information systems, regardless of their type (CRM, ERP or SCM), have to give answers to the needs of different types of organization managers, whether the levels; strategic (management), tactical (management), knowledge (innovation and development) or operational (technical and administrative). The technology infrastructure that supports information system comprises database management software systems, data storage systems, communications systems, etc. ensuring that the information systems are operational and available in an optimal way according to the needs of different users, both internal and external to the company [6].

2.2.1 Customers Relationship Management - CRM

CRM use individual customer information, from multiple sources of information (multichannel, such as telephone, email, chat, etc.) through the integration of various information technologies. The CRM system have the ability to record and provide access to different types of managers, in particular to the marketing and commercial areas, information data about prospects and customers (names, contact details, preferences, needs, exchanged emails, conversations via chat, phone calls recording, orders, complaints, data satisfaction surveys, analytical data as Customer Lifetime Value, Net Present Value, Customer Satisfaction, etc.) [11]. This information enables individualized customers relationships management, identifying them, satisfying them and retaining them. A customer who has a habit of ordering certain types of agri-food product in a particular time of year, for example, more fruit yogurts and more organic milk, can get a company's message to suggest an order for those products in the best commercial conditions, which allows maximizing the creation of value for the customer and for the organization, contributing to the organization sustainability [12].

With the emergence of Web 2.0, particularly with the spread of social networks, which is changing the way customers interact with brands, companies, state, etc., the concept of Social CRM that enables the integration of interactive platforms in the surge social platforms of communication. These systems have the ability to provide relevant content based on individual user preferences, obtaining this information, an implicit way through the monitoring of purchases by the user, or their system usage habits, in order to know what are the goods or services (and their characteristics) the user like or dislike [13, 14].

2.2.2 Enterprise Resource Planning - ERP

The CRM system must be integrated with the ERP system. This system allows to connect various departments of companies, and the main benefits are the management based on systematic processes with a single technology platform and a business with more efficient operations and oriented to customer needs [15].

Most Small and Medium Enterprises (SMEs) use an ERP system and do not use a CRM system, so they do the customer management in the ERP system. SMEs in the agri-food sector usually have two types of customers: retailers specializing in sales of food or industrial company that transform or semi-transform food. Sometimes these clients are competitors of the producers, which require the simultaneous management of a relationship of cooperation and competitiveness. The work environment for SMEs is characterized by strong pressure on prices and the quality of goods and services, and customer requirements expressed primarily on delivery times and product availability. These facts require that companies when selecting the ERP, take into account the following components: marketing and sales, administrative management (billing, stocks, etc.) and financial [16].

2.2.3 Supply Chain Management - SCM

ERP systems must be integrated with SCM systems because they are information systems that enable to aid relationships management with suppliers (search for raw materials, transformation of raw materials into intermediate or finished products and distribution of these customers). SCM systems allow connecting suppliers, production plans, distribution centers, transporters, retailers (outlets), people and information (through search processes, inventory control, distribution and delivery to provide the goods and services of their origin to consumption) [6,17]. A food distribution company, providing restaurants, and operating with a distribution center receiving the products, has to deal with the various producers of the products, making them the orders according to the needs of restaurants, receive and transport the goods to the restaurants. The optimization of operations related to the logistics of the company involves the use of an SCM system, which on the one hand solves the problems of managing the relationship with the various suppliers of products, and secondly, with restaurants that are its customers, like that the restaurants do not have to relate to the various producers to have their products [17, 15].

2.3 Technologies and systems for the audit and certification in the agri-food

A large proportion of food products is certified by regulatory and certification entities, and often it's required that those production companies control information entities have to be integrated with regulatory and certification entities.

There are systems, such as the certifying entity of Vinho Verde and Minho Regional wine, called "History of a bottle," which allows a user to enter in a Web page, the data in the warranty seal, and from that information, the system displays the information on the certification date, type of product, type of packaging, the label and the number of bottles of that pack [18]. The consortium that brings together the producers of Parmigiano Reggiano, also has a page on your site that allows by introducing the

producer identification number, find out about the cheese it produces [19]. The Vivino Wine App it is application that recognizes the label through the camcorder, from the mobile equipment, and displays the wine product information registered in the database about this product as well, where you can buy locally, from data entered by users of the application who rated the wines after the consume [20].

In addition to quality assurance, the genuineness of the products is guaranteed by certification which requires the existence of documentation that is inherent. To facilitate monitoring and access to this documentation, the Agricultural Defense coordinating entity, the Department of Agriculture and Supply of São Paulo, Brasil, offer a free application called "consultation GTA" to view from any smartphone, the authenticity of Guide Transit Animal (GTA) issued by that entity. To check the authenticity of the document simply place the phone's digital camera in QR Code (barcodes read by mobile devices) printed on the documents accompanying the animal, and immediately redirect the program for the GTA issued in the system, making it possible to compare and to guide the producer's choice, and accompanying the animal is the same issued by the system [20]. One of the key technologies for the traceability of food products is the identification, storage and retrieval of data by radio frequency (Radio Frequency Identification - RFID). The RFID chip labels can be implanted in the ear of an animal or a product, wherein the traceability will provide a safer food, connecting producers and consumers [22]. In encapsulated RFID chip, the chip is a glass capsule that is placed subcutaneously in the animal. These systems have a unique code. The decoding of this number makes up with an electronic reader and the information associated with the system is reliable, and inviolable in terms of identifying and easily editable throughout all processes associated with the global standard for traceability of GS1 (international organization that develops and implements standards for all sectors of activity). GS1 processes consist of the planning and organization, data alignment, recording of traceability data; require traceability and use of information. Nowadays there are more and more companies in the agri-food sector that use this type of technology, it is a way to ensure efficiency and visible gains in value chains [23].

3 Technological trends applied in the agri-food

The exploration of different technologies applied in food processing continues, and will continue to be done as there are technological advances, whether in terms of technologies applied to products, whether the processes, whether in marketing techniques. In terms of products, bioinformatics is beginning to convert into knowledge the data on biology and chemistry, providing detailed molecular information on human health, which allows knowing the role of food in the well-being of consumers. In terms of food, bioinformatics allows better define the physical, structural and biological properties that will lead to new cultures, processes and higher quality food in all aspects, as well as to better toxicological evaluation, making food safer. Who knows, in the future, bioinformatics can also improve the existing trend of consumer choice, in a personalized way, in the food market, the products

suitable for their diet and their health. The use of shared databases, allowing a correct structure according to the biological characteristics, as well as the use of analysis tools data recorded therein can be achieved, this customization of the power [24], which will be based on the scientific field of genetics studies relating to genomics and in nutrition called nutrigenomics, studying the different susceptibilities to diseases and their connection to food [25].

Nanotechnology applied to the agri-food sector in food processing is growing, in the optimization of food safety and packaging and agriculture, incorporated into tiny materials specifically designed to alert the consumer that a product is out of date. It may also allow creating nano-materials, whose small size allows providing nutrients to human cells that otherwise, cannot be achieved by producing materials that allow blocking substances in foods, for example, harmful cholesterol or food allergens, thus preventing them from reaching certain parts of the body [26]. The database available in http://www.nanotechproject.org/inventories/agri-food/, gives an idea of the types and dozens of existing nanotechnology projects in the agri-food sector.

Regardless of the controversies surrounding genetically modified foods (Genetically Modified Organisms - GMO), these will be certainly needed to be able to feed the population with safe food. The technologies based on biotechnology and nanotechnology allow to produce food in large quantities and in a more secure way, using transgenic seeds and herbicides suitable (whether in Ireland potato or corn in the Philippines), to ensure the future of supply food in the world, taking into account climate change and population growth [27].

There is a tendency to generalize the technological support systems associated with precision agriculture, which involves the handling of information from agricultural properties and climatic conditions. The processes associated with preparing the soil, planting, monitoring of crops and harvesting are handled by Global Positions System technology (GPS) and Geographic Information Systems (GIS), linking real-time geo-referenced information to store, analyze and visualize through different ways of mapping the traceability of the production of cereals, fruits or animals [23].

Companies also use, and will use increasingly, RFId systems integrated with GPS, because only then, will be able to solve some problems of integration and availability of information in real time, because the Hazards Analysis and Critical Control Points methodology (HACCP - Hazard Analysis and Critical Points of Control), associated with the food safety systems, which identifies the dangers and preventative measures for their control in production processes, requires the recording of information at different stages, either in a barn, a slaughterhouse or butcher [28]. The RFId technology being used to record and track milk samples throughout the journey of the collection sites to the laboratory [29]. The traceability system for monitoring the trucks transporting the milk tank, can be linked to GPS systems in mobile equipment, bar code system (EAN), and sensors positioned in the vehicle, thus ensuring that the data on the product is conveyed in good condition and that has certain characteristics, is recorded in real time on the database management system, thus ensuring up safety and food quality [30].

Technologies can be associated with any physical object; they are becoming cheaper and allow two-way communication with the environment, which will allow creating new business models based on advanced organizational schemes, called IoT (Internet of Things), which have the advantage of constituting as global networks, any object which can be connected to each other. Data on weather conditions, water levels in the soil, pesticides and fertilizers used, agricultural implements, transmission data (location, temperature, etc.) data on the quality of the product (moisture, oxygen, nitrogen or ethylene contained in the air around the product), data on the packaging, and can be obtained through sensors and computer applications, the agri-food sector has the ability to manage the precision agriculture, optimizing the use of pesticides, fertilizers and water, transport, monitoring the movements of vehicles by optimizing transport processes, control of the supply chain, by measuring on a continuous basis the environmental temperature around the product and control of storage locations, all of this to maintain quality and food safety [31].

4 The integration of ICT in business management

The key to the success of a company that has bet on e-business, as management strategy is to ensure that all processes work well in a unified system, which means, there is a full integration of different technologies with ICT, and in many cases, with the possibility of selling the products through e-commerce. Another important and decisive issue is the implementation of business intelligence systems (information for business, consisting of a set of techniques and tools that turn data into raw in significant and useful information), which are able to determine client characteristics, their profiles, their behaviors, and knowledge of marketing through the use of databases, larger organizations rely on data warehouses (historical data repository organized by topic to support managers in decisions), requiring the analysis of the data and its distribution, integrating ERP and SCM (special attention to distribution, CRM and the customization of the marketing mix) [31].

Based in the knowledge obtained, the construction of an conceptual model of integration of systems and technologies in the agri-food sector, intended to show the integration of different technologies in the food supply chain network, taking into account their different actors (farmer/producer, the company that processes the product, distributor and the retailer), the different levels of organizational management (strategy, tactical, knowledge and operational), which encompass the different functions of management (marketing, sales, human resource management, production control, accounting, etc.), different types of information systems (ERP, SCM, CRM, etc.) and supporting technologies (hardware, software, storage and telecommunications) [12].

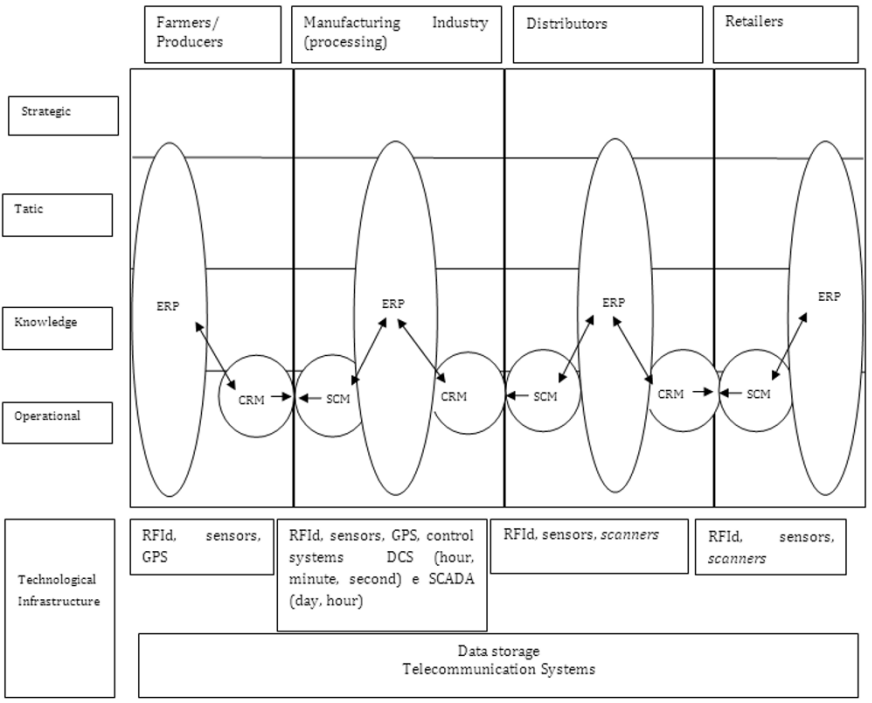


Fig. 1. Conceptual model of integration of systems and technologies in the agri-food sector.

Figure 1 represents an ideal situation where all parties have the information and technological infrastructure systems that meet the needs of all business partners, as well as the needs associated with the internal resource management organizations. However, to facilitate viewing of the figure, no SCM systems included in farmers/producers, despite these require such systems to place their orders by their suppliers (e.g., seed, fertilizer, agricultural implements, etc.) or CRM systems to retailers who sell to end customers. Thus, farmers producers, when not directly sell their products to distributors or retailers, are suppliers of manufacturing/processing industry, take orders through SCM systems of these companies, according to the orders that these companies have their distributors customers through its CRM. In turn, the distributors deliver orders from its retail customers received in their CRM (when they are not distributors to sell to end customers), which in turn ordered the products in their SCM. Retailers sell to the customer. Operating managers follow the products and the money in SCM, ERP and CRM systems, managers of knowledge innovate improving aspects related to products, processes and marketing, using sometimes the knowledge that is in ERP, SCM and CRM and knowledge management systems, tactical management (direction) defines the best tactics to achieve the goals, using the knowledge that is in all information systems. ERP covers all management levels, providing more detailed information to the operational levels and more summarized the upper levels of management. In these, there are sometimes

DSS based on metrics (without good metrics is not possible good management) that help managers in decision-making. Technological infrastructure are at the base of the figure, and the main components mentioned throughout this section are represented by focusing on the aspects that are considered most relevant, namely those related to the data storage infrastructures and telecommunications, which are incorporated in most cases by database management systems and telecommunication systems which are based on electronic systems of Electronic Data Interchange (EDI) in eXtensible Markup Language (XLM) and Electronic Business using eXtensible Markup Language (ebXML) supported by Internet and wireless communication systems. With regard to based control systems based on RFId and sensors (can measure quality standards, shapes and defects), companies are adapting them more and more as technologies to manage products and processes. Regarding control systems based on DCS, as mentioned above, these let you control automatically what goes on machines that produce food, registering data associated with the production times. These DCS systems are in turn controlled by so-called supervisory systems SCADA, enabling the recording information in an hourly and daily basis [20,7], bringing this information to systems in need, particularly those ERP systems that also incorporate, in their majority, the production control systems. Integrating information from these systems can and should be supplemented with other information, in particular with regard to transport and logistics systems, giving the guarantee of traceability of products, contributing to their quality and to the company's sustainability.

5 Conclusions and future work

The adaptation of ICT in the agri-food sector, particularly in farming, is a process sometimes slow. The same is not true in the industrial sector or in retail, which means that the alignment of corporate management needs, with the integration of technology, became one of the main differentiating factors, causing them to be more competitive meeting the needs of the market. The key forces in the future in the agri-food sector will be five: the integration of technologies in ways that allow mobility to be available at any time in information on food; the use of technologies available in the cloud (cloud computing), enabling scalability at lower cost; the ability of companies to analyze the data to obtain information to help them manage better through the analysis of data from Big Data (extremely large data sets that can be analyzed computationally to reveal patterns, trends and associations, especially in relation to human behavior and their interactions), because only with the proper use of metrics can be produced food best suited to consumers, as, for those who do and how to improve satisfaction levels, is the design of agri-food companies in the future; be on social networks to better manage the processes associated with marketing technologies, improve capabilities, companies and their brands, including customers and consumers, meeting their needs and preferences, it is the way to go; finally the possibilities afforded by the Internet of Things (IoT) that modify the ways of collecting and storing data. Having this five key forces in accounting, it is necessary a future work that integrates the knowledge of those domains in the agri-food sector, supporting the proofs of the good management practices.

References

1. Huwart, J.Y. and L. Verdier., Economic Globalization: Origins and Consequences, OECD Insights, OECD Publishing. http://dx.doi.org/10.1787/9789264111899-en (2013)
2. Ford, D., & Saren, M. Managing and marketing technology. Thomson (2001)
3. Gleick, J., The Information: A History, a Theory, a Flood. Harper Collins Publishers (2011)
4. Gordon W.T.,Understanding Media: The Extensions of Man, Critical Edition. Gingko Press (2003)
5. Kenneth Baldauf, R. S., Succeeding with Technology. Boston USA: Cengage Learning (2010)
6. Kenneth Laudon, J. L., Management Information Systems (11 Edition ed.). (P. Hall, Ed.) (2010)
7. Vorst, V. D., Beulens, A., & Paul, B. V. Innovations in logistics and ICT in food supply (2005)
8. Esteves, C., Rastreabilidade e gestão de incidentes numa fábrica de bolacha. From https://www.repository.utl.pt/handle/10400.5/1136. Repositório da Universidade Técnica de Lisboa (2008)
9. Michael Bourlakis, I. P., Intelligent Agri-food Chains and Networks. Iowa USA: Wiley-Blackwell (2011)
10. Reading Bakery, S. *Wirecut & Soft Cookie Systems.* From Reading Bakery Systems: http://www.readingbakery.com/pdfs/wirecut_soft_cookie_systems.pdf. (2012)
11. Jeffery, M., Data-Driven Marketing - The 15 Metrics Everyone in Marketing Should Know. New Jersey: John Wiley & Sons, Inc. (2010)
12. Dias, R; Afonso, J., Marketing no Agroalimentar - Fundamentos e Estudos de Caso, Vida Económica (2014)
13. Ho, S., The Attraction of Internet Personalization to Web Users. Electronic Markets, Vol.*16*, 41-50 (2006)
14. Fischer C., H. M.-G.. Agri-food chain relationships in Europe – empirical evidence and implications for sector competitiveness. *12th Congress of the European Association of Agricultural Economists.* Ghent, Belgium (2008)
15. Sheldon, D. H., Class A ERP Implementation: Integrating Lean and Six Sigma. J. Ross Publishing (2005)
16. Poba-Nzaou P., R. L., In-house development as an alternative for ERP adoption by SMEs: A critical case study. *17th European Conference on Information Systems* (pp. 581-592) (2009)
17. Mentzer, J., *Fundamentals of Supply Chain Management: Twelve Drivers of Competitive Advantage.* Sage Publications Inc. (2004)
18. CVR Vinhos Verdes. *História de uma garrafa.* From: Portal Vinho Verde, http://www.vinhoverde.pt/pt/historia-de-uma-garrafa (2015)
19. Consorzio del Formaggio Parmigiano Reggiano. Cerca Caseifici. From: www.parmigianoreggiano.it/dove_trova/caseifici/ext/CercaCaseifici/default.aspx (2014)
20. Byrne, C. Vivino helps you find that wine with image recognition. From VB Mobile: http://venturebeat.com/2011/07/29/vivino-helps-you-find-that-wine (2011)

21. Revista Leite. Aplicativo gratuito verifica a autenticidade da Guia de Trânsito Animal. From: www.revistaleite.com.br/sp-aplicativo-gratuito-verifica-a-autenticidade-da-guia-de-transito-animal-diz-saa/ (2014)
22. Regattieri, A., Gamberi, M., & Manzini, R. Traceability of food products: General framework and experimental evidence. Journal of food engineering *81 (2), 347-356* (2007)
23. Furnaleto, F., & Manzano, L.. Agricultura de precisão e a rastreabilidade de produtos agrícolas. From http://www.infobibos.com/Artigos/2010_2/AgriculturaPrecisao/index.htm (2010)
24. Desiere, F., German, B., Watzec, H., Pfifer, A., & Saguy, S., Bioinformatics and data knowledge: the new frontiers for nutrition and foods. Trends in Food Science & Technology, 12(7), 215–229 (2001)
25. German, B., Zivkovic, A., Dallas, D., & Smilowitz, J.. Nutrigenomics and Personalized Diets: What Will They Mean for Food? *Annual Review of Food Science and Technology, 2*, 97 – 123 (2011)
26. Kuzma, J., & VerHage, P., *Nanotechnology in Agriculture and Food Production - Antecipated Applications.* From: http://www.nanotechproject.org/process/assets/files/2706/94_pen4_agfood.pdf. (2006)
27. Rotman, D. Biotech crops will have an essential role in ensuring that there's enough to eat. *MIT Technology Review* (2013)
28. Caranova, A., Implementação de um sistema de segurança alimentar num talho baseado na metodologia HACCP, from: https://www.repository.utl.pt/handle/10400.5/850. Repositório da Universidade Técnica de Lisboa (2008)
29. Carreno Laguna, J., Garcia Higuera, A., Zangroniz Cantabrana, R., & de las Morenas, J. Comprehensive traceability system of milk samples using RFID. Proceedings of 2012 European Conference on Smart Objects, Systems and Technologies (SmartSysTech) , (pp. 1 - 8). Munich, Germany (2012)
30. Thompson, C., & Payne, F. *A Real-life Food Defense Challenge: Bulk Milk Transportation.* From FoodSafety Magazine: http://www.foodsafetymagazine.com/magazine-archive1/februarymarch-2010/a-real-life-food-defense-challenge-bulk-milk-transportation/ (2010)
31. Richard J. Lehmann, R. R. *Future internet and the agri-food sector: State-of-the-art in literature and research.* from Smart Food and Agribusiness: http://www.smartagri-food.eu/sites/default/files/content-files/downloads/FutureInternetandtheagri-foodsectorStateofthearinliteratureandresearch.pdf (2012)

Use of Standard and Model based on BOK to Evaluate Professional and Occupational Profiles

Pablo Quezada[1, 2], Juan Garbajosa[2], and Liliana Enciso[1]
[1] Departamento de Ciencias de la Computación y Electrónica, San Cayetano Alto, 1101608, Universidad Tecnica Particular de Loja, Ecuador
paquezada,lenciso@utpl.edu.ec
[2] Departamento de Sistemas Informaticos CITSEM, Technical University of Madrid, Ctra. De Valencia, Km. 7. E-28031, Madrid, Spain
pablo.quezada.sarmiento@alumnos.upm.es, jgs@eui.upm.es,

Abstract. Bodies of Knowledge (BOK), contain the relevant information for an area of knowledge, and it is necessary for the development of the science and application in the professional and occupational profiles and the possible incidence in the industry. This paper showed an evaluation of professional and occupational profiles based on standard Software Engineering Body of Knowledge (SWEBOK) and ontological model in order to obtain the necessary information to establish the relationship in these contexts.

Keywords: Bodies of Knowledge, BOK, Evaluation, Model, Ontologies, Professional, Standard

I Introduction

BOK contain the relevant knowledge for a discipline. BOK must be embodying the consensus reached by the community; for this reason BOK will be of applicate. This consensus is a prerequisite for the adoption of the BOK by the community [1]. A BOK may include technical terms and theoretical concepts as well as recommended practices [2].

A BOK is its common intellectual ground. It is shared by everyone in the profession regardless of employment or engineering discipline; for this reason; in this paper it is shown the evaluation of occupational and professional profiles, based in the guide SWEBOK, which is a popular guide in the field of Software Engineering. In order to evaluate occupational and professional profiles, it was used the guide SWEBOK 2014 [3], and characterization of ontological model supported by Neon Methodology [4].

The purpose of the research it was to establish a model to evaluate occupational and professional profiles taking as points of mediation BOK; also, to obtain measures of comparison between professional profiles and job offers through the BOK.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_27

II Related Works

The use of BOK has increased representatively; according to [5] and [6], the use for developing ontological models for BOK based in Knowledge and applied in the monitoring of networks around a community are explain; however [7], used BOKS for the conceptualization of shared knowledge between humans and software. They also mention that the use of BOK in building ontologies for information systems and management development software. Moreover, a professional BOK meets the set of skills, knowledge, and attitudes required for professional domain [8]. The BOK is used as points of comparison mediation of powers between work and academic contexts. For example in [9] a model using DISCO II it was proposed for the creation and comparison of profiles based on competencies. In [10] it was proposed a model for competence and its components from SWEBOK.

In [11], SWEBOK is used as a point of mediation for the comparison of academic profiles and the labor market. In [8], a useful model is proposed not only in academia but also in industry, where SWEBOK specifies the Knowledge Areas (KAS) necessaries in this context.

In [5], extend the research of [8] associating skill levels of Bloom's taxonomy of knowledge areas SWEBOK profiles Guide Software Engineering: New Graduate, Graduate with four years of experience, and experienced software engineer working in a software engineering process group.

III Methodology

Step 1: Define ontological model.

In recent years, it has increased the interest of professionals in the development and management of ontologies to develop from scratch, with the aim of linking knowledge and providing a semantic sense.

Some of the most widely used methods are as follows: METHONTOLOGY, On-To-Knowledge and DILIGENT [4]. The methodologies used to development the ontological model is called NeOn. NeOn is based on nine stages, since there are several ways for building ontologies; NeOn scenarios are flexible, allowing combined scenarios, and allowing users to customize them. For the evaluation of the profiles, the following methodology of NeOn scenarios is used:

Scenario 1: From specification to implementation.

PURPOSE: To develop ontology of BOK; a vocabulary to describe the terms associated with that domain it was created.

SCOPE: The ontology was focused on domain of BOK. The proposal of this research it was study the structure of SWEBOK 2014 in order to evaluate the professional and occupational profiles.

EXPECTED END USERS.

When a new ontology was designed, it is important to evaluate possible users. In table 1, it is showed some stakeholders.

Table 1. Expected end Users

Users	Description
Engineers.	People who study engineering.
Graduates.	Person who acquire an academic degree after complete the studies.
Stakeholders.	Many people, groups, companies, and other organizational or governmental entities have a stake in educational programs.

Requirements:

- Functional Requirements:

How is knowledge described?
How to align labor or Occupational and professional profiles using SWEBOK 2014?

- Non-functional Requirements

The ontology will be developed in English.

Scenario 2: Reusing and re-engineering non-ontological resources (NORs).

The reuse of Non-ontological resources is the second activity of NeOn which is the same methodology for analyzing non-ontological resources. In table 2, the non-ontological resources necessary for the evaluation of profiles are described.

Table 2. Non-ontological resources

Class	**Class Description**	**Properties**
BOK Ontological Model with Standars	Name of Ontological Model	include
BOK	Contain the relevant Knowledge for a discipline. BOK must embody the consensus reached by the community for which this BOK will be of application. This consensus is a prerequisite for the adoption of the BOK by the community [1].	id code levels Of Abstraction context structure by
Knowledge Area	Structure of a BOK, which define what a professional needs to understand and the tasks that a practitioner must be able to perform [3].	require composed by
Knowledge Unit	Each area is broken down into smaller	id

	divisions [3].	code description involve
Knowledge Topics	Second level of knowledge structure [3].	Associate Column Matrix Matrix Topic And Reference id code description
Knowledge Subtopics	Description of Topics [3].	id code description
Profile	A set of characteristics that identify or are thought to identify a particular type of knowledge [3].	need is part of id description code typeProfile
Skills	An ability and capacity acquired through deliberate, systematic, and sustained effort to smoothly and adaptively carryout complex activities or job functions involving ideas (cognitive skills), things (technical skills), and/or people (interpersonal skills) [3].	id code description
Detail-Profiles	Specific characteristics of each profile [3].	id code description

Scenario3: Reusing and re-engineering ontological resources. For the definition of the ontological model of BOK, the basis it was SWEBOK are the same that are structured by KAS, which have several elements such as: Units of Knowledge (UK), including a hierarchy of topics Knowledge (TK), and within sub topics (KST): List of further reading, References, Taxonomies, List of acronyms and labor profiles and professionals requiring skills to define the levels of knowledge of a professional [3]. The following ontological model has been developed based on the scenarios of NeOn methodology, which were taking for building scenarios 1, 2, and 3. The model is supported by the structure of the SWEBOK 2014, with which it was possible to define the terminology of a domain of knowledge: the concepts that constitute the domain, and relationships between concepts [12].

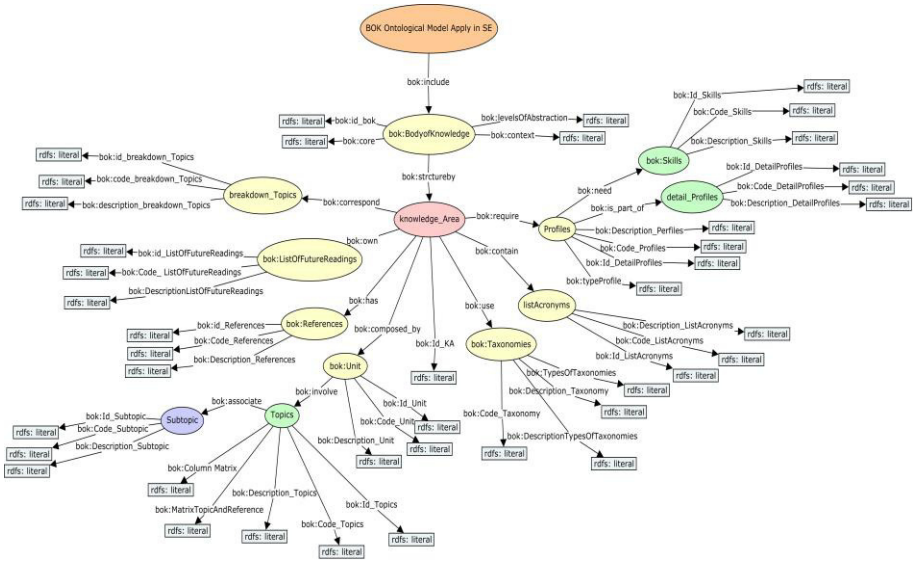


Fig. 1. Ontological Model to Describe BOK

Step 2: Evaluation of profiles through ontological models. - The ontology proposal was used to evaluate the labor and professional profiles in the area of software engineering. General ontology concepts and properties described in Scenario 2 are made, as these are needed for evaluation. To evaluate profiles it was used SWEBOK 2014, where only the Quality Knowledge Are (QKA) was taken account. The area is divided into Knowledge Units (KU), Knowledge Topics (KT), in order to deepen the concepts of knowledge and identify sub-topics.

On the other hand, it was necessary to consider another level in the structure of BOK, where the topics will be more detailed Knowledge Subtopic (KS). The KS has addressed different knowledge and skills. In the same way, to develop a BOK it is necessary to take into account: Process Model, Deliverables, Organization, Technology focus, Tools, Assignment focus and Exercise domain [13]. The sub-topics were extracted by experts Software Engineering, each sub-topic considered the breakdown of QKA. Table 3 shows the breakdown of the subtopics found in the topics of QSKA are presented.

SWEBOK 2014 Quality Knowledge Area

KA	KU	KT	KS
Software Quality	1. Software Quality Fundamentals 2. Software Quality Management	1. Software Engineering Culture and Ethics	Features and concepts of software quality Software development Software Maintenance Software Requirements Measurement methods and

Processes		acceptance criteria for evaluating the quality
3. Practical Considerations		
	Value and Costs of Quality	Software Product Product requirements Prevention cost Cost of appreciation Cost of internal failure Cost of external failure Software Projects Scope of the software project Software Requirements Software life cycle
	Models and Quality Characteristics	Quality Software Taxonomy or Software Quality model Software quality attributes Characteristics models of software quality Negotiation of the quality of Software product Planning of Software product quality Transaction of the quality of Software product Software Product
	Software Quality Improvement	Models of quality of the Software Product (internal, external, and job quality) Quality of the software engineering process Quality of software product Software Product Software life cycle Process Process of detection error/defect Quality improvement process Quality construction, through prevention and early detection of errors Software Engineering Process Product evaluation Scope of the software project Project management
	Software Safety	Software applications Develop safety-critical software. Software test environments Software functional requirements Software performance requirements

		Development processes
		Software quality assurance
	2.	Controlling software risk
	Software Quality Management Processes	Software Product
		Software life cycle Process
		Software Requirements
		Planning of Software product quality
		Software development
		Quality plan
		Software Maintenance
		Plans of Management, Development, and Maintenance for the software.
		Quality standards
		Activities and tasks of quality
		Software Configuration Management
		Software Projects
	Verification & Validation	Planning verification and validation of product
		Software life cycle Process
		Software development
		Software Maintenance
		Verification and Validation of Product
		Techniques and tools for verification and validation of the product.
	Reviews and Audits	
		Management reviews
		Technical reviews
		Inspections
	3.	Walk-throughs
		Audits
	Software Quality Requirements	Influencing factors
		Reliability
		Software integrity levels
		Process quality software
		Design methods
		Programming languages
		Software Technologies
		Software development
		Software Maintenance
		Taxonomy or Software Quality model
	Defect Characterization	
		Reliability models built based fault collected
		Software Testing
		Software Engineering Process
		Implementation of management techniques software quality
	Software Quality	
		Static techniques
		Intensive techniques of personnel

		Analytical Techniques
		Dynamic techniques
		Quality testing
	Management Techniques	Software quality models
		Metrics software quality
		Software Product
		Software Quality
		Software life cycle Process
	Software Quality Measurement	Quality processes and software improvement
		Cost of quality processes
		Cost generic quality models
		Development processes
		Software Engineering Process
		Software Engineering Management
		Reports of the software quality management
		Software quality metrics
		Software life cycle Process
		Software Engineering Process
		Software Engineering Management
		Development and maintenance processes

Step 3: Selection of the occupational and professional profiles. - Given a corpus of both job offers and professional profiles, it was obtained from of universities and employment platforms of Ecuador, two samples were taken for evaluation with SWEBOK 2014 profiles, considering among them the naked eye that may have greater alignment with a possible minor alignment with the samples to be worked, are:

1. Possibly aligned

Engineering in Computer Systems and Computer
Computer Engineering and Computer Science

2. Not aligned

Career Computer Education
Electronic and Computer Engineering

EXPERIMENTATION. - To test our theory, an experiment in which 2 profiles were used. It is based on a macro algorithm that includes the following steps:

MANUAL DESCRIPTION EXPERIMENTATION. - Manual testing is performed based on the SWEBOK 2014 guide, by reference to the area of knowledge subtopics Quality. To get the result 1, the following comparisons were performed using a matrix intersection.

R1 = (C3= ((C1=STQ vs PP) + (C2=STQ vs OP)/2)
C1 = ∑comparations/Nro. l of comparations

C2 = ∑comparations/Nro. of comparations
C3 = (∑C1 + \∑C2)/\Nro. of Subtopic

Where:

R1 = alignment between professional and job profiles
C1 = Quality y Profiles (Skills)
C2= Quality Subtopic and Jobs offerts
C3 = Results de C1 and C2
STQ = SWEBOK Topic Quality
PP = Professional Profile
OP = Occupational Profile

In both crosses (C1 and C2), in order to obtain numerical data, if there is any similarity it is assigned one (1), otherwise, the field being analyzed is left in blank. Upon completion of the comparison result C1 and C2 in percentages for each subtopic, versus the professional profiles and occupational, respectively bids are obtained. Once the percentages obtained, we proceed to C3, which consisted on comparing the total percentages of the C1 and C2. In the figure 2 show the experimentation and application of the evaluation.

KNOWLEDGE ASSESSMENT BETWEEN LABOR OFFER AND SKILL				
skill / labor offer	ENGINEERING IN COMPUTER SYSTEMS AND COMPUTER	COMPUTER ENGINEERING AND COMPUTER SCIENCE	EDUCATIVE INFORMATIVE	ENGINEERING IN ELECTRONICS AND COMPUTERS
Multitrabajos - IT Solutions Architect	47%	50%	38%	34%
Multitrabajos- Systems Engineer	41%	45%	32%	29%
Multitrabajos- .Net Developer	35%	38%	26%	22%
Software Developer, Web and/or Mobile Applications	38%	42%	29%	26%

Fig. 2. Experimentation and application of evaluation

IV Conclusions

The definition of BOK in the context of software engineering is important to respond the training needs of future professionals, so they in order to they acquire the competencies in the social, business, educational and industrial.

The Body of Knowledge as Standard is the sum total of our human understanding of the world around us. Studies in the area of strength and conditioning make up one of the many fields of knowledge, and strength and conditioning professionals must understand how our understanding is created to successfully use it to optimize their professional practices, approaches, and exercise prescriptions and applied them in occupational context.

A general structure of BOK in the software engineering was established. This structure begins with the set of KA, continues with KU, KT and ends with KST according to the research area.

V References

1. B. Penzenstadler, D. Mendez Fernandez, D. Richardson, D. Callele, and K. Wnuk,\The requirements engineering body of knowledge (rebok)," in Requirements Engineering Conference (RE), 2013 21st IEEE International, July 2013, pp. 377{379.
2. K. Taguchi, H. Nishihara, T. Aoki, F. Kumeno, K. Hayamizu, and K. Shinozaki,\Building a body of knowledge on model checking for software development," inComputer Software and Applications Conference (COMPSAC), 2013 IEEE 37thAnnual, July 2013, pp. 784{789.
3. P. Bourque, L. Buglione, A. Abran, and A. April, \Bloom's taxonomy levels for three software engineer pro_les," in Software Technology and Engineering Practice, 2003. Eleventh Annual International Workshop on, Sept 2003, p. 355.
4. UPM, \La metodologa neon," url http://mayor2.dia._.upm.es/oeg-upm/index.php/es/methodologies/59-neon-methodology , 2015.
5. P. Bourque, L. Buglione, A. Abran, and A. April, \Bloom's taxonomy levels for three software engineer pro_les," in Software Technology and Engineering Practice, 2003. Eleventh Annual International Workshop on, Sept 2003, pp. 123
6. G. Stevens, \A critical review of the science and practice of competency modeling," url http://hrd.sagepub.com/content/12/1/86.abstract, 2012.
7. Fazel-Zarandi, \Semantic matchmaking for job recruitment: An ontology-based hybrid approach," urlhttp://eil.toronto.edu/wp-content/uploads/km/papers/fazelsm09.pdf, 2014.
8. M. Azuma, F. Coallier, and J. Garbajosa, \How to apply the bloom taxonomy to software engineering," in Software Technology and Engineering Practice, 2003.Eleventh Annual International Workshop on, Sept 2003, pp. 117
9. H. Muller-Riedlhuber, \The european dictionary of skills and compe- tencies (disco): an example of usage scenarios for ontologies," in The european dictionary of skills and competencies (disco): an example of usage scenarios for ontologies, 2009, pp. 46 -479.
10. E. M. P.-A. S. Garca-Barriocanal, \Deriving competencies from the swebok ontology," url http://www.cc.uah.es/ie/projects/luisa/papers/2007/ontose07.pdf ,2007.
11. R. P. K. M, \Mediated competency comparison between job descriptions and university courses," url https://ortus.rtu.lv/science/en/publications/12361-Mediated+Competency+Comparison+between+Job+Descriptions+and+University+Courses, 2011.
12. A.Waterson and A. Preece, \Verifying ontological commitment in knowledge-based systems," Knowledge-Based Systems, vol. 12, no. 12, pp. 45 { 54, 1999. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S0950705199000076
13. J. Han, \Software engineering course design for undergraduates," in Software engineering course design for undergraduates, Apr 2011, pp. 166{172.

Extending BPMN model for improving expressiveness and machine-understandability

Mateo Ramos Merino, Luis M. Álvarez Sabucedo, Juan M. Santos Gago, Víctor M. Alonso Rorís

Grupo GIST - Escuela de Telecomunicaciones - Universidad de Vigo
{mateo.ramos, lsabucedo, jsgago, valonso}@gist.uvigo.es

Abstract. BPMN has become the preferred support for modelling and describing processes in the context of process developing. Nevertheless, several shortcomings have been identified in its application in particular usage scenarios. In particular, contexts demanding real-time monitoring of manual services, or with requirements to feed Data Analytics system can not take full advantage of BPMN. This papers address this arising issue by suggesting an extension for BPMN. This backwards compliant enhancement supports the definition of probe-oriented features to support services aimed at facilitating the fully automatic data processing in many scenarios.

Keywords: BPMN, Process Mining, Data Analytics, quality control

1 Introduction

Nowadays, the application of process mining [12] techniques for the enhancement of workflow analysis are gaining momentum. We can find several application examples not just in the academic environment ([7], [10]) but also in the business context ([1], [3], [5]) in which process mining have already been used successfully. A better understanding of workflows behavior has been achieved in those cases, leaving no doubts about the effectiveness of these techniques.

Trying to apply these techniques on a real scenario [9] with a particular type of workflows, the authors found some limitations regarding the semantics on existing workflow languages. In particular, some shortcomings have been detected in the workflow modeling language (BPMN [8]) that prevents the fully utilization of analysis techniques in this type of contexts. The goal of the present work is to reduce these disadvantages by adding new elements to convey more information about the activities in the workflow. In fact, the new elements included in this work share some of the objectives proposed as future challenges by the Task Force on Process Mining [13], applied to our scenario. In particular, this proposal is focused on some of the issues addressed in certain challenges, namely *Challenge 1* Finding, Merging and Cleaning Event Data; *Challenge 8* Providing Operational Support;*Challenge 9* Combining Process Mining With Other Types of Analysis; and *Challenge 11* Improving Understandability for Non-Experts.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_28

The resolution of the drawbacks identified for these workflows will help in the achievement of these challenges. For instance, the business processes under study tackle with activities performed by human workers. Due to the workflows nature, only a portion of the activities can support automatic monitoring task in order to, for example, generate the event log for further analysis. Therefore, some workflow activities do not generate a log but there is not explicit support in the language for this issue. The overcoming of this problem could help in challenge 1. Other drawback identified is the lack of support to link variables, product characteristics and other context elements with different flow paths in workflow. Also, the formal description of the effect caused by performing an activity on a product is not supported but very useful. The resolution of this drawbacks can be a good start for the achievement of goals proposed in challenges 8 and 9.

As we said, the aim of this work is to overcome these drawbacks by improving the language expressiveness. Due to this increased expressiveness, new information about the workflow and the semantic of the context will be available in the model. An intelligent analysis can use it for improving the results representations, helping this way to achieve the goal identified in challenge 11.

A deeper motivation is showed in following Sect. 2, identifying particular lacks found. Following, in Sect. 3, the language extension designed to overcome these lacks is presented (guided by examples) Then, in Sect. 4, a verification of the proposal is included by showing the results of its application to a particular scenario. Afterwards, we will discuss the shortcomings on the scenario modeled with BPMN and how the proposal can overcome it. Finally, some conclusions and an outlook for further research are presented on Sect. 5.

2 Motivation

As already mentioned, the use of BPMN as a tool for modelling and representation is widely adopted among practitioners. Nevertheless, this generic framework is not intended for covering all concerns that may be faced in an actual context. Actually, the standard itself provides an extension mechanism to enrich the model provided. In due course of its application on a real scenario[9], the authors found some limitations that could prevent the use of BPMN. In particular, its application brought into scene some issues unsolved, such as:

- No explicit support to present monitoring points. When tackling with non automatic operations (such as tasks performed by human workers), it is not clear how to show that new pieces of data will be included.
- No explicit support for security threshold. In case of need to take immediate actions depending of past or current values of sensitive variables, it is not clear how to express such conditions.
- Lack of support to link variables or product characteristics. In case of need to keep a reference to a single variable, it is not clear how to let the BPMN interpreter about this issue.

– Lack of descriptive activities behavior. For a software agent, it is not clear the effect of performing an activity on a product, as this can not be expressed in a formal and explicit fashion.

Also, the authors found problems to integrate the output variables of the system into the Data Analytics frameworks. It seems quite obvious the advantages of applying the techniques developed in the area of Data Analytics to schemes modeled using BPMN in an automatic fashion. In order to facilitate its integration in tools such as ProM[2], it would useful to be able to rely features to conduct this task.

Upon the identification of these shortcomings, the authors were compelled to the provision of an extension of the current specification of BPMN. Even at first glance, it could be reasonable to suggest the use of a new and different representational model, authors were prone to the definition of an extension on the top of the already existing BPMN model. Main reasons to continue on this non disruptive line are linked the critical mass already existing around BPMN in terms of users and software. The present proposal is backward compliant with the current version of BPMN and non-compliant agents will be able to still make use of the BPMN facilities already existing.

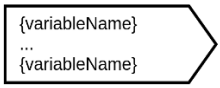
3 Proposal

The proposed extension introduces a set of elements on the top of BPMN that allow the representation of particular workflow contextual concepts. With the new proposed elements, it is possible to include some semantic features. This improvement on the quality and quantity of the represented information strengthens the understanding of the workflow by a software agent. An important part of the information related to the workflow (today available only in natural language documents) will also be represented in a machine-understandable format. By increasing the amount of information available for a software agent, we are contributing to close the gap between data and business mining techniques.

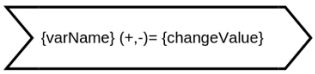
The core of the proposed extension is focused on the introduction of a set of workflow elements to support descriptions in a machine-understandable way. These elements are described in the following sections.

3.1 Monitoring point

A single variable, or a set of them, representing some product characteristic can be measured in a specific instant in the workflow. Therefore, it is possible to identify the kind of the variables, associations, and relations between them. These measured variables can also be referenced univocally and used in other points of the workflow. On Fig. 3, the reader can check in “Activity 1: Receiving the product” that it is defined a place for the measurement of some variables: product “color”, “width”, “depth” and “height”. Since the last three ones (“width”, “depth” and “height”) are related to the same concept (product size), they belong to the same group and are included inside the same stereotype.

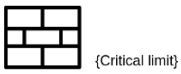


(a) Monitoring point



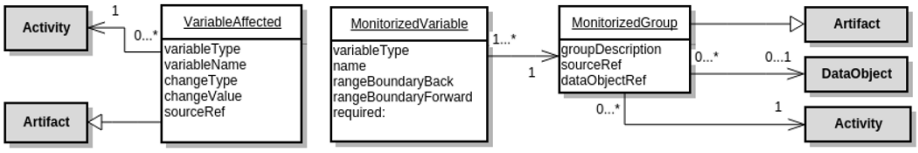
(b) Activity effect

(c) Advanced decision point

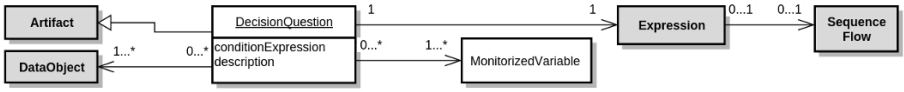


(d) Quality control point

Fig. 1: Proposed stereotypes for new elements



(a) Activity effect (b) Monitoring point



(c) Advanced decision point

Fig. 2: Meta models for new elements

Thus, it is introduced a new stereotype that represents a set of variables to be monitorized during the execution of an activity (Fig. 1a). The variable name will identify it univocally in the workflow. So, these unique measured variables can also be referenced from other workflow places (see Sections 3.2 and 3.3).

In order to represent this new BPMN element (check Fig. 2b), two new classes have been defined by extending the BPMN basic class *"Artifact"*. The class "MonitorizedGroup" represents a association of variables, that is, a container for a set of variables that are related to each other. Correspondingly, a "MonitorizedGroup" instance is composed by an unlimited number of "MonitorizedVariable" elements representing the measured variables. This hierarchical construction allows to show the relationships between measured variables.

The UML diagram also shows the connection of this new classes with two other BPMN basic elements (classes with grey background). We can see the associations with "Activity" class and with a BPMN "DataObject".

A complete set of options for describing the monitoring point and its variables is offered through several attributes. The "MonitorizedVariable" class includes a concept that has not been mentioned so far, the range. This property is used to express a range in which the measured value must remain constant (from a set of possible previous to following activities). Of course, any software agent can

use this information in its analyses. This interesting feature provides beforehand with an idea about how static or dynamic a product characteristic can be.

3.2 Activity effect

An important aspect for improving notation expressiveness is the ability to represent activity effect, i.e., how the activity affects a product or how it can change the product characteristics. The capacity to convey this implication in a machine understandable fashion must be provided. Let's reconsider, for instance, the "Activity 2: Crop dimensions" from 3 example. In this scenario, it was required to describe changes regarding the size of manufactured pieces. In particular, we need to express that "width" should have now a value of "150 millimeters" and "height" "55 millimeters". It is important to create the relationship between the activity ("Crop dimensions") and the affected product characteristics ("width" and "height"). The element activity effect is suitable for this purposes.

This element (checks Fig. 1b) contains the variable (representing a product characteristic) and the operation conducted. As a change on a monitoring point can be referenced from another point of the workflow, it is possible to create relationships between different workflow elements. To establish this relationship, it is only required to use the same variable name. This type of connections can be very useful for workflow analysis purposes, as it makes possible in further analysis to link these separate pieces of information.

To represent this new BPMN element, a new class has been created by extending the BPMN basic class "Artifact" (check Fig. 2a). This element includes attributes to expressed how an activity can change output characteristics.

3.3 Advanced decision point

In the context of this proposal, it is important to connect the possible choices and paths in a decision point with the characteristics of the product and the measured variables. One of the most interesting features here is the ability to create relationships between decision rules and unique variables present in monitoring points and in activity effect descriptions.

This new element is intended to make clear the reasons involved in the flow path choice (check Fig. 1c). In this way, it is possible to link flow paths with specific product characteristics. This feature turns out to be very useful for software agents analyzing the process because the additional data may enhance the possibilities of the applied algorithms. We can see an example of the representation of this element in Fig. 3. Notice on dashed line box under "Activity 2: Crop width". There, the path decision depends on one variable: "color". This variable is measured in "Activity 1" and is referenced using the Data Object associated. The variable feeds a object containing the expression for the decision point.

The UML diagram representing the relationships between this new element ("DecisionQuestion") and BPMN elements is included in Fig. 2c. For describing the conditional expression, this element uses the class "Expression", already existing in the BPMN language, to define a condition on a set of variables. The

"DecisionQuestion" element can be fed by a "DataObject" or by a "MonitorizingGroup" if the variable has just been measured.

3.4 Quality control point

Usually, a set of strategic spots to carry out quality procedures can be identified. Some parameters or characteristics of the product must be measured for test and results must fit in an established range of values. This is a common method for detecting hazards also. For this end, it is introduced an element designed to take care of quality control features.

This proposed quality control point includes explicit references to tested variables and activities involved in quality controls (for instance, activities with corrective actions to eliminate hazards). Also, relationships with other workflow points (for example, activities that modify the test variables) can be created. Using this support, a software agent can use this information to investigate the possible causes and give some clues about problem resolutions.

We can see an example of a Quality Control Point in "Activity 6: Search fissures and check width" on Fig. 3. The reader can note that, using a monitoring point, two variables are measured: "fissures" and "width". A critical limit for this characteristics is set: "no presence of fissures and width must be less than 155 mm". In this case, if this threshold is reached the product must be rejected. In another sample scenario, instead of reject the product, it could be possible to perform a series of corrective actions designed for get back the product.

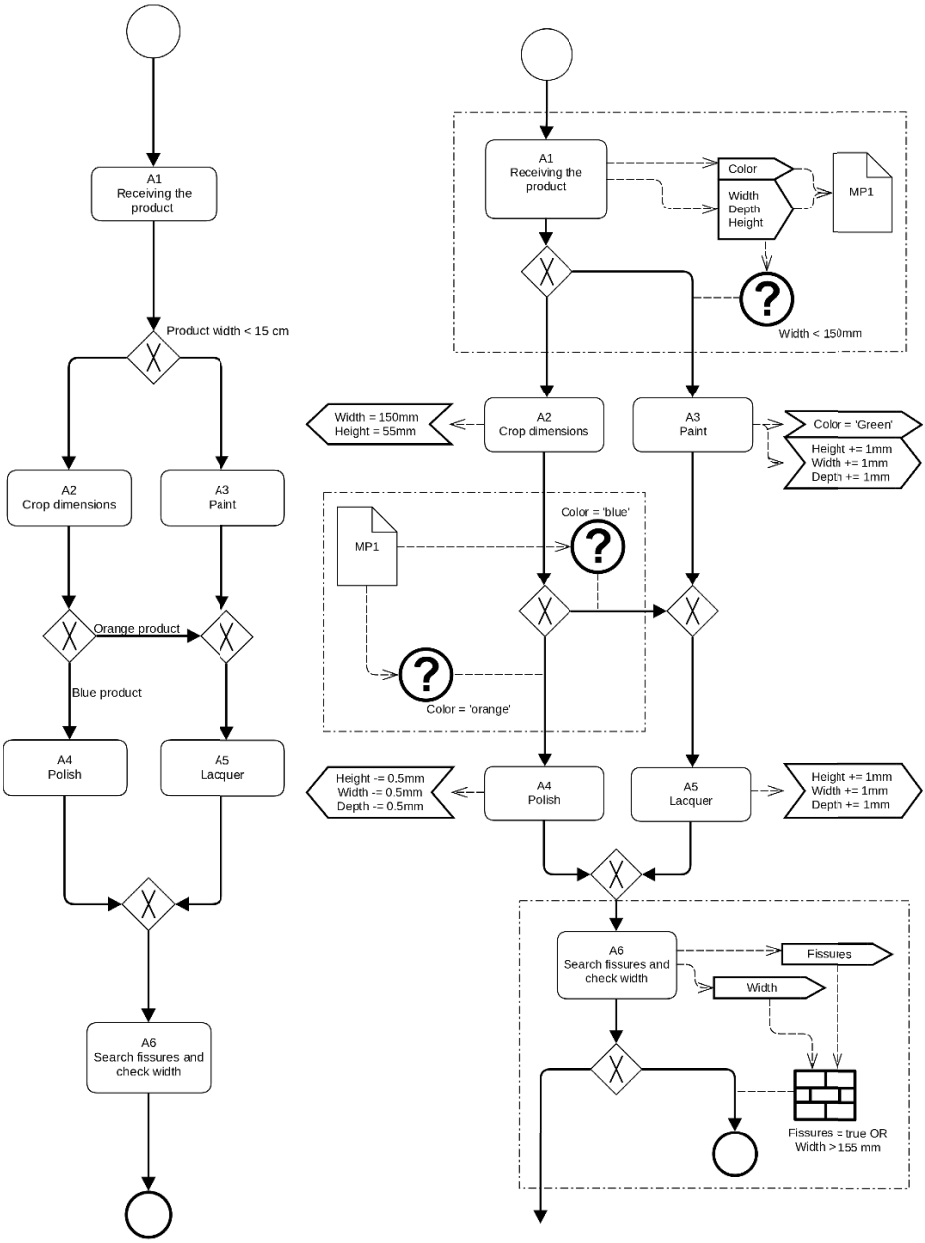
Also, a new element has been created to contain the critical limits and define the relations with variables. This element is concerned with quality measures (check Fig. 1d). The meta model for the new element ("QualityControlPoint") is similiar to "DecisionQuestion" element showed in previous section.

4 Verification of the proposed model

From a broad perspective, a sample workflow can be seen as a process with input and output products. Depending on the characteristics of input products, the workflow proposes a set of actions to be performed on these products. In this way, it is possible to obtain different output products for each combination of characteristics and inputs.

The sample scenario suggested is a manufacturing chain of metal pieces. This scenario and its workflow have the following characteristics:

- Three different pieces are the possible inputs. Depending on its characteristics (e.g., dimensions), the workflow imposes a set of actions to be performed.
- The workflow actions modify the characteristics of the pieces (e.g., its color) producing three different pieces as output (one for each input piece).
- At the end of the workflow, all the products must be tested for metal fissures. If the product does not pass the exam, it will be destroyed.
- In some preset points of the workflow, a trace on the product can be generated. With the monitoring points, some characteristics on the product (p.e., its width) can be measured.



(a) BPMN model

(b) Improving the scenario modeling with proposal

Fig. 3: Simple BPMN versus extension

4.1 Modeling the scenario with BPMN

Firstly, we show the model for the scenario using only BPMN language in Fig. 3a. As the reader can note, three different paths, one for each type of input product, is defined. Each of these paths leads to the production of three different output products. In a real context, this type of processes is supported usually by a document describing the activities, the possible paths, the monitorization points, the different control points and the actions to be performed in case of a faulty product. This information is available in natural language only and is not present in the workflow. So, a software agent can not understand this information. Some notes on identified drawbacks are presented following:

Monitorized and not monitorized activities. It is not possible to express an explicit identification of activities which could imply a monitorization of some product or flow characteristics (e.g.: width of the product). Characteristics of products can not be referenced from anywhere in the flow (e.g, in a decision point we can reference the variable "width").

Effect of tasks and flow paths. The impact that an activity has in the characteristics of a product (e.g., modify its width) are not considered either. Also, it is not possible to link this effect with the monitorized variables which represent the same characteristics of the product. And finally, there is no way to bind these concepts with the semantics behind of decision points, i.e., associate the characteristics of the product with the right path for each one.

Quality controls. Explicit expression of a quality control can not be expressed in the model. In this sense, it is important to note which are the measured critical characteristics, the defined thresholds to pass the quality control and its consequences.

4.2 Possibilities of improving the modeling with this extension

After applying the presented proposal (check Fig. 3b), several benefits can be outlined:

Monitorized and not monitorized activities. Using the "Monitorized Point" concept explained in Sect. 3.1, it is possible to clarify which activities could imply measurement points and all the information related. This can be observed in Fig. 3b. Just by analyzing the modeling for "A1", it is possible to know which variables are measured, the possibles groupings of these variables (we known that "width", "height" and "deep" are related) and the types of information. Also, we can establish a relationship between this point and other instants in the workflow, as these variables can be referenced later in the model.

Effect of tasks and flow paths As we described in Sect. 3.2, it is proposed a mechanism to describe the impact of an activity, i.e., what is the effect that the execution of this activity has in the product. The approach to describe this is by associating effects to some characteristics of the product. For example, in activity "A3" in Fig. 3b we can see the rule "width +=1 mm". That means a increase in the characteristic "width" of "1 mm". It is entirely possible, and quite convenient usually, that variables used in rules can been referenced previously

in another instant (a monitorized point, a decision point,...). Also, a mechanism and a stereotype to establish relationships between flow paths and product characteristics are provided by the "Decision Points" (Sect. 3.3). This concepts provides a great power for further analysis. A software agent can inquire about these relations and take advantage of it.

Quality controls The usage the "Quality Control Point" described in Sect. 3.4 allows association and description of actions, conditions, critical limits, behaviors, and product characteristics related to hazards or quality aspects of the product. In the sample scenario (check Fig. 3b) we can this concept in activity "A6". With this approach, this place in the flow is directly related with quality and security concepts. That is, there is an explicit link of the product characteristics with the hazards and the thresholds that can not be missed. The corrective actions to be performed in case of detecting a hazard can be also described. Again, to establish a relation between this concepts and other variables measured along the workflow is also a desirable feature (see the characteristic "width" in example). A software agent can now be aware of the semantics behind the quality control description.

5 Conclusions

BPMN is a broadly disseminated support for modeling processes. With a large penetration on the software industry, this representational model is a *de facto* and *de juri* formalization for processes. Nevertheless, as shown in Sect. 2, there are some shortcomings to be faced. Due to its original intention, some usage scenario and intended uses were not taken into account. Upon a review of current usage scenarios, the authors suggest an extension of the model to cope with the identified burdens (Sect. 3). Thus, new features are included in the model to support features regarding risk management and monitoring services.

Upon the review of the current of the art, a set of lacks identified that could prevent the use of BPMN were presented (check Sect. 2). These shortcomings were related with some of the future challenges on Process Mining proposed by the Task Force on Process Mining ([13]). The philosophy underneath these challenges guided the creation of the new set of mechanisms and elements focused on the resolution of the problems (Sect. 3). A verification of the proposal was presented. The results show the advantages of the proposal in practice (Sect. 4).

The improvement in the expressiveness is clear from the results. With the use of this extension, more information about the workflow and the semantics of the context is available in a machine-understandable way. This new information can enrich the workflow analysis. As a result, the challenges addressed are closer to its fulfillment. The aim is to increase the maturity level of business process mining techniques and to allow that these techniques can be applied in the type of workflows identified. These new features are particular suitable in contexts such as HACCP, a domain gaining momentum due to the new regulations arising in Europe[11].

Authors are confident about the adoption of this new features as they are already being applied in related projects [9]. Currently, authors are working on the closing the gap between models using this enhancements and Data Mining techniques. As this extension in BPMN is driven by probe-oriented concept, it seems to the authors feasible to use the output data to automatically feed Data Mining tools such as ProM[2], Orange[6] and Weka[4].

6 Acknowledgement

This work has been partially funded by the European Regional Development Fund (ERDF), the Government of Spain and the Regional Government of Galicia under the TACTICA and GRC2013-006 projects.

References

1. BPI LAB, U.N.I.o.S., Technology: Samsung electro-mechanics (2013)
2. van Dongen, B.F., de Medeiros, A.K.A., Verbeek, H., Weijters, A., Van Der Aalst, W.M.: The prom framework: A new era in process mining tool support. In: Applications and Theory of Petri Nets 2005, pp. 444–454. Springer (2005)
3. Fluxicon: Case study - Refund Service Process. Available at `http://www.win.tue.nl/ieeetfpm/lib/exe/fetch.php?media=:casestudies:processmining_refundprocess-en.pdf` (accessed October 12, 2015).
4. Hall, M., Frank, E., Holmes, G., Pfahringer, B., Reutemann, P., Witten, I.H.: The weka data mining software: an update. ACM SIGKDD explorations newsletter 11(1), 10–18 (2009)
5. Perceptive software: Case study - Electric and Gas Utility. Alliander (2012). Available at `http://www.win.tue.nl/ieeetfpm/lib/exe/fetch.php?media=:casestudies:perceptive_alliander_case_study.pdf` (accessed October 12, 2015)
6. University of Ljubljana.: Orange Data Mining.
7. Mans, R.S., Schonenberg, M., Song, M., van der Aalst, W.M., Bakker, P.J.: Application of process mining in healthcare–a case study in a dutch hospital. Springer (2009)
8. OMG: Business process model and notation (BPMN) version 2.0 (2011), version 2.0
9. Sanz-Valero, J., Álvarez Sabucedo, L., Wanden-Berghe, C., Alonso Roris, V., Santos Gago, J., et al.: Sun-pp236: Deployment of a tag-based system to ensure traceability management of parenteral nutrient mixtures. Clinical Nutrition 34, S111 (2015)
10. Tu/e: Isalas Question. Available at `http://www.win.tue.nl/ieeetfpm/lib/exe/fetch.php?media=:casestudies:isalacasestudy.pdf` (accessed October 12, 2015)
11. Diario Oficial de la Unión Europea: Reglamento (ce) nº 852/2004 del parlamento europeo y del consejo de 29 de abril de 2004, relativo a la higiene de los productos alimenticios. Tech. rep., DOUE 30/04 (2004)
12. Van Der Aalst, W.: Process mining: discovery, conformance and enhancement of business processes. Springer Science & Business Media (2011)
13. Van Der Aalst, W., Adriansyah, A., de Medeiros, A.K.A., Arcieri, F., Baier, T., Blickle, T., Bose, J.C., van den Brand, P., Brandtjen, R., Buijs, J., et al.: Process mining manifesto. In: Business process management workshops. pp. 169–194. Springer (2012)

Ontological Semantic Agent in the Context of Big Data: a tool applied to Information Retrieval in Scientific Research

Caio Saraiva Coneglian[1], Elvis Fusco[2], José Eduardo Santarém Segundo[3], Valdir Amancio Pereira Junior[2], Leonardo de Castro Botega[2]

[1] Information Science Department. Universidade Estadual Paulista (UNESP), Marília, São Paulo, Brasil
caio.coneglian@gmail.com
[2] Computer Science Department. Centro Universitário Eurípides de Marília (UNIVEM), Marília, São Paulo, Brasil
fusco@univem.edu.br
[3] Universidade de São Paulo (USP), Ribeirão Preto, São Paulo, Brasil
santarem@usp.br

Abstract. The large increase in the creation and dissemination of data on the Internet can offer information of high value-added to organizations. This information can be provided by heterogeneous databases that may not be considered relevant by most systems, e.g., social media data, blogs and more. If organizations would use such sources, they could build a new management vision known as Competitive Intelligence. In the context of architectures of Information Retrieval, this research aims on implementing a semantic extraction agent for the Web environment, allowing information finding, storage, processing and retrieval, such as those from the Big Data context produced by several informational sources on the Internet, serving as a basis for the implementation of information environments for decision support. Using this method, it will be possible to verify that the agent and ontology proposal addresses this part and can play the role of a semantic level of the architecture.

Keywords: semantic web; semantic agent; ontology; Big Data.

1 Introduction

The massive diffusion of generated data is testing the ability of the most advanced techniques of information storage technological, treatment, processing and analysis. The areas of treatment and information retrieval are being challenged by the volume, variety and velocity of semi-structured and unstructured complex data, offering opportunities for adding value to business-based information providing organizations a deeper and precise knowledge of their business.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_29

Opportunities to add value to the business-based information arise due to both the internal and external environment. Hence, there is a need for a new approach to structure Information Technology (IT) companies to transform data into knowledge, which cause broader impact.

To aggregate and use information that are scattered in the internal and external environments of organizations, there is the concept of Competitive Intelligence, which according Fleisher [1] is a process by which organizations gather actionable information about competitors and the competitive environment and, ideally, apply it to their decision-making and planning processes in order to improve their performance.

A proactive informational process leads to a better decision, whether strategic or operational, in order to discover the forces that govern the business, reduce risk and drive the decision maker to act in advance, besides protecting the generated knowledge.

In the current scenario of the information generated in organizational environments, especially in those who have the Internet as a platform, there is data that, due to its characteristics, is classified as Big Data [10]. In the literature, Big Data is defined as the representation of the progress of human cognitive processes, which generally includes data sets with sizes beyond the capacity of current technology, methods and theories to capture, manage and process the data within a specified time [2]. Gartner [3] defines Big Data as the high volume, high speed and/or high variety of information that require new ways of processing to allow better decision making, new knowledge discovery and process optimization. In the process of information search for Competitive Intelligence and Big Data robots, data mining techniques on the Internet are used. According to Deters and Adaime [4] robots are systems that collect data from the Web and assemble a database that is processed to increase the speed of information retrieval.

According to Silva [5], the extraction of relevant information can rank a page according to a domain context and also draw information structures them and storing them in databases. To add meaning to the content fetched, the robots are associated with Web search semantic concepts, which let the search through a process of meaning and value, extracting the most relevant information.

The ontology in the philosophical context is defined by Silva [5] as part of the science of being and their relationships; in this sense, the use of ontologies is essential in the development of semantic search robots, being applied in Computer Science and Information Science to enable a smarter and closer search to the functioning of the cognitive process of the user so that data extraction becomes much more relevant.

Thus, an agent presents itself as a solution to retrieve information on the web by semantic means. Currently, the content is organized in a jointly manner, in which syntactic structures do not have semantic data aggregation. In this sense, the role of the agent is to extract the information from the content and use syntactical ontology to achieve semantic relations and apply them to retrieval information.

This research aims to implement a semantic agent for searching on the Web and allowing the retrieval, storage and processing of information, i.e., Big Data from various informational sources on the Internet. Such semantic agent will be the main mechanism for building a computational architecture that transforms disaggregated information on an analytical environment of strategic, relevant, accurate and usable

knowledge to allow managers the access to opportunities and threats in the field of higher education institutions, based on concepts of competitive intelligence. The semantics of the agent will be built using ontological structures.

To achieve this goal, the Semantic Agent will be built using the domain of higher education institution, addressing the problem related to search to scientific papers.

2 Information Retrieval in Big Data

The traditional information systems are unable to cope efficiently with all new data sources and multiple contexts of information that have mainly the Internet as a platform. Problems are encountered in retrieving, standardizing, storing, processing and usage of information generated by various heterogeneous sources that are the basis for enabling systems for decision support organizations.

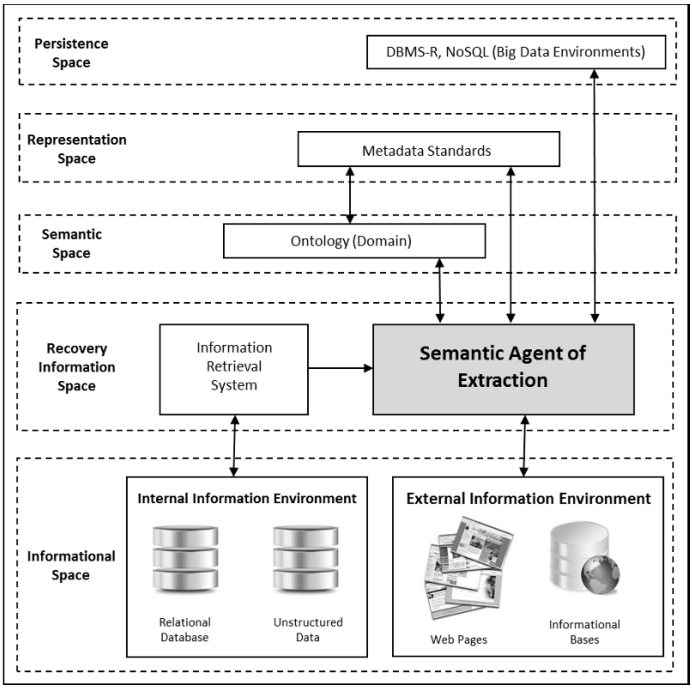


Fig. 1. Architecture Context of Semantic Agent of Extraction

In this context, it is questioning whether the computing environments of information actually present completely all relevant information to decision makers in organizations. The solution proposed in this paper is to create an architecture for information retrieval in the context of Big Data as seen in Figure 1.

This architecture was proposed so that the recovery of the information can be made using the semantic space. The architecture has the agent as the structure of

information retrieval and integrates with all elements and layers of the architecture. This architecture will be used at an institution of higher education, because in this area there are many information not being used several times in competitive intelligence.

This architecture distinguishes itself from others by doing all the recovery information using the same domain, therefore, only will be extracted information relating to the problem in accordance with the defined ontology.

With the exponential growth of information within the Web, the process of information retrieval is faced with a new challenge: to recover information efficiently, thus rescuing information that present real value and are immersed in many other pieces of data. In order to understand this process, it is necessary to address the question of Big Data and how this process is changing the way we see the information within the Web.

3 Semantic Agent of Extraction

The creation of a software agent that aggregates semantically information available on the web in a given domain can bring grants to a computational platform for creating an information environment for decision support giving a through broader view of the internal and external scenarios of information relevance in organizational management.

In this context, we understand the extreme importance of using agents to extract data through scrapper semantic search with the use of technologies like NoSQL persistence in information processing with characteristics of Big Data, essential in the recovery, storage, processing and use of various types of information generated in these environments of large volume data sets on Competitive Intelligence.

In the context of the architecture presented in Figure 1, this research are dealing the problem of automatic and semantic information extraction of web environments that have as informational sources: web pages, web services and database with the development of the agent semantic of data extraction.

This agent should communicate with internal and external information spaces of Big Data basing their search on ontological rules on a metadata standard to perform the semantic extraction of the domain proposed and supported by other systems in a broader context of Information Retrieval.

From this semantic search, the scrapper actuates as a tooling strategy in the search and find the information that really add value to the decision-making process. Inside a huge and massive data structure scattered throughout the web, it is essential that the search engines do not support only syntactic structures of decision in information retrieval, but also in investigations of the use of semantic extraction agents.

Our research uses the domain of higher education institutions as a case study to apply the proposed computing platform in the architecture described in Figure 1. For the development of the prototype of the ontology, we used the database discipline, to perform the search for scientific papers

3.1 Ontological Conceptual Notation

To create the ontology, first it was necessary to check within the domain of database discipline, which are the classes that are involved in this issue.

It was checked what were these classes, and analyzed the hierarchy between them, based on the experience of the authors ' research and other researchers, and thus was sealed the hierarchy between the classes. To build the ontology was used Noy [6] methodology, that explains the seven steps that are required to build an ontology: 1. Determine the domain and scope of the ontology; 2. Consider reusing existing ontologies; 3. Enumerate important terms in the ontology; 4. Define the classes and the class hierarchy; 5. Define the properties of classes—slots; 6. Define the facets of the slots and; 7. Create instances.

It was drafted this conceptual notation of ontology, using the Protégé software [8]. It was built the relationship between classes.

The agent will act on this proposed ontology that this scenario is called Task Ontology, according Mizoguch [7].

It is an ontology that solves a specific problem within a domain, that is, solves the problem of scientific research within the domain of database discipline.

We implement the ontology in Protégé software, creating the class diagram and its properties, being implemented in a file OWL (Web Ontology Language) (WC3, 2002H).) There after the Owl2Java [9] tool transformed OWL in classes Java (Java, 2004); thus making the implemented ontology.

3.2 Working Method of the Semantic Agent

The search agent captures information by means of pre-defined web pages and uses the ontology to classify and make a semantic search.

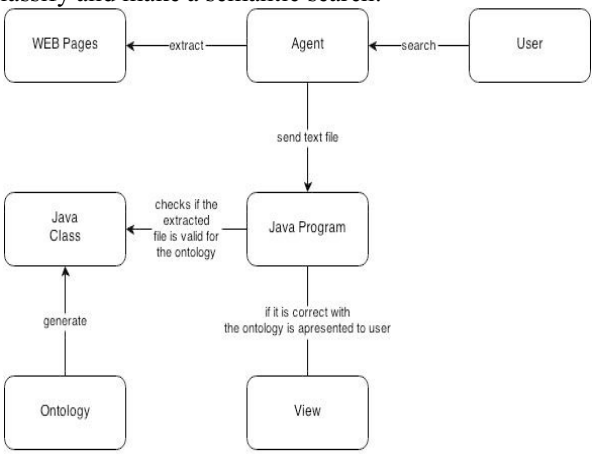


Fig. 2. Scheme of operation of agent

Figure 2 shows the process made by the system. The user performs a search on any subject, the agent extracts of databases summaries relating to this topic. These

summaries will go through a process where they will be analyzed, taking into consideration the words contained in this summary are present in the field that sought theme. This will be possible using a built ontology, which deals with a specific topic in the area of scientific research.

The sequence of tasks performed by the agent is described as follows:

3.2.1 Information Extraction

The agent extracts the abstracts from IEEE Xplore page (http://ieeexplore.ieee.org) based on the research the user carries out. Based on the location of the abstracts in the HTML page, the agent extracts the information and transforms it into a String chain.

The agent process is divided into three phases: search in the page, extraction of the titles and abstracts, and return of a list of the papers to the main program.

- Search in the HTML page: this first phase is characterized by performing a search in the IEEE Xplore search system, so that the search is characterized by a request to this system inserted in the url, which is the theme that the user want to search. For example, if the user wants to perform a search on Data warehouse, the agent will open a connection, and look at the following address (http://ieeexplore.ieee.org/search/searchresult.jsp?Newsearch=true&QUERYTEXT = datawarehouse). From this page, the IEEE returns an HTML containing articles related to this topic.
- Extraction of titles and abstracts from the page: after returning from the HTML, the agent extracts the title and the abstract of each paper It is made possible by analyzing the HTML page by checking the tags whose data abstracts and titles are inserted. In this manner, for each item it is create a Java object that contains information about title, abstract and link to the full article. To perform this removal of data inside an HTML page, we used the tool JSOUP, which works as an HTML parser, in other words, working with the HTML page, so that it can extract the class data, tags and structures of HTML.
- Development of a list of articles extracted: finally, the agent creates a list of all the items that were extracted from the HTML page. This list will be used by the main program, which will join the ontology with this information retrieval agent.

Thus, this search robot is able to perform a syntactic extraction of the articles contained in the IEEE Xplore database. Therefore, the search robot retrieves the items that have been indexed by the database, creating a list of all the articles presented to be used in the ontology.

3.2.2 Use of Ontology for Information Retrieval

In order to effectly have the semantics presented, the program makes use of ontology to assess which of the results obtained from the database are actually useful, and related to the context of that search. This integration takes place in five stages:

First, it is checked where the term searched by the user is found within the ontology. For example, if the user performs a Datawarehouse search, the system

checks where this term is found within the ontology. It is obtained the hierarchically higher and lower classes to the search term. In the case of Datawarehouse, it is obtained the lower classes: OLAP, OTAP and modeling, as well as the upper class Database. It is then checked in the abstract and title of the searched papers whether it contains or not the words that make part of that hierarchy of the search term. In the case of Datawarehouse, it would be verified if the terms OLAP, OTAP, modeling, Datawarehouse and database are contained within the abstracts and titles of the extracted papers. Next, it is done a comparison between the amount of terms in the hierarchy and those contained in the abstract and the title of the article, thereby resulting in a percentage quantity of terms contained in the hierarchy, which are within the abstract and the title of the article. In the same example, if the terms Database, OLAP, Datawarehouse and modeling are contained within an article, it will contain four of the five terms of the hierarchy, which results in a percentage of 80% of the terms. Finally, it is presented to the user all the items that reached a percentage above 35%.

3.2.3 Presentation to User

The user will be held in an initial screen of search, and then the system will make it from the ontology integration process with user requirements. After the extraction and process of the articles, the system returns to the user a screen containing the articles and links of these articles that the system extracted and considered related to the search performed by the user. This result can be seen in Figure 3, where the names and links are presented so that the user can access the full article.

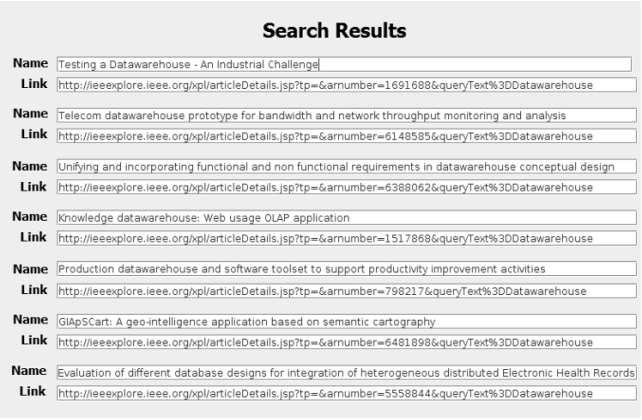


Fig. 3. Scheme of operation of agent

4 Results

In order to check if the system is extracting and verifying the semantics of extracted articles, a search was made with the user searching for the term "Datawarehouse".

The Datawarehouse term hierarchy are the words: Database, Datawarehouse, OLAP, OTAP and modeling.

In Table 1, you can view all the titles of the articles that have been extracted from the IEEE Xplore website, the amount of jail terms of ontology that were found in the abstract and title, the relationship between the terms found in the article and the terms of the chain the ontology of the term "Datawarehouse" (in this case will be the percentage resulting of dividing the amount of words found in the ontology by 5, which are the terms contained in the ontology chain hierarchy) and this paper meets or not the minimum requirement of at least 35% of the terms contained in the abstract and title.

Table 1. Analysis of Extracted Articles

Title	*Number of words*	*%*	*Will be presented ?*
Testing a Datawarehouse - An Industrial Challenge	2	40	**YES**
Telecom datawarehouse prototype for bandwidth and network throughput monitoring and analysis	3	60	**YES**
Unifying and incorporating functional and non functional requirements in datawarehouse conceptual design	3	60	**YES**
Knowledge datawarehouse: Web usage OLAP application	2	40	**YES**
Datawarehouse and dataspace — information base of decision support syste	1	20	NO
The implementation of datawarehouse in Batelco: a case study evaluation and recommendation	1	20	NO
E-Business Model Approach to Determine Models to Datawarehouse	1	20	NO
Production datawarehouse and software toolset to support productivity improvement activities	2	40	**YES**
A genomic datawarehouse model for fast manipulation using repeat region	1	20	NO
A datawarehouse for managing commercial software release	1	20	NO
Modeling Analytical Indicators Using DataWarehouse Metamodel	1	20	NO
An SLA-Enabled Grid DataWarehouse	1	20	NO
Business Metadata for the DataWarehouse	1	20	NO
A partition-based approach to support streaming updates over persistent data in an active datawarehouse	1	20	NO
Study of localized data cleansing process for ETL performance improvement in independent datamart	1	20	NO
Visualizing Clouds on Different Stages of DWH - An Introduction to Data Warehouse as a Service	0	0	NO
GIApSCart: A geo-intelligence application based on semantic cartography	2	40	**YES**
JISBD 2008 + TELECOM I+D 2008 = INTRODUCTIONS	0	0	NO
Normed principal components analysis: A new approach to data warehouse fragmentation	0	0	NO
Enriching hierarchies in multidimensional model of data warehouse using WORDNET	0	0	NO
The fragmentation of data warehouses: An approach based on	0	0	NO

principal components analysis			
Evaluation of different database designs for integration of heterogeneous distributed Electronic Health Records	2	40	**YES**
Keynote talk data warehouses: Construction, exploitation and personnalisation	1	20	NO
Security Analysis of Future Enterprise Business Intelligence	0	0	NO
QVT transformation by modeling: From UML model to MD model	1	20	NO

In the case of 25 articles, seven out of them fulfilled the requirements, which are presented to users. This presentation can be viewed in Figure 3.

5 Conclusions

This paper presents the use of ontologies to improve the Information Retrieval process.

The objective of this research is to add semantics to the information retrieval process by using the information in the context of Big Data to perform a process that adds more value to the searches performed

In order to prove this goal, it was used the domain of scientific research in which the user, when performing a search of scientific articles in databases, is faced with the problem of having a very large number of documents, but much of these are not actually useful and do not attend the user's need.

It was then created an ontology and a search robot, and the connection between them was established so that the initial goal was achieved.

For testing, in a way to assess the actual operation of this process, the search robot was implemented with the ability to extract articles from the IEEE Xplore database, and the ontology has been built with the field of database discipline.

After testing, it was observed that the use of ontology for the search agent is an effective way to obtain valuable information and be able to meet the informational needs of the user.

The ontology can be effective in this case, because it becomes a way of organizing semantic information, and in this manner, only significant information will be presented to the user.

Although the Semantic Web term has already been used for some years, there is still a limitation in their use, because much of the Web is organized in a syntactic form in which most pages are created so that only humans can read what is written without being structured in a way that computational agents can extract the data inside a context with the implied meaning in the HTML.

The extraction agent can extract the documents from the web, and a program can process information by using ontology, thereby presenting the most relevant results.

In this manner, the results obtained by using the prototype developed can substantially narrow down the amount of items presented to users. This research aims, therefore, at making the user get, in a process of Information Retrieval, more significant, quality results. Thus, the user can evaluate more information that is meaningful and does not waste time with data that does not meet their needs.

Therefore, in order to address the issue of how to insert intelligence in the recovery of web pages which do not contextualize their information, the present research

proposes that the process of adding semantics to these pages takes place outside the Web, that is, the extraction of pages occurs in a syntactic way, and from what was extracted, information is checked by semantically entering into this process. This method was very efficient since it is in fact able to make a smarter search, which goes beyond simple formulas of searches, which observe only the syntax of the texts, and is able to analyze the context in which the extracted documents are inserted, and then visualize if that document fulfill the user's needs.

Acknowledgments. The work presented in the paper was supported by the CAPES and FAPESP (Fundação de Amparo a Pesquisa do Estado de São Paulo), process 2015/01517-2.

References

1. Craig S. Fleisher and David L. Blenkhorn, "Managing Frontiers in Competitive Intelligence". Greenwood Publishing Group, 2001.
2. D. Graham-Rowe, et. al. "Big data: science in the petabyte era". Nature, 455, 1-50, 2008.
3. Laney Douglas. "The Importance of 'Big Data': A Definition." Gartner (June 2012), 2012.
4. Janice I. Deters and Silsomar F. Adaime, "Um estudo comparativo dos sistemas de busca na web" ("A comparative study of search systems on the web"), Anais do V Encontro de Estudantes de Informática do Tocantins. Palmas, TO, 189-200, 2003.
5. Tércio. M. S. Silva, "Extração De Informação Para Busca Semântica Na Web Baseada Em Ontologias" ("Information Extraction for Semantic Search In Web Based On Ontology"). Florianópolis, 2003.
6. Natalya F. Noy and Deborah L. McGuiness, "Ontology Development 101: A Guide to Creating Your First Ontology". <http://www.ksl.stanford.edu/people/dlm/papers/ontology-tutorial-noy-mcguinness-abstract.html> [retrieved: 11/27/2015], 2001.
7. Riichiro Mizoguchi, "Tutorial on Ontological Engineering". NEW GENERATION COMPUTING-TOKYO- 21.4, 363-364, 2003.
8. Protégé. Stanford University. <http://protege.stanford.edu/> [retrieved: 10/10/2015].
9. Owl2Java.<http://www.incunabulum.de/projects/it/owl2java> [retrieved: /14/2015].
10. Coneglian, Caio Saraiva, and Elvis Fusco. "Recuperação da Informação em Ambientes Semânticos: uma ferramenta aplicada à publicações científicas." Journal on Advances in Theoretical and Applied Informatics (ISSN 2447-5033) 1.1 (2015): 30-37.

Designing an IT Artifact: Framework for the Entire Process of IT Demand Management

Igor Aguilar Alonso[1], José Carrillo Verdún[1] and Edmundo Tovar Caro[1]

[1] Universidad Politécnica de Madrid, Escuela Técnica Superior de Ingenieros Informáticos, Campus de Montegancedo, Boadilla del Monte, 28660, Madrid, Spain
igor.aguilar@fi.upm.es, jcarrillo@fi.upm.es, etovar@fi.upm.es

Abstract. This paper presents a proposed IT artifact, denominated framework for the entire process of IT Demand Management (IT-DM), which identifies the phases, main activities, and sub-activities of each of the phases of the IT-DM viewed from a strategic level view. This framework is the result of the combination of conceptual models and standards related to IT and business because currently there is a lack of frameworks or methodological guides to assist senior executives and IT professionals of the organization to manage the IT demand and help them to solve the gap that exists between business and IT. We also conducted a supplementary survey incorporating forty two respondents to evaluate our proposed. Our work has a twofold contribution: First, is the IT artifact design. Second is the evaluation positive of the IT artifact.

Keywords: IT demand management framework; Phases for IT-DM; Main activities; Sub-activities; Business; IT artifact, Corporate Governance of IT.

1 Introduction

By considering that Information Technology (IT) is a broad field that during the last years have appeared different publications and conceptual models in relation with IT Governance [1], [2], [3], [4], [5]. The IT Governance framework of the IT Governance Institute (ITGI) [6] defined five cover domains: Strategic alignment of IT with the business, Value delivery of IT, Management of IT risks, IT resource management, and Performance measurement of IT. The publication of Forrester Research [5], establish that implementing good IT Governance requires a framework based on three major elements: Structure, Process, and Communication. The Institute of Directors in Southern Africa (IoDSA) formally introduced the King Code of Governance Principles and the King Report on Governance (King III) [7]. After many proposals, the Corporate Governance of IT was standardized with first edition ISO 38500-2008 [8]: Corporate Governance of IT and after was modified by the second edition with ISO 38500-2015 [9]: Governance of IT for the organization, this standard establishes clearly the difference between governance and management of IT.

The IT Governance framework of Forrester [5], argued that IT-DM is one of the processes of the IT Governance, considered a key process for business success and has been understated by board of director and senior executives [17].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_30

The demand for products and IT services comes from the needs of the different business processes of customers in the form of ideas, new business opportunities with high level information schedules deadlines; costs and benefits, which is defined as a mega-project, that IT projects which are determined should be classified and qualified to be implemented by the IT department. Within the management of demand there are some requirements that are routine, while others are strategic and complex, such as new applications to support new business opportunities [10].

Today one of the problems facing boards of directors and financial managers is how to establish the profitable on IT project investments. The major obstacle of the IT-DM process, it is not managed properly from a strategic point of view for achieving the objectives of the business, affecting to the IT Governance.

Having carried out the Systematic Literature Review (SLR) process, and due to the lack of studies, models or standards that provide specific guidance for the IT-DM in its different types (strategic, tactical and operational) [11], [12], [13], as argue Susan Cramm [14] and thesis by Aguilar Alonso [15] that prevent the best practices for IT-DM, and other problems that affecting IT organizations, as well as the difficulty in deploying applications and organizational culture [16]; unawareness of the importance of IT investments is to create value to the business [17].

For this reason, there is a need to have a very close link between strategic planning and project processes from the beginning [18], taking into account the Design Science Research (DSR) [19], [20] specifically in subfield of the IT and information systems (IS) discipline [21], [22]; we proposes the design of an IT artifact called "Framework for the Entire Process of IT Demand Management" with a new vision, considering the IT from the first moment of the business planning, establishing the phases, main activities, and the identification of sub-activities.

The objective of this paper is to show the design and results of the evaluation of the framework for the entire process of IT-DM, structured in phases, main activities, and sub-activities as a contribution to solve identified organizational problems on a context composed by the confluence of people, organizations, and technology [23]. This will allow helping the business owners, members of the board of directors, senior executives, and IT professionals to manage business demand.

The following sections present the development and implementation of the research path. The related work section describes the antecedents and including related works. The contextualization and methodology section describes research context and methodology used for the IT artifact proposed for IT-DM. The architecture for IT artifact section describes the phases, main activities, and sub-activities. The evaluation of the IT artifact design section describes the evaluation of the responses of the survey concerning with the IT artifact design, and finally we have the conclusions and future works.

2 Related works

Among the most relevant literature we find very little academic research exploring this topic, the little literature existent are conceptual publications useful for IT artifact design and summarized as the following.

Derek Thomason [24] argues that the demand management as the way to achieve profitability to satisfy customer needs at the same time which guarantees service and quality. It consists of four components (creation, communication, supply planning, and order management) which should be carried out at three levels (strategic, tactical, and operational). The demand for IT services is very large; it has been segmented into three broad categories: strategic demand, tactical demand, and operational demand [11]. Susan Cramm [14] said that the demand management is defined as a process to which it is assigned limited capital and human resources necessary for the overall benefit of the business, and allows improving the relationship between IT and business. On the other hand, a proposed method for the strategic alignment [25], taking into accounts a classification of four types of demand: support, factory, delivery, and strategic. John Kamauff [26] argues that the demand management as the science and art of understanding, coordination and control of all sources of demand so that operations can efficiently deliver products or services in time to satisfy the customer needs. IT-DM is a process for management of the requests made by customers, this process is one of the elements of the impact on the Corporate Governance of IT, in fact, is an excellent starting point for the implementation of the strategies of government [27]. However, Christine Legner [28] in her research aims at developing a design theory for an end-to end demand management process. It is based on an extensive Action Design Research study (ADR) involving experts from 13 companies, her main contribution is a set of seven principles that guide the effective design of IT-DM. Joao Pombinho [29] said that the role of IT-DM is instrumental in addressing this issue due to its unique positioning between business and IT. He advocates that the classical Business/IT alignment should primarily be reformulated as a more general Business/Business alignment.

Our previous exploratory study in 2013 in different companies in the world to determine the status of the IT-SDM [30], involved to 130 respondents distributed as follows: IT professionals had a share of 28%, business owners a share of 14%, chief operating officers (COOs) a share of 13%, chief executive officers (CEOs) and chief information officers (CIOs) a share of 11% each, and board members they share of 8 %. The obtained results show that the respondents doesn´t know the use of standards, methodologies, and tools; this confirms the existing gap in the use of standards for IT management, as indicated other studies that many standardization efforts fail suffering from low acceptance rates among staff and rather superficial use [31], [32].

On the other hand, the respondents considered that the development of a methodology and other tools for IT-DM would be very useful for senior executives and IT professionals within the organizations [30].

3 Contextualization and Methodology

3.1 Research context

The research context is based on the analysis of the existing research literature of SLR and take into an account the results of Case Study of Strategic IT Demand

Management in Organizations [30], which was designed to cover a wide range of different professional organizations from all over the world; we obtained the response of 130 members who participated in an exploratory study for understand the current status of IT-SDM in organizations and understand how business owners, members of the boards of directors, senior executives and IT professionals in different parts of the world manage IT demand at the strategic level; among the members that participated they were members of the board of directors, senior executives, business owners and IT professionals.

We design the IT artifact that we called it the "Framework for the Entire Process of IT Demand Management", which was sent jointly with a survey at the professionals which took part in the study exploratory for considerations and evaluation of the proposed IT artifact design. On the survey realized, we obtained the responses of 42 respondents distributed as well as it is indicated: CIOs and IT professionals 21% each, CEOs 14 %, business owners 10 %, CFOs and COOs 7 % each, CXOs 5 %, and other 14 %. The results and conclusions of the survey are shown in the sections 5 and 6.

3.2 Research methodology used to develop IT artifact

Our proposal will seek to develop and the evaluation of the IT artifact design, we employ the Design Science Research (DSR) [19], [20] and Action Design Research (ADR) paradigms that is fundamental to IT/IS discipline, and others different research techniques. First, was conducted the SLR related with IT-DM, noting the absence of work related with the research. Second, was realized an exploratory study because this case allows the investigation of a contemporary phenomenon in its real life context within the organizations [33]. Third, we developed an IT artifact taking into account the ADR based on the ensemble view of IT artifacts that involves the interaction of design efforts and contextual factors throughout the design process [34]. Moreover, in design also was utilized the knowledge base obtained by SLR and exploratory study [30]. Fourth, our research interest goes beyond the construction of a framework and an idea of what needs to be designed in the DSR component of research artifacts with a determined purpose [20].

Therefore, we conducted a survey for evaluating the framework design for IT-DM, and fifth, we employ ADR, which is a research method for generating prescriptive design knowledge through building and evaluating ensemble IT artifacts in an organizational context [35], [36].

4 Architecture for the IT Artifact

Based on the IS research framework [20], and the CRISP-DM methodology [37]; we design an IT artifact using some references found in the knowledge base, the proposed framework have a high degree of abstraction, and considered three hierarchical levels, as well as it's detailed in the schemes of Figure 1 and Figure 2.

It is considered of hierarchical levels because the methodology goes from the generic model to the most specific cases.

The first hierarchical level consists of six phases that having a cyclic sequence, starting with the business plans including IT needs until deployment of the IT infrastructure and business processes. For establishing the phases of the framework, it is necessary to take into account the life cycle process of demand management business, where each main process is considered as a phase as shown in Figure 1.

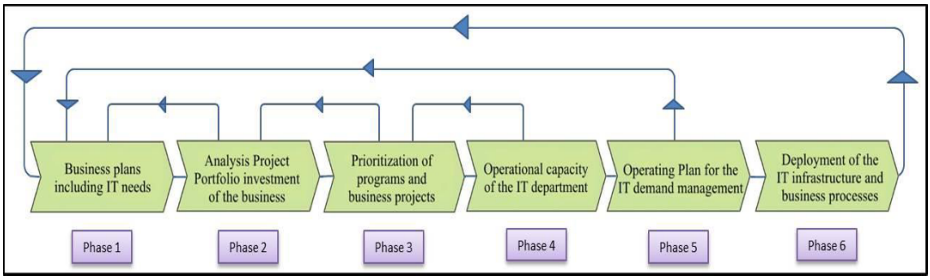


Fig. 1. IT Demand Management Framework.

The second level is composed of main activities that are emerging in hierarchical form of each of the phases of the framework, which extend vertically as shown in Figure 2.

The third level considers the sub-activities that are the projection of each of the main activities, which extend horizontally.

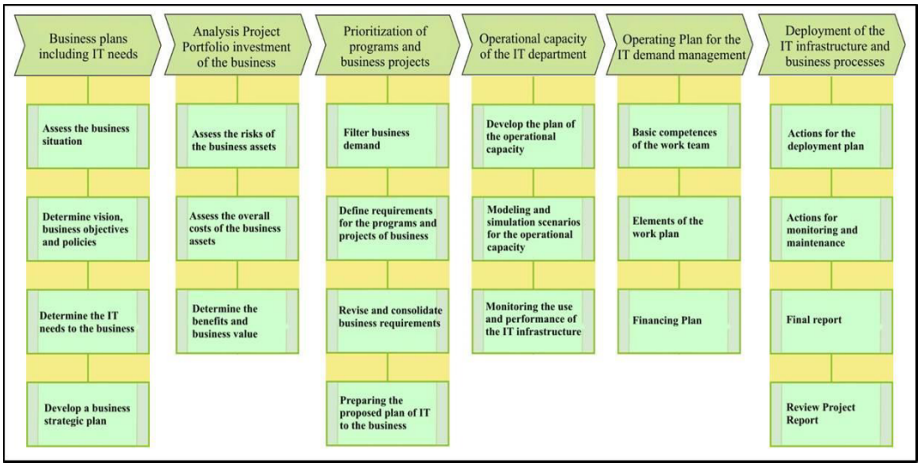


Fig. 2. Phases and main activities.

The following sub-sections are detailed each of the phases of the methodology with its main activities and sub-activities for the proposed framework of the IT-DM.

4.1 Phase 1: Business Plans including IT needs

The understanding of business is a very complex phase and must be understood before starting the project development, during this stage it creates bonds of confidence between business experts and the client, for a better understanding of the structure of the organization, allowing both to establish a common vision of the organization, once understood the business, develop business objectives, vision, policies, taking into account the requirements for the development of the project considering the IT needs to serve as support for business processes [18]. Table 1 shows the main activities and sub-activities of this phase.

Table 1. Phase 1 with its main activities and sub-activities.

Activity 1: Assess the business situation
Sub-activities
1. Make an inventory of resources for each stage of the business.
2. Determine the requirements, assumptions and business constraints.
3. Determine the risks and contingencies for business.
4. Detail the terminology for business.
Activity 2: Determine vision, business objectives and policies
Sub-activities
1. Establish the business vision.
2. Establish the business objectives.
3. Establish business policies.
Activity 3: Determine the IT needs to the business
Sub-activities
1. Determine IT platforms for business.
2. Determine IT resources to business operations.
3. Determine the requirements of hardware/software.
4. Determine the HR requirements of IT.
5. Determine the requirements of material resources.
Activity 4: Develop a business strategic plan
Sub-activities
1. Elaborate the business plan.
2. Initial assessment of the tools and techniques for business.
3. Develop strategies for business.
4. Creation of the portfolio for the business needs.

4.2 Phase 2: Analysis of portfolio investments in business projects

The business portfolio [38] of projects plays an important role, because the business demand is classified according to certain characteristics established. To implement a business it is very important to perform risk assessments of all business assets and assessment of the overall costs, benefits and IT value that provides to the business. Table 2 shows the main activities and sub-activities of this phase.

Table 2. Phase 2 with its main activities and sub-activities.

Activity 1: Assess the risks of the business assets
Sub-activities
1. Determine the risk of different resources for each selected scenario.
2. Determine the total risk of the portfolio of business projects.
Activity 2: Assess the overall costs of the business assets
Sub-activities
1. Calculate the costs of resources for each scenario of the business.
Activity 3: Determine the benefits and business value
Sub-activities
1. Determine the ROI of business.
2. Determining the value of IT to the business.

4.3 Phase 3: Prioritization of programs and projects of the business

The process of prioritization of programs and projects of the business is a key process for effective IT-SDM [39] [40], which is realized in the portfolio management office (PMO) with many projects in general, this also is integrated within project portfolio management Office (PPMO) [41], [42] that through its various roles is a predictor of portfolio success. Table 3 shows the details of this phase.

Table 3. Phase 3 with its main activities and sub-activities.

Activity 1: Filter business demand
Sub-activities
1. Classify demand in IT portfolios.
2. Prioritize demand for execution.
Activity 2: Define requirements for the programs and projects of business
Sub-activities
1. Document the detailed requirements of the programs and projects business.
Activity 3: Revise and consolidate business requirements
Sub-activities
1. Check the requirements of the programs and projects of the business.
2. Document and consolidate the requirements of the programs or business projects.
Activity 4: Preparing the proposed plan of IT to the business
Sub-activities
1. Generate documentation of the proposed plan of IT to the business.
2. Approval of the IT plan for business.
3. Prepare work instructions for the next stage.

4.4 Phase 4: Operational Capacity of the IT Department

The operational capacity of the IT department [41], makes available to customers, users and of the own IT department the resources: technological, human, material and others to perform the tasks in an efficient manner without incurring additional and unnecessary costs, avoiding degradation of quality of service; considering the current

and future state of technology, to forecast future capacity needed, analyze the performance of the infrastructure to monitor the use of existing capacity, models and perform simulations for different capacity predictable future scenarios; this will allow adequately dimensioned services and applications; aligning business processes and the actual needs of clients and manage demand for computing services by rationalizing their use. Table 4 shows the details of this phase.

Table 4. Phase 4 with its main activities and sub-activities.

Activity 1: Develop the plan of the operational capacity
Sub-activities
1. Determine the infrastructure TI department.
2. Determine the technology and tools to use.
3. Determine the specialized HR.
4. Determine material resources.
Activity 2: Modeling and simulation scenarios for the operational capacity
Sub-activities
1. Determine the model scenario of the IT infrastructure.
2. Determine the model for the business process.
3. Perform simulation models in the scenario of the IT infrastructure.
Activity 3: Monitoring the use and performance of the IT infrastructure
Sub-activities
1. Prepare the plan for permanent monitoring and supervision of the IT infrastructure.
2. Prepare the plan for permanent monitoring and supervision of business processes.

4.5 Phase 5: Operational Plan for the IT Strategic Demand Management

The operational plan for IT-DM describes the detailed activities of the members that participate in the IT-DM process [17] to be held during the fiscal year plan; this turn can be divided into quarters or semesters. Table 5 shows the main activities and sub-activities of this phase.

Table 5. Phase 5 with its main activities and sub-activities.

Activity 1: Basic competences of the work team
Sub-activities
1. Determine the functions of members of teams.
2. Establish roles and responsibilities of each member in a position within the team.
Activity 2: Elements of the work plan
Sub-activities
1. Make schedules for projects to develop.
2. Make the for resource allocation plan.
3. Prepare the annual budget.
Activity 3: Financing Plan
Sub-activities
1. Make the analysis of the cash flow for the needs.
2. Determine the most important milestones.
3. Identify sources of capital.

4.6 Phase 6: Deployment of IT Infrastructure and Business Process

The deployment phase is the implementation of IT projects of business [42] after the model has been built and validated the acquired knowledge is transformed into action within the business process. The deployment comprises the implementation of programs/projects to be executed in the scenario of the infrastructure under the monitoring and continuous monitoring of critical business processes.

Generally an IT project does not end with the implementation of the model that should be documented and present the results understandable to the user, with the purpose of achieve an increase of knowledge. Likewise, you must ensure the maintenance of the application and the possible dissemination of the results. Table 6 shows the main activities and sub-activities of this phase.

Table 6. Phase 6 with its main activities and sub-activities.

Activity 1: Actions for the deployment plan
Sub-activities
1. Detail the phases of the deployment plan of the technological infrastructure.
2. Detail the phases of deployment for business processes.
Activity 2: Actions for monitoring and maintenance
Sub-activities
1. Determine the plan for continuous monitoring and supervision.
2. Determine the plans of preventive and corrective maintenance.
Activity 3: Final report
Sub-activities
1. Develop a model for the annual report.
2. Presentation of the annual final report.
Activity 4: Review Project Report
Sub-activities
1. Make a summary of lessons learned.
2. Make the documentation and dissemination.

5 Evaluation of the IT artifact design

For evaluation of the framework design for IT-DM have taken part forty two respondents, the greater part were the same respondents who have taken part in the previous exploratory study in 2013.

On survey for the evaluation of the IT artifact highlight the responses to two questions realized of multi-response listed below.

Q1. How do you evaluate the proposed framework´s structural design, in phases, main activities, and sub-activities?

Figure 3, shows the results of the evaluation and the table of the technical analysis summarizes the details of the survey.

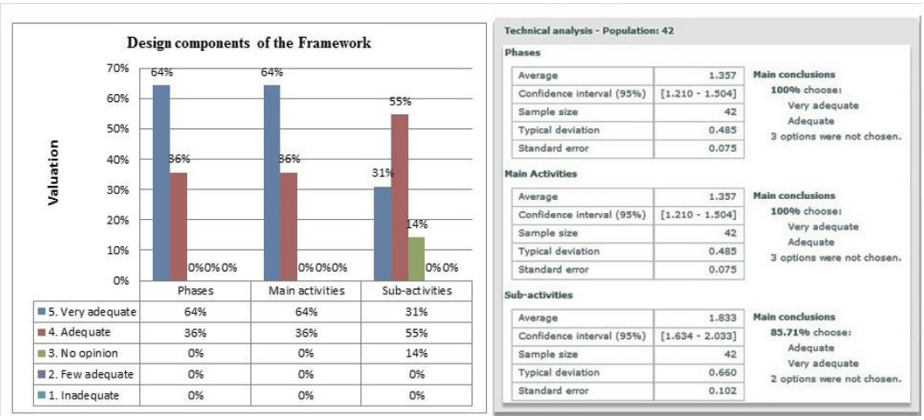


Fig. 3: Evaluation of framework structure for IT-DM.

The most important details are shown below:

- The evaluation of the phases and main activities, the respondents indicated the value of (5. Very adequate) that represents 64%, and with a value (4. Adequate) that represents 36%.
- The evaluation of the sub-activities, the respondents indicated with the value (4. Adequate) that represents 55%, with a value (5. Very adequate) that represents 31%, and on the other hand, with a value (3. No opinion) that represents 14%.

Q2. In what measure do you agree that the investments made by the company to improve the IT-DM processes and appropriate use of the proposed framework will improve the best practices of Corporate Governance of IT, will improve business processes and, increase profitability of the business in your organization?

Figure 4, shows the results of the evaluation; the table of the technical analysis summarizes the details of the survey.

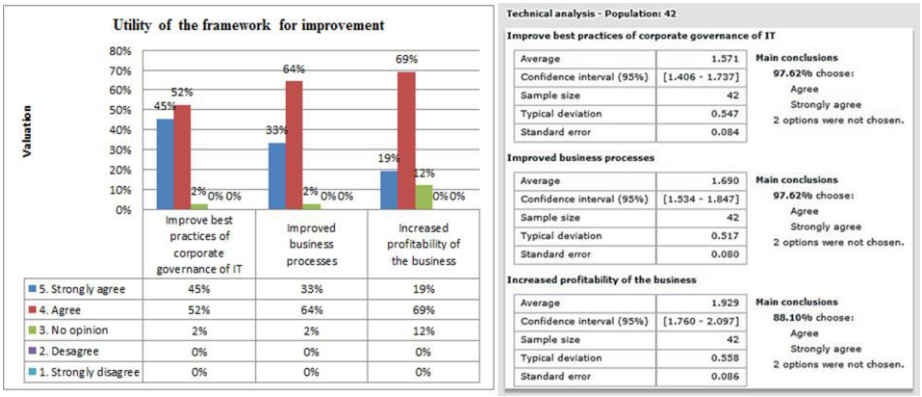


Fig. 4: The utility of the framework for realizing improvements.

The most important details are shown below:

- The respondents think that the framework is useful for improves best practices of Corporate Governance of IT, they indicated the value of (4. Agree) that represent 52%, and with a value (5. Strongly agree) that represent 45%.
- The respondents think that the framework is useful for improve business processes; they indicated the value of (4. Agree) that represents 64%, and with a value (5. Strongly agree) that represents 33%.
- However, the respondents think that the framework is useful for increased profitability of the business; they indicated the value of (4. Agree) that represents 69%, and with a value (5. Strongly agree) that represents 19%.

6 Conclusions and future works

The conclusions can be summarized as the following:

- The framework design will help at senior executives and IT Professionals to know and understand the entire of IT-DM process from a strategic viewpoint for the best management in organizations.
- The evaluation of the framework design that considers phases, main activities, and sub-activities has had a favorable opinion by the respondents. It is necessary to take an account that this can be adapted according at the type and size of each organization.
- The respondents consider that the investments made by the company to improve the IT demand management processes and making appropriate use of the proposed framework or other standards will contribute to cover the gap existent of the use of standards and methodologies for IT management, allowing to improve the best practices of Corporate Governance of IT, improve business processes and, increase profitability of the business of the organizations.
- IT-DM is considered as one of the processes of great importance for success of business, so you must ensure that the right job will be identified, funded and implemented. When demand management is fully controlled, provides senior executives and IT professionals the information and capabilities to understand IT costs, evaluating potential investments and convert investment permitted by IT towards business results.
- When demand is not properly managed, sometimes can get to offer products that do not correspond to the customer really wants, or paradoxically, products that correspond to what the customer wants, but do not give the expected results, despite the fact that is near enough to build to specifications.
- In the near future, it is necessary to make another case study for receiving feedback to improve the framework. On the other hand, we will continue researching for making other frameworks and methodologies for the IT-DM types.

Acknowledgments

We acknowledge the collaboration of the Innovation Group – GICAC for develop this publication and different organization that have been participated in this study.

References

1. Weill, P., & Ross, J. W. IT governance: How top performers manage IT decision rights for superior results. Harvard Business Press, pp. 6-7. 2004.
2. Alan Calder and Steve Moir, IT Governance: Implementing Frameworks & Standards for the Corporate Governance of IT, IT Governance Publishing, March 2009.
3. A Business Framework for the Governance and Management of Enterprise IT. ISACA. 2012.
4. Organization for Economic Cooperation and Development, Principios para el Gobierno Corporativo. Ministerio de Economia y Hacienda de España. 2004.
5. Symons, C. (2005). IT governance framework. Forrester Research.
6. Board Briefing on IT Governance, 2nd Edition, ISACA. 2003.
7. Wyngaard, R. G., & Hendricks, P. S. (2010). South Africa's King III: Highlighting the need for a separate non-profit governance code. Int'l J. Civ. Soc'y L., 8, 176.
8. ISO/IEC 38500:2008, Corporate Governance of Information Technology, International Standard, First edition 2008-06-01.
9. ISO/IEC 38500:2015, Information technology - Governance of IT for the organization, International Standard, Secondt edition 2015-02-15. 21.
10. Michael Gentle. IT Success: Towards a New Model for Information Technology. Published by John Wiley & Sons. ISBN 978-0-470-72401-9, October 2007.
11. Cray Symons, Bobby Cameron, Laurie M. Orlov, Lauren Sessions. How IT Must Shape And Manage Demand. Best Practices. June 15, 2006.
12. Aguilar Alonso, I., Carrillo Verdún, J. D., & Tovar Caro, E. (2008). Importancia de la gestión del proceso de la demanda de TI. Revista de Procesos y Metricas, RPM, 5(2), 25-34.
13. Alonso, I. A., Verdún, J. C., & Caro, E. T. (2010). Information technology to help drive business innovation and growth. In Innovations in Computing Sciences and Software Engineering (pp. 527-532). Springer Netherlands.
14. Susan Cramm, Executive Coach, Maturing Your Demand Management Practices,Valudance, 2007.
15. Aguilar Alonso, Igor. Estructuras, Procesos, Indicadores para Gestionar el Proceso de la Demanda Estratégica en las TI. Diss. Informatica, 2013.
16. IT Governance Institute, An Execitive View of IT Governance. 2009.
17. Alonso, I. A., Verdún, J. C., & Caro, E. T. (2009, November). IT, Senior Executives and Board of Directors Contribute to the Success of the Business: Implicates on the IT Demand Process--Life Cycle. In Computer Sciences and Convergence Information Technology, 2009. ICCIT'09. Fourth International Conference on (pp. 149-156). IEEE.
18. Alonso, I. A., Verdún, J. C., & Caro, E. T. (2008, December). The importance of IT strategic demand management in achieving the objectives of the strategic business planning. In Computer Science and Software Engineering, 2008 International Conference on (Vol. 2, pp. 235-238). IEEE.
19. Gregor, S., & Hevner, A. R. (2013). Positioning and presenting design science research for maximum impact. MIS quarterly, 37(2), 337-356.
20. Von Alan, R. H., March, S. T., Park, J., & Ram, S. (2004). Design science in information systems research. MIS quarterly, 28(1), 75-105.

21. Drechsler, A., & Dörr, P. (2014). What kinds of artifacts are we designing? An analysis of artifact types and artifact relevance in IS journal publications. In Advancing the impact of design science: Moving from theory to practice (pp. 329-336). Springer International Publishing.
22. Drechsler, A. (2015). Designing to Inform: Toward Conceptualizing Practitioner Audiences for Socio-technical Artifacts in Design Science Research in the Information Systems Discipline. Informing Science: the International Journal of an Emerging Transdiscipline, 18.
23. Davis, G. B., and Olson, M. H. Management Information Systems: Conceptual Foundations, Structure and Development (2nd ed.), McGraw-Hill, New York, 1985.
24. Thomason, D. IT and demand chain management. Volume: 83 , Issue: 3. IET Journals & Magazines. 2004.
25. Xiang, Yiming, Xiaobo Wu, and Baoliang Hu. "Strategic Alignment Methods Based on Demands Classification of Information Technology." Advanced Management of Information for Globalized Enterprises, 2008. AMIGE 2008. IEEE Symposium on. IEEE, 2008.
26. Kamauff, John W. Manager's Guide to Operations Management. McGraw-Hill, 2010.
27. IT Demand Management for the Real World. Mercury Business Technology Optimization. 2006.
28. Legner, Christine, and Jan Löhe. "Improving the Realization of IT Demands: A Design Theory for End-to-End Demand Management." 2012.
29. Pombinho, João, David Aveiro, and José Tribolet. "The Role of Value-Oriented IT Demand Management on Business/IT Alignment: The Case of ZON Multimedia." Practice-Driven Research on Enterprise Transformation. Springer Berlin Heidelberg, 2013. 46-60.
30. Alonso, I. A., Verdún, J. C., & Caro, E. T. (2013). Case Study of Strategic IT Demand Management in Organizations–Exploratory Results. Procedia Technology, 9, 900-909.
31. Mueller, T., Dittes, S., Ahlemann, F., Urbach, N., & Smolnik, S. (2015, January). Because Everybody is Different: Towards Understanding the Acceptance of Organizational IT Standards. In System Sciences (HICSS), 2015 48th Hawaii International Conference on (pp. 4050-4058). IEEE.
32. Russo, N. L., Hightower, R., & Pearson, J. M. (1996, September). The failure of methodologies to meet the needs of current development environments. In Proceedings of the British Computer Society's Annual Conference on Information System Methodologies (pp. 387-393).
33. Yin, R. K. , Case Study Research : Design and Methods (4th ed.). Thousand Oaks, California: Sage Publications. 2009.
34. Meum, T. T. An Action Design Research Approach to Developing Emergency Management Systems. 2014.
35. Sein, M., Henfridsson, O., Purao, S., Rossi, M., & Lindgren, R. (2011). Action design research.
36. Helfert, M., & Ostrowski, L. (2012). Design Science Evaluation–Example of Experimental Design. Journal of Emerging Trends in Computing and Information Sciences, 3(9), 253-262.
37. Chapman P., (NCR), Clinton J., (SPSS) Kerber R., (NCR), Khabaza T. (SPSS), Reinartz T. (DaimlerChrysler), Shearer C. (SPSS), and Wirth R. (DaimlerChrysler), "CRISP-DM 1.0 step-by-step data mining guide", Thechnical report, 2000.
38. Bruneel, J., Ratinho, T., Clarysse, B., & Groen, A. (2012). The Evolution of Business Incubators: Comparing demand and supply of business incubation services across different incubator generations. Technovation, 32(2), 110-121.
39. Alonso, I. A., Verdún, J. C., & Caro, E. T. (2010). Project Prioritization as a Key Element in IT Strategic Demand Management. In Innovations and Advances in Computer Sciences and Engineering (pp. 417-422). Springer Netherlands.
40. Costantino, F., Di Gravio, G., & Nonino, F. (2015). Project selection in project portfolio management: An artificial neural network model based on critical success factors. International Journal of Project Management.
41. Unger, B. N., Gemünden, H. G., & Aubry, M. (2012). The three roles of a project portfolio management office: Their impact on portfolio management execution and success. International Journal of Project Management, 30(5), 608-620.
42. Tsaturyan, T., & Müller, R. (2015). Integration and governance of multiple project management offices (PMOs) at large organizations. International Journal of Project Management, 33(5), 1098-1110.
43. Maia, D., Santos, R., & Lopes, R. Business-Driven Long-term Capacity Planning for SaaS Applications. IEEE Transactions on Cloud Computing, (1), 1-1(2015).
44. Dahiya, D., & Mathew, S. K. (2015, January). Impact of ICT Infrastructure Capability on E-Governance Performance: Proposing an Analytical Framework. In Emerging ICT for Bridging the Future-Proceedings of the 49th Annual Convention of the Computer Society of India (CSI) Volume 1 (pp. 603-610). Springer International Publishing.

Open Source vs Proprietary Project Management Tools

Veronika Abramova[1], Francisco Pires[2] and Jorge Bernardino[1,3]
[1] ISEC – Superior Institute of Engineering of Coimbra
Polytechnic of Coimbra, 3030-190 Coimbra, Portugal
[2] Bettertech – Business Software
3000-116 Coimbra, Portugal
[2] CISUC – Centre of Informatics and Systems of the University of Coimbra
3030-290 Coimbra, Portugal
a21190319@alunos.isec.pt, flpires@gmail.com, jorge@isec.pt

Abstract. The dimensional growth and increasing difficulty in project management promoted the development of different tools that serve to facilitate project management and track project schedule, resources and overall progress. These tools offer a variety of features, from task and time management, up to integrated CRM (Customer Relationship Management) and ERP (Enterprise Resource Planning) modules. Currently, a large number of project management software is available, to assist project team during the entire project lifecycle. We present the main differences between open source and proprietary project management tools, describing the key features and how those can assist the project manager and the development team. In this paper, we analyse three open-source project management tools: OpenProject, ProjectLibre, Redmine, and three proprietary tools: Bitrix24, JIRA, and Microsoft Project.

Keywords: Open Source Software (OSS), Project management, PMBOK

1 Introduction

Project Management consists of a set of tasks and processes that are focused on creating a product or providing a service. The PMBOK Guide defines a project as a temporary group activity that produces a unique product, service or result. In this context project management is: the application of knowledge, skills and techniques to execute projects effectively and efficiently [1]. Project Management refers to the planning, monitoring and controlling of all aspects of a project, with the people involved in the project aiming to achieve the objectives on time and on budget to a specific quality standard. One of the earliest perspectives defines tools and techniques applied to diverse resources in order to accomplishment a unique, complex, one-time task within time, cost and quality constraints [2]. Today, there is a large amount of available project management tools that try to improve project management by organizing all the necessary information. Not only there are available proprietary solutions, but also a large number of open source tools [3].

Open source software (OSS) has generated much excitement in the software market. There are different solutions that try to satisfy user requirements and provide

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_31

better functionalities [4, 5, 6]. Those tools have been widely used for long time and are continued being developed and improved to be able to compete with proprietary solutions. In this paper, we get a closer look at the project management tools while considering open source as well as proprietary software. For functionalities description and comparison, we choose open source tools: OpenProject, ProjectLibre, and Redmine, while proprietary tools chosen are: Bitrix24, JIRA, and Microsoft Project. This choice was supported on our research and tools popularity based on the number of posts and publications that mention that software.

The remainder of this paper is organized as follows: section 2 discusses open source alternative tools, describing them and presenting a feature's comparison table. Section 3 describes proprietary solutions and also compares their features. Finally, section 4 presents the conclusions and future work.

2 Open Source Tools

There is a variety of project management alternatives that provide a large amount of useful features during project development, starting from time and task tracking (scheduling) and up to cost and resource management. While considering available open source alternatives, it is important to notice that there are a vast number of tools that provide similar features and are able to compete with proprietary software [7]. In this section we describe three of the most popular available open source tools: OpenProject, ProjectLibre, and Redmine.

2.1 OpenProject

OpenProject is an open-source project management software tool that allows defining project tasks associated to an order list and allocates the resources (people, materials, machines) that are used in each task and their costs. There is also a possibility to view Gantt charts, PERT (Program Evaluation and Review Technique) diagrams for management of project tasks, WBS, RBS and cost charts. The WBS can be viewed within the application, which allows issuing reports, evaluating the histogram and progress reports. Differently from some of the open source alternatives, OpenProject includes human resource management that allows better task management as well as team management. Another possibility that this tool provides is financial resource management and cost tracking. It is possible to keep track of all the effort spent and analyze the costs by filtering available data. It is possible to view the cost and time spent as well as and the remaining budget with a breakdown per work package. Figure 1 shows a basic OpenProject scheduling that allows project task and time tracking.

It is important to notice that the main focus of this application is agile development, where a project can be easily distributed into tasks and there is a possibility of managing User Stories and resources allocated to them. In terms of compatibility with other available software, OpenProject is able to open native Microsoft Project files and contains similar features [18]. Some of the available features are: Overview one or multiple projects; Create schedule (timeline); Manage

requirements in the product backlog; Create user stories and tasks from the backlog view; Book time or units spent on tasks directly to work packages; Keep track of how much effort the project activities require; Monitor the sprint effort using burn down charts.

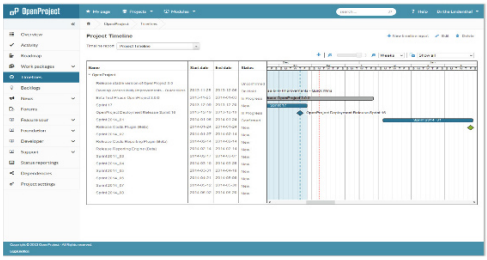


Figure 1. OpenProject Timeline (Source: https://community.openproject.org/news/41-new-design-for-openproject)

Consider that unlike most of the available project management tools, OpenProject is only available for Linux. However, one of the main aims of OpenProject is establishing active community that would help this tool improve ever more. Therefore, at the end of 2013, was created OpenProject Foundation (OPF), inspired by Ubuntu Foundation and Apache Software Foundation. The main goal of this foundation is to constantly improve OpenProject and ensure overall product quality.

2.2 ProjectLibre

ProjectLibre is open source project management software that provides management assistance during a project development. It was released in 2012 as multiplatform software developed in Java by Marc O'Brien and Laurent Chretienneau, under the company Projity, as a branch of already existent project management software – OpenProj. The development of OpenProj was discontinued and developers used this available tool as a base and added some new features and improvements. This tool is known as open source alternative for Microsoft Project [12, 13, 14]. Some of the available features are: Microsoft Project 2010 compatibility; Ribbon user interface; Earned value costing; Gantt and PERT charts; Resource breakdown structure (RBS) chart; and Work breakdown structure (WBS) chart.

ProjectLibre is a system that is mainly focused on longer phases and iterations, providing an overview of overall WBS and RBS during project lifecycle. In terms of installation, ProjectLibre can be easily installed on local system using MSI – engine used to install software on Windows. That means that a project is represented by a file that is stored in a disk system and may be saved and posteriorly loaded. This differs from most of project management tools that attempt to provide on-line collaborative environment that can be accessed and used from anywhere.

As presented on Figure 2, ProjectLibre has a Ribbon styled navigation menu, which is very similar to MS Software style. This GUI makes this tool more user-friendly while trying to compete with MS Open Project.

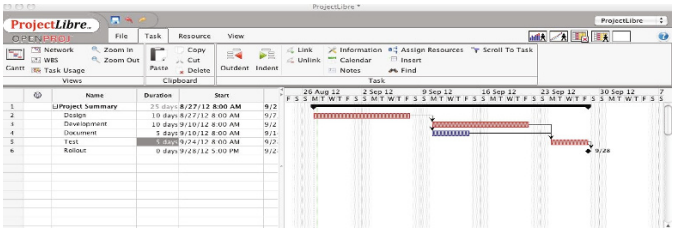


Figure 2. ProjectLibre Gantt Chart (Source: http://sourceforge.net/projects/projectlibre/)

2.3 Redmine

This open source project management tool was firstly released in 2006 while being developed in Ruby on Rails by JP Lang [8]. One of the advantages of this tool using Ruby is the use of "gems" which is an easy way of distributing and installing software. Redmine includes calendar and Gantt charts to aid visual representation of projects and their deadlines. It also features multi-project support, role based access control, a per-project wiki, and project forums. Some of the features provided by Redmine are, as follows [10]: Multiple projects support; Budgeting; Issue tracking system; Gantt chart and calendar; News, documents & files management; Feeds & email notifications; Per project wiki and forums; and Time tracking.

While being a popular tool, there is a variety of plugins that can be added to Redmine to somehow enhance it. This enhancement may be the installation process or management and visual customization to fit better accordingly to a specific company [10, 11]. Differently from most Open Source tools, Redmine has a large amount of plugins that are distributed by developers that are built on top of Redmine and are capable of somehow enhancing its capabilities.

Figures 3a) and 3b) show Redmine user interfaces. However, while Figure 3a) shows basic GUI, Figure 3b) presents a plugin that improves Redmine visual characteristics, making GUI more appellative.

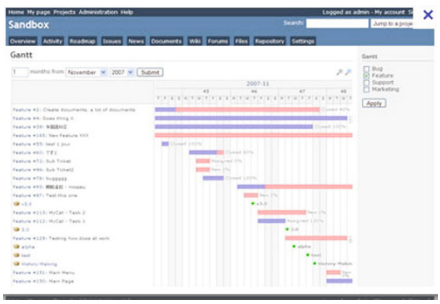


Figure 3. a) Redmine Interface

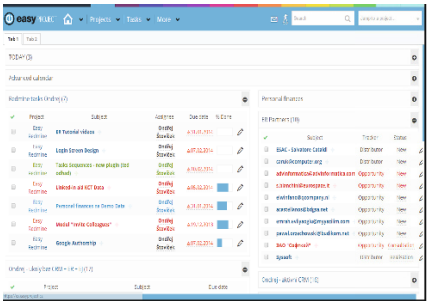


Figure 3. b) Easy Redmine Interface.

2.4 Open Source Features Comparison

In the previous sections we described some of the most popular open source project management alternatives. In Table 1 we present the comparison list of features. This side-by-side comparison will let us understand better which offers more functionalities. Note that we considered some of the main possibilities that are more important during project lifecycle.

Table 1 - Open Source Tools Features

	OpenProject	***ProjectLibre***	***Redmine***
Language	Ruby	Java	Ruby
Multiplatform	Linux Only	Yes	Yes
Web-based	Yes	No	Yes
Issue tracking	Yes	No	Yes
Scheduling	Yes	No	Yes
Resource management	No	Yes	No
Document management	Yes	No	Yes
Reporting	No	No	No
Portfolio Management	Yes	No	Yes
Forum	Yes	No	Yes
Email Support / Integration	Yes	No	Yes
Resource management	No	Yes	No
Repository integration	Yes	No	Yes
Task management	Yes	Yes	Yes
Budget management	Yes	Yes	Yes[1]
Time tracking	Yes	Yes	Yes
CRM	No	No	Yes[1]
Charts	Yes	Yes	Yes
Simulation Scenarios	No	Yes	Yes[1]
Import/Export data	Yes	Yes	Yes

[1] Available using plugin.

After evaluating the results, we concluded that although Redmine is one of the most popular open source alternatives and while it provides all the core features, most of those are additional modules and add-ons that mostly are not open source. That means that while the core system is open source additional features may have to be bought from the providers. When it comes to Open Project, this tool is limited to the

Linux operating system. This may be a limitation for some of the development teams. Overall, ProjectLibre may be the best alternative since this software provides most of the important features. One of the drawbacks is it not being web-based and, as previously stated, differently from other tools, requires local installation and created a project file on the local disk system.

3 Proprietary Tools

In the second part of our evaluation we describe proprietary tools. Similarly to the previous section, that presents open source alternatives, we choose three popular proprietary project management tools: Bitrix24, JIRA, and Microsoft Project. After a brief description we present a feature comparison table that allows an easier comparison of the possibilities of those tools.

3.1 Bitrix24

Bitrix24 is a proprietary project management tool [15]. This is a web-hosted software which means that there is a possibility of using this tool without any installation. However, there is also a possibility of using a self-hosted version that would require an internal configuration, per company. This is one of the most popular proprietary tools for project management. It allows not only scheduling and task management but also to allocate all the necessary resources, those being physical, human or even monetary. Differently from some of the available solutions, when creating a Bitrix24 environment, there is a possibility of internally manage all the company employees as well as clients. It is also possible to recreate organizational chart that would represent existing departments and assign each of employees to their working space.

This tool looks professional and organized but may be complex when logging since all the latest announcements, for example daily/weekly assignments, private messages, forum updates, tasks and groups will pop to notify all the changes that have been made since last login.

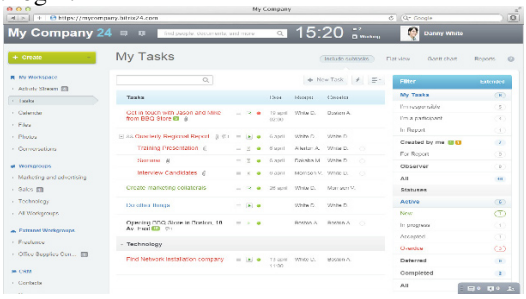


Figure 4. Bitrix24 Interface (Source https://www.getapp.com /)

Figure 4 shows Bitrix24 user interface. Just by its visual aspect we can easily difference this tool from previously described. Some of the main features are [15]:

Task and schedule management; Employee management; CRM; Reporting; Online Document management; and Charts. It is important to consider that staff, client and enterprise management are some of the most important features of this tool. There is a possibility of assigning responsible employees to projects, clients as well as teams. Also, a full client sheet provides all the necessary information that may be useful for the future projects or as evaluation of already completed ones, for example, locations, previous projects, previous responsible, contacts, etc.

3.2 JIRA

JIRA Software is a proprietary issue tracking tool, which is developed and managed by Atlassian [16]. Differently from previously described project management tools, main focus of Jira consists of feature and issue tracking. The name of this software comes from the widely known movie Godzilla. Originally, in Japanese, it is pronounced as "gojira", posteriorly "go" was dropped and JIRA became the software name. This project management tool, similarly to Bitrix24, may be used as either a self-hosted or cloud-hosted. When is chosen self-hosting, this tool supports multiple platforms which may be usefully accordingly to the enterprise architecture. As previously stated, this tool not only allows task management but focuses mainly on issue tracking and agile development. It works well with the agile development methods such as of SCRUM [17]. One of the main characteristics of this tool is a large amount of available features. Although the main focus of JIRA is agile issue tracking, it provides a core set of any project management tool. Some of the available features are: Issue and task tracking; Bug reports; Feature requests; Reporting; and Notifications.

Figure 5 presents JIRA interface. On this figure we can see that any team member can keep track not only of all the tasks, but other team members' tasks and progress. Pie chart acts as additional comparison, providing easy visual understanding of how many issues have been addresses by whom.

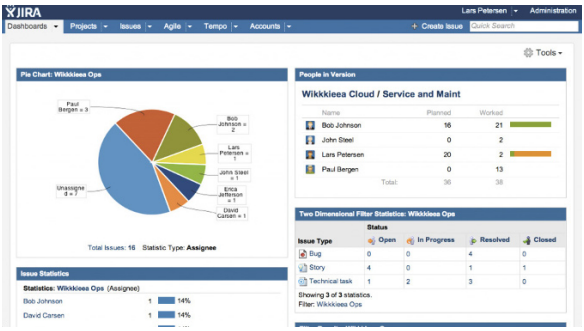


Figure 5. JIRA Dashboard (Source: http://blog.tempo.io/2012/lean-customer-development-delivering-solutions-to-your-customers-on-time-and-on-budget/)

Currently there are a lot of plugins that are added accordingly to the enterprise needs. However, it is important to notice that most of those add-ons are enterprise and

have to be bought from the distributors. That means that core JIRA distribution only provides main features.

3.3 Microsoft Project

Microsoft Project is a management tool with the right blend of usability, power, and flexibility all of which help to manage projects more efficiently and effectively. It allows project managers to stay informed and be able to control project work, schedules, and finances, keeping project teams aligned, and creating more productivity through integration with familiar Microsoft Office system programs [18].

It is a proprietary software tool for project management designed to assist the project managers in developing a plan, assigning resources to tasks, tracking progress, managing a budget, and analyzing workloads. Some of the available features are: Timeline; Integration with another Microsoft Tools; Scheduling and Task management; Reporting; and Task path tracking.

Microsoft Project provides a standard MS Office-like interface and a set of project and time management functionalities. Figure 6 shows a basic MS Project interface. Ribbon menus provide easier usability since these days most of software users are familiar with other MS tools, like Office, that this interface becomes more friendly and easier to understand even if used by an inexperienced user.

One of the important features of this tool is the user management based on the access levels. That means that there are different classes of users that can have differing access levels to projects, views and other project-related data. This type of access restrictions increases project security level and provide a higher control over project tracking.

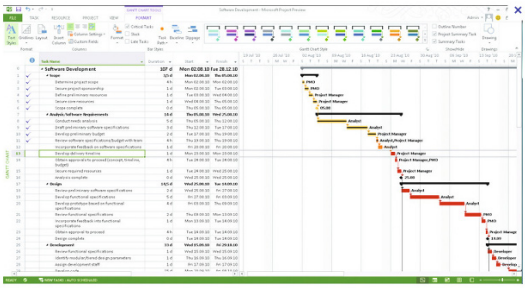


Figure 6. MS Project interface (Source: https://www.getapp.com/project-management-planning-software/a/microsoft-project/)

3.4 Proprietary Features Comparison

In Table 2 we present some of the main features of the three proprietary popular tools: Bitrix24, JIRA, and MS Project. Although all of those tools require payment, we did not consider licensing and pricing on this comparison. Our main goal is present their features in a most comparable way to features available in open source tools.

Table 2 - Proprietary Tools Features

	Bitrix24	***JIRA***	***MS Project***
Development Language	PhP	Java	.NET
Multiplatform	Yes	Yes	No
Web-based	Yes	Yes	No
Issue tracking	No	Yes	No
Scheduling	Yes	No	Yes
Document management	Yes	No	No
Reporting	Yes	Yes	Yes
Portfolio Management	No	No	No
Monitoring	Yes	Yes[1]	Yes
Forum / Wiki	Yes	Yes[1]	No
Email Support / Integration	Yes	Yes[1]	Yes
Resource management	Yes	Yes[1]	Yes
Repository integration	Yes	Yes[1]	Yes
Task management	Yes	Yes	Yes
Budget management	No	Yes[1]	Yes
Time tracking	Yes	Yes	Yes
CRM	Yes	Yes[1]	Yes[1]
Simulation Scenarios	No	Yes	Yes
Import/Export data	Yes	Yes	Yes
Custom Integrations	No	Yes	Yes
API	Yes	Yes	Yes
SSL Security	Yes	Yes	Yes
Mobile Version	Yes	Yes	Yes

[1] Available using plugin.

Accordingly to Table 2, JIRA may be compared to Redmine, where there is a core package with the main functionalities and additional features are add-ons. Bitrix24 is the tool that provides more options to its users and since it is web-based it does not require any installation. Finally, Microsoft Project, as previously stated, is known as proprietary version of open-source ProjectLibre and, therefore, it not only has similar available features but same type of local install since both of those tools are not web-based.

4 Conclusions and future work

In the previous sections we described some of the most popular open source and proprietary tools while considering some of the main available features. We described three open-source project management tools: OpenProject, ProjectLibre, Redmine and three proprietary tools: Bitrix24, JIRA, and MS Project. While comparing available features, we concluded that proprietary and open source do not differ much. We believe that open source tools are capable, to some level, to keep up with proprietary tools and offer some of the basic necessary functionalities. However, after comparing some of those tools it terms of use, we defend that proprietary tools offer a more user friendly and intuitive interface.

As future work we intend to install and evaluate these tools by comparing user interface and overall ease of use of those alternatives in an enterprise, and understand the applicability and maturity level of project management tools in support of Projects for Big Data, Cloud, Mobile, Social Networking and Industrial Internet of Things (IIoT) environments.

References

1. A Guide to the Project Management Body of Knowledge (PMBOK® Guide)—Fifth Edition, Project Management Institute, Inc.
2. Oliveira, J., Tereso, A., Machado, J.R. “An Application to Select Collaborative Project Management Software Tools”. WorldCIST 2014: 467-476 (2014).
3. Ferreira, M., Tereso, A. “Software Tools for Project Management - Focus on Collaborative Management”. WorldCIST 2014: 73-84. (2014)
4. Bernardino, J., “Open Business Intelligence for Better Decision-Making” International Journal of Information Communication Technologies and Human Development (IJICTHD), Volume 5, Issue 2, pp. 20-36 (2013).
5. Tereso, M., Bernardino J., “Open Source CRM Systems for SMEs” International Journal of Managing Information Technology (IJMIT) November 2011, Vol. 3, N. 4, pp. 41-56.
6. Sampaio, D., Bernardino J., “Open Source Accounting Software for SMEs”, in press International Journal of Business Information Systems, 2015
7. Daniel G.R. Andersson. “Comparing Open Source and Proprietary Enterprise Content Management Systems”. IT University of Göteborg Göteborg, (2008).
8. Hartl, M. Ruby on Rails Tutorial, 2nd Edition. Published by Addison-Wesley. (2012)
9. http://project-management.com/redmine-software-review/. Retrieved on 24.06.2015.
10. https://www.redmine.org/plugins. Retrieved on 24.06.2015.
11. http://www.redmine.org/projects/redmine/wiki. Retrieved on 24.06.2015.
12. http://www.techrepublic.com/blog/it-consultant/take-your-project-management-application-open-source-with-projectlibre/. Retrieved on 24.06.2015.
13. http://opensource.com/business/13/5/projectlibre-microsoft-project. Retriv. on 24.06.2015.
14. http://www.projectmanagement.com/tools/275877/ProjectLibre-open-source-replacement-of-MS-Project. Retrieved on 24.06.2015.
15. https://www.bitrix24.com/
16. https://www.atlassian.com/
17. Mishra, A. and Mishra, D. “Software Project Management Tools: A Brief Comparative View”. ACM SIGSOFT Software Engineering Notes,Volume 38 Number 3. (2013).
18. Carter, E. and Lippert, E. “Visual Studio Tools for Office: Using C# with Excel, Word, Outlook, and InfoPath”. (2006).

Dimensioning Virtual Organizations based on Risk Levels

Jonathan Emannoel Ferreira[1], Adriano Fiorese[1],

Department of Computer Science (DCC)
Santa Catarina State University (UDESC)
89219-710 Joinville, SC, Brazil
j_jef_hilux@hotmail.com, adriano.fiorese@udesc.br

Abstract. In an increasingly competitive market, small and medium enterprises have the option to take advantage of collaboration opportunities to consort their core competencies to achieve an objective. In fact, this is the purpose of the so-called Virtual Organizations (OVs), which aim to attend a goal joining partner forces. However, when these Virtual Organizations are created, it is necessary to deal with the maximum number of participants involved in the process and the risk involved in these relationships, which should be measured through a well-defined process. This paper aims to present an approach to dimensioning the number of participants involved in the formation of a Virtual Organization composed of several service providers (SPs). This approach is based on the overall risk level of the participants and uses different Risk Analysis Methods to assess the suited number of participants to be part of a Virtual Organization.

Keywords: Virtual Organization, Dimensioning, Risk Analysis

1 Introduction

Recent years have witnessed the explosion of the use of computers in daily life and business. Information Technology and Communication (ICT) began to stand out in everyday use of organizations, from the development of the interconnection between machines (Internet) to the popularization of mobile devices (tablets and smartphones). The increasing use of technology in business operations allowed the organizations to be assisted in decision-making and how to manage their new products, thus sharpening the competitiveness and expanding trade barriers.

The quest for efficiency and fast responsiveness to market stimuli presents a series of new challenges for enterprises leading to a question: how to attend several demanding customers in such a short time and with a great quality of service? One answer that can be found in the literature is: Virtual Organizations (VOs). A VO consists of a set of independent organizations (companies) that share resources, skills, costs, risks and information, where each member collaborates in a certain function in order to achieve a mutual goal [4, 6].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_32

The VOs have many advantages ranging from adaptability and flexibility to the ability to quickly respond to market changes. However, it is not always easy to determine the number of participants to begin the process of collaboration. This task is often performed based on the VO manager's perception and on successive attempts based on trial and error. Therefore, the use of a scientific and well defined approach to dimensioning the number of VO participants supports the VO manager decision regarding the number of competencies and sub-competencies to be managed and it also increases the confidence of partners involved in the VO formation and operation [5, 9].

Thus, this paper addresses the problem of dimensioning the number of VO participants based on their overall risk level. Therefore, this work consists on analysing the VO behavior regarding the involved risks when raising the number of partners involved in its formation.

The remainder of this paper is organized as follows: Section 2 covers the essential concepts for understanding how VO works, as well as understanding their risks and their dimensioning. Section 3 describes how the proposed dimensioning approach is structured. Subsequently, Section 4 describes the scenarios and simulations in order to validate the designed proposal. Finally, Section 5 presents conclusions and future work.

2 Related Work

2.1 Virtual Organizations

As aforementioned, different enterprises, i.e., service providers, can collaborate in order to achieve a particular goal. This paper uses the definition of VO formation according [6], which recommends a series of steps ranging from the identification of the collaboration opportunity to the launching passing through partners search and selection ones.

In the context of this work, the VO dimensioning works as an auxiliary approach to decision making in the partners search and selection step. This is the moment when the VO manager analysis the necessary partners to compose a VO. Thus, the dimensioning process execution instigates the VO manager to check if there really is a need to allocate certain partners, splitting or not the core competency in sub-competencies to attend the same collaboration opportunity (OC).

2.2 Risk Analysis

The word risk is associate to notions of uncertainty. Risk is the chance of something happens causing a negative impact on the objectives on a given task. In the literature it is found some definitions for risk. Bernstein [3] and Alawamleh [1] state that risk is the probability of an adverse event, causing a kind of uncertainty, generated by decision alternatives of an administrator.

Several risk factors threat the alliance operations between partners. These factors can be used to derive risk levels. Particularly, risk levels can be measured

by means of occurrence probability, consequence degree and control degree [12]. According Alawamleh [1] risk comes from three sources: organization internal sources; organization external sources and; organization environment.

Taking this into account, the risk definition in the context of VOs becomes the likelihood of one or more participants do not attend the minimum demanded requisites of the CO and because of that compromising the success of the VO operation. Moreover, it is worth noting that participants depend on each other, raising the probability of fault occurrences. In this sense, using the Alawamleh's definition [1], it is possible to say that the risk in VO can be involved in: 1) Internal risks: reliability and quality of the participants; 2) External risks: cultural, social and operational environment of the participants; 3) Organization environment: network infrastructure or means of interaction of the participants.

Several risk analysis methods have been proposed in literature. Particularly, regarding risk analysis in the context of VO, Vieira et al. and de Lemos et al. [11, 15] present different risk analysis methods based on historical key performance indicators such as confidence, collaboration, information sharing and communication processed by a combination of multi-criteria decision making approaches. Basically, these approaches are applied in the partners search and selection step of the VO creation stream leading to the selection of the least risky partners therefore minimizing the chance of VO failure during its operation.

This risk analysis approach is well suited for the purposes of VO dimensioning. It makes possible to choose the right quantity of partners to compose a VO without raising the global risk to unacceptable levels.

2.3 Dimensioning Overview

According [14], dimensioning should be done whenever the responsible for a particular operation feels the need of checking if his resource sets are correct and well balanced regarding current and future demand. Moreover, it should be prioritized not only at the beginning of a project but also in the optimization of existent structures.

The attention to the client needs fosters enterprises union. The availability of the number of resources and people that have appropriate skills, experiences and competencies at the opportune place and moment becomes an stimuli to the involved organization managers. It is worth noting that the VO composition do not has a limitation on the participants number. However, this flexibility needs to be identified and measured through a well defined process.

The determination of the number of participants for the formation of a VO is not easy and widely explored in the literature. Most publications highlight the advantages of the formation of the VO itself rather than how it is actually done [6, 10]. It is important to note that only a proper structural configuration (e.g., techniques, methods or approaches) can take advantage of all the benefits expected by a VO (e.g., sharing skills, resources, costs, risks, trust and information). Considering that, the number of participants is an essential variable on this context. Therefore, this paper focuses on the process of how to find the best total number of participants in a VO.

Several important contributions are found in literature depicting characteristics that can be used to achieve suitable VO dimensioning. Some of these characteristics [2] are: a) time, which involves delivery time, short or long-term contracts, etc.; b) cost, which involves market performance, profitability, necessary resources, etc.; c) risk in the association with other participants. This work copes with the risk characteristic. Thus, the dimensioning is achieved analysing the VO behavior based on the existent risks between the involved participants.

3 Proposed Dimensioning Approach

As aforementioned, the proposed dimensioning approach is based on the risk assessment of the VO participants. Sections 3.1 and 3.2 present the two risk analysis methods used to accomplish that. These methods work at the set of service providers committed to the VO creation and they assume these service providers keep available a key performance indicators (KPI) historic. According Nelly et al. [13], a KPI is considered a metric or a combination of metrics that aims to quantify the efficiency and/or effectiveness of part or the full process, project, system or product.

Therefore, the partner's risk level is generated by these methods using KPI historical data. Regarding this work, the four risk sources that presented more occurrences in the Alawamleh's work [1] were used as KPIs. These KPIs are: confidence, communication, collaboration and information sharing.

3.1 MARTP

The MARTP method [16] aims to measure how risky is to use a particular SP in the VO composition. MARTP is split in two stages. First stage analyses the individual SP risk and the second stage performs a collective risk analysis involving all selected SPs. MARTP is presented in Fig. 1a.

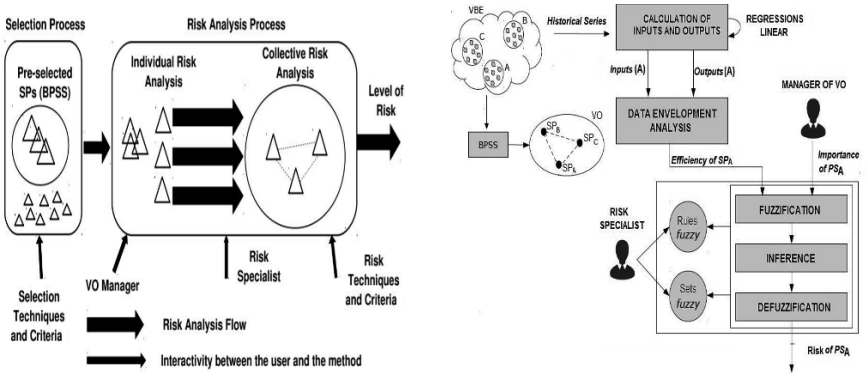
The first stage (left side of Fig. 1a) performs the individual risk analysis using the Event Tree Analysis (ETA) technique [8]. It uses as input the service provider KPI historical data and presents as output a service provider risk level percentage and a logical value 1 or 0 according the SP is under or above a risk limit, respectively. This stage applies an event aggregation approach by multiplying the success and failure events associated with each KPI historical value. The second stage (right side of Fig. 1a) performs the collective risk analysis using the Fault Tree Analysis (FTA) technique [8]. It takes as input the logical values generated on the fist stage and generates as output the information regarding the set of partners that is able to proceed with the VO formation.

3.2 DEA x Fuzzy

The DEA x Fuzzy method [11] presents the same purpose of the MARTP method. However, though both methods aim to measure how risky is to use

a particular SP in the VO composition, DEA x Fuzzy uses different techniques and stages. In any case, the number of stages are the same. DEA x Fuzzy is split in two stages. The first one performs the efficiency analysis for each one of the SPs that aims to be part of the VO. The second one performs the service provider impact analysis on the entire potential VO assuming this SP fails. DEA x Fuzzy method is presented in Fig. 1b.

Thus, on the first stage (top of Fig. 1b) is performed the SP efficiency analysis using the Data Envelopment Analysis (DEA) technique [7]. This stage reveals the compared SP efficiency value by means of successive linear regressions on the KPI historical values. On the other hand, on the second stage (bottom of Fig. 1b) is performed the SP impact analysis on the entire VO using a Fuzzy technique [17].



(a) MARTP Method [16] (b) DEA x Fuzzy Method [11]

Fig. 1. Risk Analysis Methods

3.3 Proposal

This Section addresses necessary parameters and how the proposed dimensioning approach works. Thus, some limitations and assumptions regarding the collaboration opportunity and the partners involved are needed to the overall dimensioning approach understanding.

1. This work assumes the collaboration opportunity can be attended by several different VO sizes. This means that it is possible to test several VO with different number of partners from the minimal necessary of two to the maximum proposed by the VO manager.
2. This work also assumes that service providers being tested in a particular VO were already been selected by a partners selection method.

Fig. 2 shows the architecture of the proposed dimensioning approach.

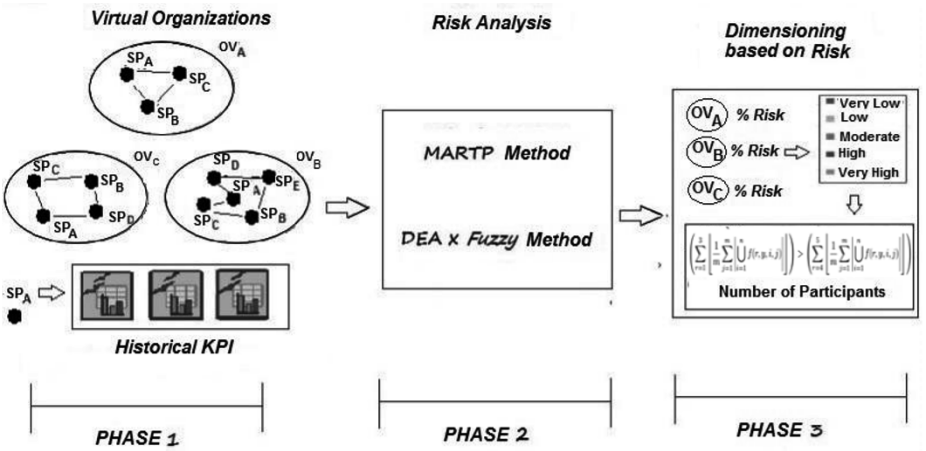


Fig. 2. Dimensioning Approach Overview

Phase 1 (Input) is composed by the input data used: a) Service providers previously selected; b) Key performance indicators (KPIs): confidence, communication, collaboration and information sharing; c) Historical values of KPIs: the set of values, for each KPI, assigned on participations in VOs already executed and finish for each service provider involved.

Phase 2 (Risk Analysis) takes as input data the service providers and their historical KPI values from Phase 1. This phase executes the risk analysis methods MARTP and DEA x Fuzzy, described on Section 3.1 and 3.2, respectively. At this phase the service providers are submitted to each risk analysis method in order to comnpute the risk level of the entire VO.

Phase 3 (Dimensioning based on Risk) takes as input the risk levels of each VO tested, which are obtained in Phase 2. These data are processed and transformed in two results to the VO manager. The first result is an histogram showing the aggregated risk levels for each size of VO. Second result is the maximum number of necessary participants to attend the VO creation.

Thus, according Fig. 3, histogram presents at the x-axis the VO's number of participants and at the y-axis the number of simulated VO. Five columns are presented for each VO size. Each column represents the risk level scale defined and used in the computation of the maximum number of participants. These scales represent from the left to the right, respectively, the following values for risk levels: Very Low: 0 to 20%; Low: 21 to 40%; Moderate: 41 to 60%; High: 61 to 80% and; Very High: 81 to 100%.

In this work, the maximum number of necessary participants to attend the VO creation demand is related to the risk level associated with the different VO sizes. Thus, it depends on the VO manager to define which is the considered acceptable risk levels so that a relationship between this level and the VO size can be established. For the evaluation effects, this work considers as acceptable

the risk level scales from very low to moderated. Therefore, considering this, the VO size is determined by the highest number of participants in VOs, whose averaged cumulative amount of simulations with very low, low and moderate risk levels is greater than the averaged cumulative amount of simulations (for that number of participants) with high and very high risk levels.

The presented concepts can be formalized as follows:

Consider the risk analysis methods, represented by the set $M = \{1, \cdots, m\}$ where each element is associated with a particular risk analysis method used in the dimensioning approach. Also, considers $SP = \{2, \cdots, k\}$ a set where each element represents the number of service providers (enterprises) able to be part of a VO and $OV_y^x = \{v_i, \cdots, v_n\}$ the set whose elements represent the risk level values obtained in n simulations using the risk analysis method $x \in M$ for a VO composed of $y \in SP$ service providers. Finally, lets $R = \{1, 2, 3, 4, 5\}$ the set of risk level scale associate to a risk level percentage: 1 - Very Low: 0 to 20%; 2 - Low: 21 to 40%; 3 - Moderate: 41 to 60%; 4 - High: 61 to 80% and; 5 - Very High: 81 to 100%.

$$\text{Now consider: } f(r, y, i, x) = \begin{cases} v_i \in OV_y^x \wedge 0 \leq v_i \leq 20 \wedge r = 1, \\ v_i \in OV_y^x \wedge 21 \leq v_i \leq 40 \wedge r = 2, \\ v_i \in OV_y^x \wedge 41 \leq v_i \leq 60 \wedge r = 3, \\ v_i \in OV_y^x \wedge 61 \leq v_i \leq 80 \wedge r = 4, \\ v_i \in OV_y^x \wedge 81 \leq v_i \leq 100 \wedge r = 5 \end{cases}$$

the function that returns a value from OV_y^x according the risk interval r. Finally, the VO dimension is formally defined by Eq. 1:

$$Dim = \max \left\{ y \mid y \in PS \wedge \left(\sum_{r=1}^{3} \left\lfloor \frac{1}{m} \sum_{j=1}^{m} \left| \bigcup_{i=1}^{n} f(r, y, i, j) \right| \right\rfloor \right) > \left(\sum_{r=4}^{5} \left\lfloor \frac{1}{m} \sum_{j=1}^{m} \left| \bigcup_{i=1}^{n} f(r, y, i, j) \right| \right\rfloor \right) \right\} \quad (1)$$

Therefore, according the math presented in Eq. 1, the maximum number of service providers for the VO formation is the highest $y \in PS$ value that fits the risk level criterion defined on the dimensioning approach.

4 Evaluation

4.1 Setup

The proposal validation is addressed through simulation. The scenarios taken into account perform a defined minimal number of simulations for each VO size (number of SP). Such definition is based on a 95% confidence interval resulting

in a total of 100 simulations. Each simulation generates a risk level value that will later be organized according the risk intervals very low, low, moderate, high and very high, as already mentioned. It is important to note that for the same VO size 100 simulations are performed for each risk analysis method. In this work, methods MARTP and DEA x Fuzzy are used.

Each service provider receives a dataset with historical KPI data. The historical KPI data corresponds to 10 values for each KPI. They are arbitrarily generated using the uniform statistical distribution in the same way from Viera et al. [15]. These historical KPI values range in a normalized interval of $[0.01, 1.00]$, which means SP had received grades ranging from 1% to 100% in previous VO participations for each KPI.

4.2 Results

This section aims to conduct the analysis of the results obtained through simulations. The simulations involve seven (7) distinct scenarios, wherein each one represents a VO size ranging from the minimal of two to the maximum partners proposed by the VO manager, which in this work is eight, according [15]. In this work, each scenario generates two sets of performed simulations, i.e., one set for each risk analysis method. Fig. 3 and Table 1 present the consolidated simulation results in order to assist the VO manager decision making regarding the VO dimensioning.

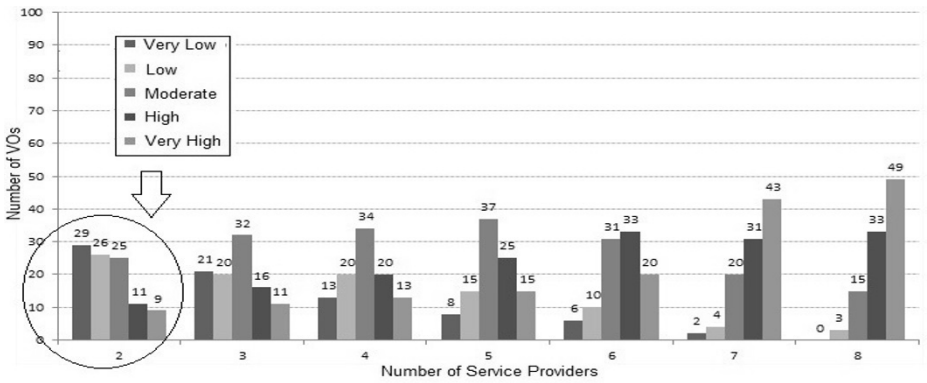


Fig. 3. VO's Risk Levels

According results in Table 1, it is possible to identify four (4) possible VO sizes attending the acceptable risk level criterion defined by the proposed dimensioning approach. These are VOs whose sizes are composed from 2 to 5 service providers. Therefore, according that criterion, the maximum number of participants to compose a VO is five partners.

Also, from the results shown in Fig. 3 may be noted that the greater the number of SPs composing a VO, the more likely increase the VO risk level as a

Table 1. Maximum number of VO participants

VO size	Total	Risk Level	
		Very Low to Moderate	High and Very High
2		80	20
3		73	27
4		67	33
5		60	40
6		47	53
7		26	74
8		18	82

whole. It is also worth noting that most of the evaluated VOs present very low, low and moderate risk levels. However, these values grow up when there is an increase in the number of SPs for each OV, eventually reaching levels of high and very high risk levels.

Having this in mind, it seems that the more SP being analysed the greater the likelihood of these SPs have very different levels of skills leading to a riskier scenario to the VO formation, which justifies the raising in the high and very high risk scale.

5 Conclusion

This paper addressed the VO dimensioning problem taking into account the need to find the maximum number of participants to start the process of VO creation. Reasoning on that, a VO dimensioning approach was proposed aiming to assist the VO manager decision making process of VO creation.

The proposed dimensioning approach assists the VO manager in the competence and sub-competencies management process, i.e., it assists the decision to aggregate more or less participants to a VO, based on the risk involved in this aggregation. In this sense, it may be noted that the proposed dimensioning approach allows careful evaluation of the VO composition regarding the number of participants by assessing the impact of the risk in the VO formation.

Accomplished results show, according the scenarios simulated, the maximum number of participants to a Virtual Organization formation is five (5).

Future work includes testing the dimensioning approach in near-real scenarios. In addition, further work can enhance the proposed approach adding more KPIs (e.g., cost) and new risk analysis methods. Also, the improvement of the proposed risk dimensioning criterion is a good target for further work. Last but not least, a comparison between other dimensioning strategies is planned.

6 References

References

1. Alawamleh: Collaboration Risk Evaluation and Management for Small and Medium Size Enterprises in Virtual Organisations. Ph.D. thesis, Coventry University (2010)
2. Baum, J.A., Calabrese, T., Silverman, B.S.: Don't go it alone: Alliance network composition and startups' performance in canadian biotechnology. Strategic management journal 21(3), 267–294 (2000)
3. Bernstein, P.L.: Against the Gods: The Remarkable Story of Risk. Wiley (Aug 1998)
4. Busi, M., Bititci, U.S.: Collaborative performance management: present gaps and future research. Journal of Productivity and Performance Management 55(1), 7–25 (2006)
5. Camarinha-Matos, L.M., Afsarmanesh, H.: A framework for virtual organization creation in a breeding environment. Annual Reviews in Control 31(1), 119–135 (2007)
6. Camarinha-Matos, L.M., Silveri, I., Afsarmanesh, H., Oliveira, A.I.: Towards a framework for creation of dynamic virtual organizations. In: Collaborative Networks and Their Breeding Environments, pp. 69–80. No. 186 in IFIP Federation for Information Processing, Springer US (2005)
7. Cooper, W.W., Seiford, L.M., Tone, K.: Data Envelopment Analysis: A Comprehensive Text with Models, Applications, References and DEA-Solver Software. Springer, New York, 2nd edn. (Nov 2006)
8. Ericson, C.A., et al.: Hazard analysis techniques for system safety. John Wiley & Sons (2005)
9. Grabowski, M., Roberts, K.H.: Risk mitigation in virtual organizations. Journal of Computer-Mediated Communication 3(4), 0–0 (1998)
10. Kasper-Fuehrer, E.C., Ashkanasy, N.M.: The Interorganizational Virtual Organization : Defining a Weberian Ideal. International Studies of Management & Organization 33(4), 34–64 (2003)
11. de Lemos, F.S.B., Vieira, R.G., Fiorese, A., Junior, O.C.A., Malschitzki, R.P.: A hybrid dea-fuzzy method for risk assessment in virtual organizations. Proceedings of the 11th FLINS Conference on Decision Making and Soft Computing (2014)
12. Li, Y., Liao, X.: Decision support for risk analysis on dynamic alliance. Decision Support Systems 42(4), 2043–2059 (2007)
13. Nelly, A., Gregory, M., Platts, K.: Performance measurement system design. Journal of operations and production management 15(4), 80–116 (1995)
14. Patten, T.H.: Manpower Planning and the Development of Human Resources. John Wiley & Sons Inc, New York (Jun 1971)
15. Vieira, R.G., Correia Alves, O., Fiorese, A.: A multicriteria method for evaluating risks in virtual organizations. In: Industrial Informatics (INDIN), 2014 12th IEEE. pp. 477–482. IEEE (2014)
16. Vieira, R.G., Junior, O.C.A., Fiorese, A.: A risk analysis method for selecting service providers in p2p service overlay networks. In: Proceedings of the 16th Conference on Enterprise Information Systems, Lisbon, Portugal. pp. 200–211 (2014)
17. Zadeh, L.A.: Fuzzy sets. Information and control 8(3), 338–353 (1965)

Analysis of Application Integration and Portals

Leonardo Grandinetti Chaves[1,2] , Rodrigo Baroni de Carvalho[2]
SENAC – MG [1], Puc Minas University[2],
Av. Dom José Gaspar, 500,Minas Gerais ,Brazil
{grandineti@hotmail.com, rodbaroni@yahoo.com.br}

Abstract. The purpose of this paper is to analyze the level of system integration among organizations that have deployed intranets or portals. In spite of being independent technologies, portals and EAI have in common the integration issue, and the combined usage of both may produce the synergic effect on application integration processes. The paper presents an instrument to analyze the integration level. According to the identified issues, this study suggests some guidelines for system integration projects.

Keywords: Portals, integration, technology.

1 Introduction

At the beginning of computing, information was processed in centralized systems. The demand for systems integration occurred in an environment that was more heterogeneous. However, over time, the paradigms of computing were changing and new technological platforms emerged. As a consequence, most of the organizations currently use multiple types or generations of systems developed over the years. These legacy systems have value for businesses, but this may mean little if they cannot "talk" to other systems, thus becoming islands of information. Adding to this complex scenario the advent of web-based technologies, generating the need for integration between this environment and a set of applications dispersed among the various departments in the organization.

In the mid-1990s, an approach known as EAI (Enterprise Application Integration) emerged as an alternative making possible the integration of enterprise applications with less customization than required by the ERP systems (Enterprise Resource Planning) (1). The EAI contemplates the tools, methods and planning that enable the organization to gain a competitive advantage with the integration of all applications in an enterprise system unified, able to share the information and support the processes of business flow. The approach of EAI search the unrestricted sharing of data and business processes (5), reducing the complexity of integration (6). In addition, some technology companies have provided their products with new features and capabilities to meet those needs.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_33

In parallel to the movement of systems integration, since the end of the 1990s, the term "portal" has been used to designate a new focus on systems based on the intranet and Internet. The volume of information that needs to be managed by organizations is that with portal technology originated from the Internet is very useful for organizing the corporate environment. Organizations have implemented portals in an attempt to consolidate departmental intranets, because one of the main attractions of portal 2 technology lies in its ability to integrate disparate sources of information through a single interface to the user (21). The mission of corporate portals is to do away with the islands of information systems, by integrating them into a single application that would be port of entry for all users.

Although they are independent technologies, the portal and the EAI have in common the goal of integration. The ability of the portal to provide a unified interface to the information systems can be highly leveraged with the adoption of EAI in the rear. Considering the potential for synergistic combination between these two technologies, this article proposes to analyze the level of integration of applications in the context of intranets and enterprise portals of medium and large Brazilian organizations.

The article is organized as follows: section 2 presents an overview of the technology of EAI. Section 3 discusses the main features of a corporate portal, identifying variables to the instrument for the evaluation of the level of integration. On the basis of the problems identified in 94 Brazilian organizations, sections 3 and 4, it is proposed a roadmap for systems integration. The conclusion summarizes the main points and suggests future work.

2 Mechanisms and Systems Integration

Recently, the term EAI has been used to label solutions for integration of systems that use middleware technologies (2, 3, 4, 9). Some patterns of EAI are described in (1, 3, 4, 14, 17) and in (2) is presented with a view to reducing the middleware components in the industry. Based on the literature of the technologies used in EAI, are presented below, some types of solutions and technologies that provide support for the integration of enterprise systems.

There are systems of middleware that allow an application to communicate with another application. A type of middleware called point-to-point allows an application to establish a connection with a application B and communicate through messages or calls of procedures, RPCs, among others. The middleware is responsible for establishing communication and translation of messages between the application A and the application B. An example for such a link are the applications connected by middleware guided by messages (MOM).

In the integration of applications in an organization, the number of end-to-end solutions can grow exponentially to allow sharing of information between different systems. The connections between the systems can be set up in disarray, without centralized control and management. To resolve this type of problem, a class of middleware products allows the connection many-to-many applications.

Application Servers and ESBs (Enterprise Service Bus) are some examples of the type of middleware many-to-many, among others (2, 3, 4, 7). The Application Servers are the communication in a variety of ways including calls to procedures and connections of type MOM. They can be used to ensure that the rules of business and maintain the integrity of the data or even allow the creation of entire applications with transaction services. Its usefulness in EAI is facilitated due to its ability to integrate 3 back-end and the possibility of uniting various applications using adapters and connectors. Additionally, the standard most commonly used is the Java within the initiative of J2EE (Java Enterprise Edition) (10, 11, 13, 17) and an alternative are the implementations of the scaffold of Microsoft's .NET (8).

Already the ESBs consist of the implementation of the principles of service-oriented architectures (SOA) that describe a type of information technology infrastructure in that its components can be accessed as services and are called through an interface (7). Some commercial vendors have incorporated this type of architecture to their respective Application Servers (7, 10, 11, 13).

For the integration of data, some tools do the work to move and transform the data while maintaining the integrity of a database management system (Oracle's for another Oracle's. There is also an approach called database system unifying that enables us to treat different models, restrictions and languages of consultation between separate databases in an organization (12). A class of middleware includes extraction, transformation and loading (ETL) of critical applications of the organization for the data warehouses with the purpose of providing support to the decision-making processes (2, 12). Another type of middleware, called bridge or SQL gateway, facilitates access to Oracle's through a common interface as the Java Database Connectivity (JDBC) and others, thus allowing access to the databases that reside in distinct environments.

The communication between the applications can also be done through some types of interfaces. For example, a type of connection establishes a common point of integration using communication mechanisms of the interfaces of the users. This means that applications that operate in the mainframe environment can be displayed visually to the user. This type of integration can be achieved by technologies similar to those adopted in terminal emulators. Another mechanism allows, through the programming interface of the applications (API), access the processes and data from ERP systems such as SAP, Baan and others. Another type of technology includes systems for workflow or workflow management, which allow the definition and the automation of workflows and the mapping of processes in organizations. These systems can be built as a tool in ERP systems or in a set of integration solutions (8, 10, 15).

The frameworks are important allies in the understanding of the complexity of the elements to be integrated in the context of EAI, for they establish the relationships between the various technology components to be integrated and also allow the reuse of subsystems, architectures, and the code in existing applications. Some standards are used in the context of J2EE from Sun and Microsoft's .NET.

In called componentization, you can define data and business rules as reusable components that will be integrated with legacy systems. This means that any Java application, or .NET can be developed and carried out the encapsulation of another

existing application environment in the mainframe. however, the challenge is in the resources needed for its implementation from a single solution provider.

Finally, in some integration scenarios, the corporate portal uses a common interface for the integration of data and processes. This approach allows the use of Web browsers on the client side for access to systems and data sources of corporate organizations on the server side. The Application Servers and Web servers provide the basic infrastructure for solutions based on portals (3, 15, 16).

3 Portals

The intranet is an important channel of communication between the company and the employee, and is usually characterized by the acronym B2E (business to employee) as opposed to symbols used for Web systems for e-commerce and B2B (business to business) and B2C (business to consumer). The integration of collaborative systems with the intranet and the structuring of networks of communities make the intranet can also be characterized by the acronym E2E (employee to employee).

The intranet can be defined both technically and functionally. In technical terms, the intranet is a computing environment heterogeneous that connects different hardware platforms and operating systems through an integrated interface with the user (26). Already from an organizational point of view, the intranet is a tool capable of integrating people, processes and information.

Since the end of the 1990s, the term portal has been used to designate a new focus on systems based on the intranet and Internet. The corporate portal represents a variation of the concept already very familiar to Internet portals, such as Yahoo and other. Despite the growth of the market of portals, remains valid observation (23) that the terminology related to the term corporate portal has not yet stabilized. For the sake of completeness and technological independence, it was decided to adopt the definition proposed by (22):

"*The corporate portal is a custom interface to online resources that allows information workers to access and share information, to make decisions and perform actions regardless of their physical location, the format of the information and the location in which it is stored.*"

The components of a corporate portal can be interpreted as evidence that aggregate benefits distinct functional for the user. In the literature, can be found different relationships of features of portals and checklists (16, 24, 25, 26, 29 and 30). Among the features mentioned most of existing proposals, can be highlighted as follows: integration, categorization, search engine, content management, workflow, collaboration, personalization, notification and map of knowledge.

Integration is the functionality of the portal that serves as the basis for the other components, and the greatest effort required for the construction of a portal is precisely the systems integration (27). The integration of the various systems is the main problem in the implementation of portals, because without this integration the portal will be just a pretty facade for a structure chaotic informational (25). The technological movement associated with portals can be perceived as the stage latest of an ongoing trend of systems integration, which also has the data warehouses and ERP

systems as representatives (25). The type of digital information accessible through the portal varies from highly structured, as the stored in relational databases, until highly unstructured, such as documents, Web pages and electronic messages (30).

Already the functionality of categorization of portals is associated with the definition of organizational information such as lists of terms, hierarchies of categories, Thesaurus, software and ontology. The existence of classification schemes contributes to increase the quality of the searches and consequently the quality of the results obtained by the end user (28). In (30), is defended the position that companies need to develop categories and information structures that make sense for their own business and their specific communities who use the portal, because many organizations have discovered that people don't tend to use search engines.

The functionality of presentation is responsible for paradigm of single point of access (SPOA - single point of access) that characterizes the portal. The corporate portal aims to be a user-friendly interface and integrated, that is, a front-end based on Web standards that east end user in his navigation through the various information systems. The collaboration functionality is related to the ability of the portal is a virtual meeting place for people who share common goals, giving rise to communities of interest and discussion groups. The component of collaboration expands the role of the portal of a kiosk passive information for a forum of organizational interactions (24).

4 Proposal for the Integration of Applications

In view of the above problems, can be proposed a roadmap for the integration of applications in the context of portals, based on (19). The script uses a set of solutions presented in section 2, and is derived from a set of industry standards. The roadmap also adopts integration practices of corporate systems and proposes an approach of bottom-up to the definition of the portal. The suggested steps are the following:

- **Architecture:** comprises the preparation of an updated portrait of systems architectures and which applications and data warehouses that require sharing information. This is an initial step to analyze what technology middleware will allow solving a particular problem. The organization must also understand the processes and data that are available, as each one remains without the cooperation of the other and that it is a requirement of one system or another. Cloud computing also must be taken into account even if the systems are hosted in the provider.

- **Group:** involves the prioritization of the consolidation of systems with similar functions, diagnosing the processes which are competitors among themselves and that they have the same features.

- **Standard:** consists in the use of standards including data models and objects. The definition of an integration architecture and the selection of systems and

technologies are important in understanding and analysis of the elements and technological solutions to be used. In addition, it is recommended to re-use of components by using best practices.

- **Mapping and division:** encompasses the logical division of integration components in origins and destinations. The workflow and integration of applications can be understood and mapped with the adoption of this practice.

- **Project Management:** includes the definition of the integration project using practices such as those described in PMBok (20). Includes the identification of scope, technical requirements, quality assurance software, testing methodology, change management and implementation;

- **Development:** consists of the construction of integration services, including the recommendations of the architecture or solution adopted and implementation of ongoing testing of integration. The set of technological elements and business rules commonly bring an additional complexity to the process of integration.

- **Business requirements:** consists in the identification of business processes that require integration of applications. This alignment is important for the setting of priorities and the establishment of plans for short, medium and long term.

5 Conclusions

The linkage developed throughout this article relative the features of portals and the technology of EAI intends to contribute to an increased understanding of the issue of integration. From this perspective, the corporate portal can greatly benefit from tools and techniques existing EAI. Otherwise, the portal can become just a superficial showcase and disposable architecture of chaotic systems.

Another contribution of the article is the roadmap proposed in section 4. This script is not intended to be a full and definitive version for the integration of the entire universe of corporate applications, but a guide to the basic steps of the process of integration of applications. This map is intended for future work analysis of the continuous processes of integration. This guide should also consider the evolution of business processes. The application and extensions of maturity software models will be considered with solutions for application integration.

In situations in which the architecture of information systems is complex and marked by heterogeneity, it is fundamental to prioritize which systems should be integrated initially to the portal. Resources are few and there are deadlines for 'integrating everything at once ". In possession of an instrument of evaluation and a

roadmap, organizations will have better conditions to enjoy the benefits of synergy between the technologies of EAI and corporate portals.

References

1. Lee, J. ; Siau, K. ; Hong, S. Enterprise Integration with ERP and EAI Communications of the ACM, vol. 46, pp. 54-60, 2003.
2. Stonebraker, M. Too much middleware. SIGMOD Record, Vol. 31, No. 1, 2002.
3. Linthicum, D. S. Enterprise Application Integration . Addison-Wesley , 2000.
4. Linthicum, D. S. Next Generation Application Integration: From Simple Information to Web Services. Pearson Education, 2004.
5. Cummins, F. A. Enterprise Integration. John Wiley & Sons, 2002.
6. Schelp, J. , Schwinn, A. Extending the Business Engineering Framework is Application Integration Purposes. In: ACM SYMPOSIUM ON APPLIED COMPUTING, 2005, Santa Fe, USA. Proceedings ... Santa Fe: ACM Press, 2005.
7. Craggs, S. Best-of polynuclear leucocytes ESBS. In: GLOBAL EAI SUMMIT, 2004, Banff, Canada. Proceedings ... Banff: EAI Industry Consortium, 2004.
8. Microsoft Biztalk server. Microsoft Corporation. Available at: http://www.micro soft.com/technet/prodtechnol/biztalk/default.mspx. Access at: Jul 05.
9. Erl, T. Service Oriented Architecture - A Field Guide to Integrating XML and Web Services. Pearson Education, 2004.
10. Oracle Application Server. Oracle Corporation. Available at: http://www.oracle. with /APPSERVER/INDEX .html. Access at: Jul 05.
11. ButlerGroup Application Servers. The facts and How They Compare. Technology Evaluation and Comparison Report. United Kingdom, 2002 (Technical Report).
12. Elsmari, R. ; Navathe, S. B. Fundamentals of Database Systems . 3Ed. Addison-Wesley, 2000.
13. Sun Application Server. Sun Corporation. Available at: wwws.sun.com/ software /PRODUCTS/APPSRVR/HOME _APPSRVR.html. Access at: Jul 05.
14. Hohpe, G. ; Woolf, B. Enterprise Integration Patterns. Designing, Building, and Deploying Messaging Solutions. Addison Wesley, 2004.
15. Websphere Business Integration Server Foundation is Multiplatforms. IBM Corporation. Available at: http://www-306.ibm.com/software/integration/wbisf/ Editions/multi.html. Access at: Jul 05.
16. Hazra,T. K. Building Enterprise Portals: Principles to Practice. In: 22th INTERNATIONAL CONFERENCE ON SOFTWARE ENGINEERING - ICSE'02, 2002, Florida, USA.
    Proceedings ... Florida: ACM, 2002.
17. Juric, M. B. ;, S. E. ; Leander, R. ; Nagappan, R. Professional J2EE EAI. Wrox Press, 2001.
18. Oracle Application Server. Oracle Corporation. Available at: http://www.oracle.com/technology/products/ias/index.html . Access at: Jul 05.
19. Schmidt, J. ; Field, S. EAI Methodology . In: GLOBAL EAI SUMMIT, 2004, Banff, Canada. Proceedings ... Banff: EAI Industry Consortium, 2004. 8
20. PMI Standards Committee. The guide to the project management body of knowledge. Project Management Institute, 2000.
21. Choo, C. W. ; Detlor, B. ; Turnbull, D. Web Work: information seeking and knowledge work on the World Wide Web . Boston: Kluwer Academic Publishers, 2000.

22. Collins, H. Enterprise Knowledge Portals: next generation portal solutions is dynamic information access, better decision making and maximum results. New York: Amacon, 2003.
23. Days, Claudia Augusto. Corporate Portal: concepts and characteristics. Revised Information Science, v. 30, No 1, p. 50-60, jan-Apr. 2001.
24. Delphi Group. An enterprise portal bridge to e-business. Online. Document written in 2000 and captured on 19/09/2001 . Available on the Internet via WWW. URL: http://www.delphigroup.com .
25. Firestone, J. Enterprise Information Portals and Knowledge Management. ButtwerworthHeinemann /KMCI Press, 2003.
26. Marcus, R. ; Watters, B. Collective Knowledge: Intranets, Productivity and the promise of the knowledge workplace. Microsoft Press, 2002.
27. Richardson, W. C. ; Avondolio, D. Professional portal development with open source tools . Indianopolis:Wrox Press, 2004.
28. Rollett, H. Knowledge Management: processes and technologies. Boston: Kluwer Academic Publishers, 2003.
29. Portals community. Portals Fundamentals. Document captured in 04/23/2003. Available online at http://www.PortalsCommunity.com/library.
30. Land, J. C. ; Gordon, C. corporate Portals: the revolution in knowledge management . Sao Paulo: Editora Business, 2002.
31. EXAME Magazine. Best and Largest: the 500 largest companies. Sao Paulo: April, 1928). 2005.

A descriptive tour of the Semantic Structures apply to video surveillance systems

Héctor F Gómez A[1], Silvia Elena Malo Martínez[2], Claudia Paola Cartuche Flores[2]

[1]Universidad Técnica Particular de Loja,Departamento de Computación y Electrónica
hfgomez@utpl.edu.ec
[2]Universidad Técnica Particular de Loja,Departamento de Arquitectura y Artes
{semalo, cpcartuche}@utpl.edu.ec

Abstract. Automatic systems that monitor human behavior for detecting security problems are a challenge today. In this work, we analysing the semantic structure required to representing the human behaviour in high-level semantic events. We identify the principal components of different ontologies and describe the goal of each semantic structure. This work describes *Horus*, because we believe that this framework is a good example of a methodology composed to different levels, the goal is to describe human behavior a video surveillance systems. We propose an idea to complete *Horus* based in semantic structures. The finish work is obtain an art state about semantic structures apply to video surveillance systems, and generating conclusions and future works from of theory.

Keywords: high-level activities, video scene understanding, human behavior recognition, video-surveillance, multisensory surveillance, ontology-based recognition.

1. Introduction

During the last decade, ontologies have been used in multiple domains such as natural language processing, e-commerce, integrating intelligent information, retrieving information, integrating databases, bioinformatics, education, and the semantic web. Ontologies seem appropriate for the aforementioned purpose due to their capacities of representation, of reuse, of consistency [1]. Ontological engineering has worked on these aspects for years. Additionally, ontologies provide vocabulary and organization of concepts that represent a conceptual framework for analyzing, discussing or retrieving information in a domain. Over the last years, ontologies have been clearly involved in the concept of semantic web, which entails an associated technology of languages, reasoners, standards, and tools such as RDF, OWL and SparQL. The recognition of basic situations with low-level semantics such as trespassing perimeters, or identifying a license

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_34

plate, an object, or even a riot in video surveillance systems is not the only aim of this work. This study describes the semantic process to recognize more complex activities or situations of high-level semantics and higher abstraction. Going from sensor signals, and even images, to this type of interpretation involves a much higher level of semantics that can only be achieved by relating the information obtained from the context. This interpretation always depends upon knowledge, capacity of expression, and the specific language of the expert. Our goal is describe structures of representation of explicit knowledge that collect generalities and particularities of situations of interest with the purpose of identifying them automatically in the monitored scenarios, because we think that ontological engineering and semantic technologies form a unique framework for the explicit representation of situations of high-level semantics, and facilitate a fast prototype of security and surveillance systems with a similar abstraction level to that of a human agent. *Horus* [2] is describe in this work, because is the framework to work with semantic structures to define events in relations to human behavior. *Horus* is a video surveillance application that needs semantic structures to validate the different levels of events. We propose an idea to complete *Horus*, based in semantic structures, because the framework work with signals of video surveillance dispositive (low semantic level) and produce high level events (identify human behavior). For obtaining the human behavior we think that the *Horus* need a good semantic structure. In the next section, we examine several studies that propose the usage of semantic technologies for modelling human activities. This was achieved by identifying key technologies, approaches and; issues and main characteristics. In section 5, we describe the conclusions and future works of this research.

2. Semantic Structures in video surveillance systems

As a society we ask for more security and surveillance. Citizens want to feel safe and to know in advance the dangers that lie ahead. The events of September 11, 2001 changed the public perception of video surveillance and surveillance technology, favoring the investment and acceptance of losing a certain amount of privacy, which is necessary, especially in public places. The aim of these researches is to establish a monitoring and video surveillance system that works with multi-sensor networks to carry out an intelligent observation of large metropolitan areas. The size and complexity of these networks needs cameras with a higher capacity of local computing; for instance, these cameras can set off an alarm if they detect that someone jumps a fence or opens a door when they are not allowed to do it. GeoVision systems can identify people and provide precise details of the suspects' face. Thus, in this type of systems, the

cameras not only capture images, but also can process them through mathematical models to identify objects and people. The parameters with which mathematical models work (position, size, or speed of the objects) are data; for this reason, they occupy much less bandwidth, which in turn decreases the cost of transmission. Wireless cameras then send all the information to a central unit where these data are processed in order to identify people or infer the type of activity done. (SINC, 2012) [3]. In this respect, there are solutions that have been proposed. Most of them are based on the use of structures that interrelate the various types of implied knowledge at different levels of description, starting with low-level semantics, and then, reaching a level that performs quality descriptions that help in the search and retrieval of activities and situations in security and surveillance systems. This is not an exclusive problem of security and surveillance systems. Regarding interpretation of video sequences, other applications can be found; for example, applications related to information retrieval and automatic classification [4]. On the other hand, the need for automated systems is evident in the case of recognition of complex activities, especially if we include here the applications in the area of healthcare and welfare. However, despite all efforts in research, it has not been possible to integrate this process into one conceptual and functional structure. Having an architecture that contains multi-sensor systems to help the human operator make decisions based on a recognized situation of interest is clearly a theme that has to be tackled with scientific solutions.

High-level semantic interoperability has not been solved because a common conceptual model that groups each one of the security and surveillance systems is missing [5]. Some works on security and surveillance systems have been developed only to solve the problem of performing queries on multisensory semantics [6]. The Geospatial Consortium (OGC)[1] works on open standards of semantic queries in multisensory systems. The main problem here is the response time, especially when the volume of data increases. This problem was fixed by IRISnet [7] through a mechanism of hierarchical semantic query. As a result, the response time of the semantic query on heterogeneous sources was improved; however, there are problems when reusing the semantic structure, which makes the application for different scenarios difficult. [8]. The SWAP framework designed the SWAP architecture that works with multisensory data and infers high-level activities. SWAP has three levels that comprise the sensor, the objective, and the decision; each level is operated by an agent. SWAP's semantic operability allows for reusing of its conceptualization in different security and surveillance systems. However, working with multi-agents is quite complex, which turns system

[1] Geospatial Consortium: http://www.opengeospatial.org

operability into a difficult task. [9] . In this respect, Priamos was developed. Priamos is a middleware architecture that works with multisensory data and attempts to infer situations of high-level semantics. Due to the ease of use of this architecture, it can be used for designing specific interfaces for security and surveillance systems. However, Priamos lacks an interface for the easy management of its operations on the part the user, which makes its portability difficult.

An integral semantic structure for the fusion of multisensory information and algorithm processing needs a relation with the scenario since different groups conceptualize and use data sensors in different ways. In addition, a structure to relate information must be planned with the purpose of inferring activities or situations according to the type of scenario that is being monitored. It is also important to choose the appropriate sensors in order to infer a determined activity or situation. For instance, monitoring brain functions helps in the recognition of human behavior problems. These brain functions can be processed by using electrocardiograms or magnetic resonance imaging; or, in more abstract situations, a combination of motion and water flow sensors help infer AVD such as having breakfast, taking medicine, and watching television [10].

Over the last years, wireless sensor networks have generated a great interest, opening numerous opportunities and lines of research. The idea presented in [11] about Satellite Sensor Networks is proof of the development of frameworks that seek to expand sensor networks. This framework helps researchers interact with data from other networks in any part of the world. This idea is easier to translate into action if we compare it with the current model of social networks in which millions of people worldwide interact. Individual (or collective) entities share their information with the rest of the network, which results in: 1) the rest of the entities can access these data, and 2) the network itself can process these data and use them for future actions.

The combination of sensor networks and ontologies has produced very good results for the design and implementation of frameworks. For example, the distributed video-sensor framework-architecture that works with the CORBA ontology in order to develop a distributed tool based on standards that allows for the development of intelligent visual monitoring system. - Starting from a single image obtained from the video generated in different places and a Personal Identification Number (PIN), the identity of the person depicted on the image can be verified-. CORBA defines the standards that are necessary to work in heterogeneous scenarios and an algorithm based on neural networks in order to identify people by their faces.

In multisensory geolocation applications, the customization of GIS mobile applications can be done by using technology of the Semantic Web

that provides different tools to store information related to user's preferences. For instance, tourist semantic frameworks that show customized tourist information based on user's preferences. In this case, semantics is used in these applications since relational databases are insufficient when geographical data are used. For this purpose, there is a spatial ontology and data query mechanisms that help solve problems of spatial location when the first alternative has failed. *Horus* is a modular architecture used for the management of multisensory input that incorporates a conceptualization model to share information of interest among multiple scenarios. The multisensory sources are mainly related to image sensors since these sensors are widely used for monitoring activities. However, other sensor technologies such as wireless sensor networks (WSN) are also integrated as generic objects in *Horus*. The *Horus* framework is distributed and hybrid. The remote nodes perform low-level processing as well as data retrieval, whereas a central node is in charge of gathering and fusing information. *Horus* includes detection of simple objects, and tracking and detection of activities (Castillo, Fernández, & López, 2011). Its task is ambitious due to the great variety of scenarios and activities that can be used. In its architecture, a series of operation levels are established in which the input/output of the interfaces are clearly identified. These levels are flexible because they can be easily adapted to a final system. Their infrastructure is based on the model-view-controller (MVC) paradigm, which divides an application into: a) entities, b) the definition of its main functions, and c) the connections among these functions.

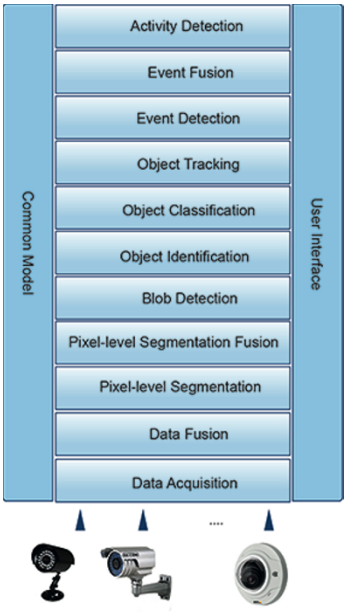


Fig. 1. The *Horus* modular system. Source: (Intelligent monitoring and activity interpretation framework - INT3 *Horus* general description, 2012)

In event-based systems, MVC gives information about changes in the applications and provides a representation that is adapted to the user´s needs. The model receives the inputs for the application and interacts with it to update the objects and represent new information. [13]. The modules developed in *Horus* are able to perform sensor fusion. Basically, the work of the authors of this study is describing an idea of the activity recognition phase by designing a general framework in order to establish a hierarchical modeling of situations of high-level semantics and their inference based on the information obtained in previous phases.

The intention is to exploit all this technology, which is, as it was previously mentioned, initially web-oriented, but it permits an explicit, reusable and distributed representation of a modular domain that will be appropriate for the conceptual, methodological and technological framework used to complete *Horus* (see Figure 2) how describe [14]:

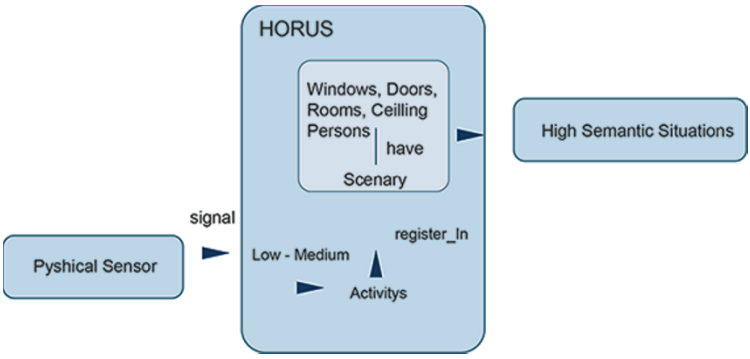


Fig.2. Semantic Model: The knowledge structure is used to model scenarios, activities and situations

In summary, the hypothesis of this study is that ontological engineering and semantic technologies form a unique framework for the explicit representation of situations of high-level semantics, and facilitate a fast prototype of security and surveillance systems with a similar abstraction level to that of a human agent. This framework must meet the following requirements:

- Work with multisensory signals and their integration with the purpose of eliminating the difficulty of the security and surveillance systems to combine multiple heterogeneous devices in one monitoring network.
- Conceptualize sensors and its semantic relations in order to work directly with the semantic sensor instead of the physical sensor.
- Represent knowledge. The ontology must be capable of conceptualizing the elements of the scenario and its relations. The knowledge structure must have characteristics that make it possible to work with security and surveillance systems that are

predictive – a priori – or with surveillance systems of retrospective analysis, i.e. systems that infer or analyze situations after they have occurred.

- Import ontologies. The structure is adapted to combine with other ontologies developed in different domains with the purpose of reusing knowledge representations in the various fields of science.
- Conceptualize and infer activities. In this process, the expert's knowledge is used to conceptualize activities or to apply inference rules or axioms to the activities registered in the scenario. This study focused on inferring activities of medium and high-level semantics, leaving the low-level semantics for *Horus*.
- Conceptualize and infer situations. The knowledge engineer establishes the relations among the activities and designs the semantic rules and axioms to infer a situation. Additionally, there must be a semantic capacity to adapt the structure to new conceptualizations of activities and situations that are the product of learning acquired through computer algorithms. Based on the knowledge of situations of interest, two types of tasks are proposed: a) conceptualize and model human expert's knowledge (according to the basic activities that can be recognized by the sensors or by video image processing), and b) conceptualize and model situations in which the knowledge does not exist but it is possible to find it in records (cases database) of the situations that could be recognized. In this case, the process is particularly complex (Sunico, 2008) [15] and it will require the use of intelligent recognition algorithms. The present work studies both a) and b) and works with the expert's knowledge when it can describe scenarios and situations clearly; and in scenarios in which there is an expert, but not very precise knowledge, and the situations of interest are attempted to be found automatically. Here, situations consist of activities that, individually, are not suspicious, but these activities are suspicious when they are analyzed in a certain sequence and repetition.

This framework includes detection of simple objects, and tracking and detection of activities. In order to complete this framework, the following levels were developed [12]:

- Fusion of sensor information: This level is in charge of fusing sensor data to improve the quality of information (more complete and precise information).
- Location and filtering: This level isolates objects of interest on input images.

- Location and filtering of fusion: This level fuses images obtained in the phases of location and filtering because there might be several location results and filtering methods performed in the framework (for example, one result focused on color images and another on infrared images).
- Blob detection: The level of blob detection filters errors on images and detects them correctly in previous levels. This level is in charge of retrieving information associated to errors for a more effective analysis of the objects.
- Object identification: This level works with objects that are free of errors. This improves the collection of information and produces the cartographic coordinates of the object in the real world instead of just working with image coordinates.
- Object classification: This level is quite important because it analyzes the activity and provides information about the object. Additionally, there is a classification of objects and it is also possible to give information about the orientation of objects.
- Tracking objects: This level traces coordinates of the objects of an image in a scenario. This level also uses information of the common model regarding the map, the situation of sensors and their range of coverage.
- Event detection: The level of event detection generates semantic information related to the behavior of the objects in the scenario.
- Event Fusion: Event fusion occurs in a system for tracking and multisensory interpretation in which several sensors monitor a common scenario. It can be explained here that, usually, events generated from different sources do not match. For this reason, it is necessary to unify information from different sensor data generated in the previous level before event fusion.
- Activity detection: This final level of the architecture is in charge of the analysis and detection of activities that are already associated with temporary characteristics. After the case fusion, the current level has a better knowledge of what is happening in the scenario, considering the detected events.
- General module: This module gathers information from the different levels while providing primitives to access information.
- Scenario modeling: Despite the fact that scenario modeling does not appear as a level in the definition framework, it is a key aspect that makes it possible to work with sensor information in order to locate objects in the scenario.
- After meeting. These requirements, the aim is to obtain ontological designs that are adapted to security and surveillance systems in order to conceptualize and infer situations of interest

of high-level semantics. The use of semantic techniques to model knowledge is an interest of current research on the modeling of situations. In fact, the application of ontologies has become comparable to the algorithms that recognize events on video [16].

3. Conclusions

The basis of this theory, this study is not limited to a physical control system. On the other hand, from the theoretical point of view, the use of semantic technologies facilitates surveillance prototypes, modeling, and the implementation of a scenario and situations for the three semantical hierarchical levels. Because of the type of situations on which this study attempts to work, it is particularly important to find a weak suspicion. It is not about the recognition of theft or robbery. It is rather about having previous suspicion and establishing a behavior that is suspicious enough. Moreover, it has been clearly demonstrated that the framework can be used to obtain sequences of high-level semantics with explicit knowledge - i.e. a priori knowledge - that the expert can easily model and explain. In this article we propose the need to complete *Horus* by adding situation recognition. In fact, this study has made important contributions in this aspect. On the one hand, it was methodologically convenient to differentiate between events of medium and high- level semantics and those that had a low level. Therefore, on the basis of this theory, this study is not limited to a physical control system. On the other hand, from the theoretical point of view, the use of semantic technologies facilitates surveillance prototypes, modeling, and the implementation of a scenario and situations for the three hierarchical levels previously described. *Horus* is the orchestra director because it has the methods necessary to model and infer situations of interest based on levels of hierarchical composition. The contribution of the authors of this study to *Horus* is a conceptual, methodological and technological framework that can infer situations of high-level semantics based on its multisensory fusion module. The framework described in the present work consists of layers and modules that are useful for the following activities: 1) the expert describes the situation of interest, 2) the knowledge engineer abstracts details of the situation and models levels of hierarchical and semantic compositions, and 3) the models are exported to OWL in order to work with semantic inference tools.

4. References

1. Akdemir, U., Turaga, P., Chellapa, R.: An Ontology based Approach for Activity Recognition from Video. Proceeding of the 16th ACM international conference on Multimedia, pp. 709-712, 2008.
2. Castillo, J., Fernández-Caballero, A., Serrano-Cuerda, J., Sokolova, and M.V.:

Intelligent monitoring and activity interpretation framework - INT3 *Horus* general description. In: 16th International Conference on Knowledge-Based and Intelligent Information & Engineering Systems. Lecture Notes in Artificial Intelligence, San Sebastian, 2012.

3. Albanece, M., Chellapa, R., Moscato, V., Picariello, A.: Constrained Probabilistic Petri Net Framework for Human Activity Detecion in Video. Multimedia, IEEE Transactions on, vol. 10, pp. 982-986, 2008.
4. Arens, M., Nagel, H.: Behavioural knowledge representation for the understanding and creation of video sequences. In: Proceedings of the 26th German Conference on Artificial Intelligence, Heidelberg, 2003.
5. Reed, C., Botts, M., Davidson, J., Percivall, G., Collins, F.: Ogc sensor web enablement:overview and high level architecture. Autotestcon, 2007.
6. Lewis, M., Cameron, D., Xie, S., Arpinar, B.: ES3N: A semantic approach to data management in sensor networks. In: Semantic Sensor Networks, Athens, 2006.
7. Gibbons, P., Karp, B., Ke, Y., Seshan, S.: Iris-Net: An architecture for a wordwide sensors web. IEEE Pervasive Computing, pp. 22-33, 2003.
8. Moodley, D., Simonis, I.: A new architecture for the sensor web: The SWAP framework. In: Sensor Networks Workshop, Athens, 2005.
9. Konstantinou, N., Solidakis, E., Zoi, A., Zafeiropoulos, A., Stahopoulos, P., Mitrou, N.: Priamos: A middleware architecture for real-time semantic annotation of context features. In IE, Ulm, 2007.
10. Hongeng, S., Nevatia, R.: Multi-Agent Event Recognition, in Proc. of the 8th Intl. Conf. on Computer Vision (ICCV '01). In: Eighth International Conference on Computer Vision, Vancouver, 2001.
11. Colitti, W., Steenhaut, K., Descouvemont, N., Dunkels, A.: Satellite based wireless sensor networks: global scale sensing with nano- and pico-satellites. In: Proceedings of the 6th ACM Conference on Embedded Network Sensor Systems, New York, 2008.
12. Castillo, J., Fernández, A., López, M.: A Framework for Multisensory Intelligent Monitoring and Interpretation of Behaviors through Information Fusion. In: 2011 Seventh International Conference on Intelligent Environments, 2011.
13. Sokolava, M., Castillo, J.C., Fernández-Caballero, A., Serrano-Cuerda, J.: Intelligent Monitoring and Activity Interpretation Framework - INT3*Horus* Ontological Model. IOS Press, pp. 980-988, 2012.
14. Gómez, H., Martínez, R., Arias, S., Rincón Zamorano, M.: Using semantic technologies and the OSU ontology for modelling context and activities in multisensory surveillance systems. International Journal of Systems Science, pp. 798-809, 2014.
15. Hu, W., W.T., Wang, L., Maybank, S.: A survey on visual surveillance of object motion and behaviors. In: IEEE Transactions on Systems, Man and Cybernetics Part C,," IEEE Transactions on Systems, Man and Cybernetics Part C, vol. 34, no. 3, pp. 334-354, 2004.
16. Riboni, D., Pareschi, L., Radaelli, L., Bettini, C.: Is ontology-based activity recognition really effective?. In: Pervasive Computing and Communications Workshops, Seattle, 2011.

An agile approach to developing an Information System for Anti-Doping Control in Brazil

Francisco Medeiros[1], Juliana Medeiros[1], Fausto Ayres[1], Caio Viana[2], Josemary Rocha[3], Victor Viegas[3], Eder Mendes[3], Ana Santos[4]

[1] Federal Institute of Education, Science and Technology of Paraíba (IFPB), Brazil
[2] University Center of João Pessoa (UNIPÊ), Brazil
[3] Institute of Higher Education of Paraíba (IESP), Brazil
[4] Integrated College of Patos (FIP), Brazil
{fcopetroniomedeiros, julianadantasmedeiros, fausto.ayres, aiacos, josemaryfreire, victormesquita88, fmeder, anacarlags}@gmail.com

Abstract. Sports organizations, regulators, sponsors and athletes have become more and more concerned about anti-doping control. Despite the investments made in the past few years, recent studies show that Brazil´s sports confederations have not systematized the doping control process nor have they yet dealt satisfactorily with problems to do with transparency with regard to disclosing the results of tests. This study puts forward an Information System to support the Confederations in implementing anti-doping procedures. The Information System is being developed using an agile approach. To date, the Product Backlog has 133 functionalities, of which 71 have already been validated with some Olympic confederations. It is also hoped that the proposed integrated database of doping tests can help managers to draw up a public policy for this area.

Keywords: Information System, Athletes' Health, Anti-Doping Control, Knowledge Management

1 Introduction

Doping control in Sport is a complex challenge. This is a reason for the bodies responsible for its regulation at the national as well as global context to be concerned. We are constantly made aware of news of cases of doping, in various sports. This is damaging to the notion of the Olympic spirit, harms athletes' health and undermines the values of sport. Many types of investments have been made by the Federal Government of Brazil in order to make progress in this matter. One such example was the creation of the Brazilian Anti-Doping Authority (ABCD, in Portuguese) in 2011.

The doping control process in Brazil is undergoing structural changes that will come into effect prior to the Olympic Games in 2016. Those that stand out are cooperation with overseas laboratories and the re-accreditation of the Brazilian Laboratory for Doping Control (LBCD, in Portuguese) by the World Anti-Doping Agency (WADA) [11].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_35

However, despite the investments already made, as described in ABCD's Annual Report [1], a number of actions still need to be implemented to overcome the challenges in this area. One such current problem is the lack of up-to-date information on doping control, which has an adverse impact on drawing up anti-doping public policies. Access to up-to-date and reliable information is a basic condition for decision making.

The Brazilian Olympic Committee (COB in Portuguese) oversees 52 confederations of various sports, including 30 Olympic federations, 19 Bound National Federations and 3 Recognised National Federations. Bound and Recognised federations are those that cover sports that are not included as Olympic sports [4]. However, the transparency of the confederations as to positive cases is not satisfactory and neither is their verdict on these. The main confederations have deficiencies in their exercise of doping control and in making data public.

In this context, the general objective of this research study was to design an Information System for the purpose of supporting the Confederations in the doping control process and thereby to provide up-to-date information that might assist decision making and the formation of public policy in Brazil in this area.

The remainder of the paper is organized as follow: Section 2 summarizes the context in which the research was conducted. Section 3 details the methodology used. Section 4 presents the evaluation of the results. Finally, Section 5 draws some conclusions and indicates future research studies arising from this paper.

2 Background

A relevant study in anti-doping control was conducted by Lipicer [6] who examined the impact of global anti-doping initiatives on the Republic of Slovenia, sports policies and the role of wider national political and legal frameworks.

ADAMS [2] is a WADA system for managing doping tests that stores the tests that have been conducted by accredited laboratories. Sports Federations that have an agreement with WADA can access the ADAMS system (view only).

The objective of the Information System developed in this project, called the System for Doping Control (SCDP, in Portuguese), is to support anti-doping measures, thereby complementing ADAMS, by providing functionalities that ADAMS does not have. SCDP sets out to be active throughout the doping control process. These include functionalities to purchase doping kits, to select the athletes who will be tested, to complete the doping form, to detail the results, and to initiate hearings and pass sentences when tests are positive. The scope of ADAMS, for the confederations, is restricted to consulting the results of the tests conducted by accredited laboratories.

Currently, when undertaken, doping control is performed independently by each sports organization (confederation, association, etc.) with the support of spreadsheets and documents, but there is no database and no support from any software. In addition, there is no standardization between the sports bodies. Thus, the regulators in Brazil do not have a consolidated view of the process used. Nor is there accurate, detailed and up-to-date information about the tests that would enable a thorough analysis of doping, for example, by region, sport, prohibited substance or age group.

The Athlete Scholarship Program of the Federal Government [3] lays down the non-violation of anti-doping rules as an additional requirement that candidates for this award must meet and sets out penalties for holders of this award who violate the anti-doping rules. However, due to there being no automated and centralized control, this Program does not hold up-to-date information on positive tests. Therefore, it is dependent on information that it obtains from the press, based on accusations or from the Confederations. Figure 1 shows the context in which the SCDP project is placed.

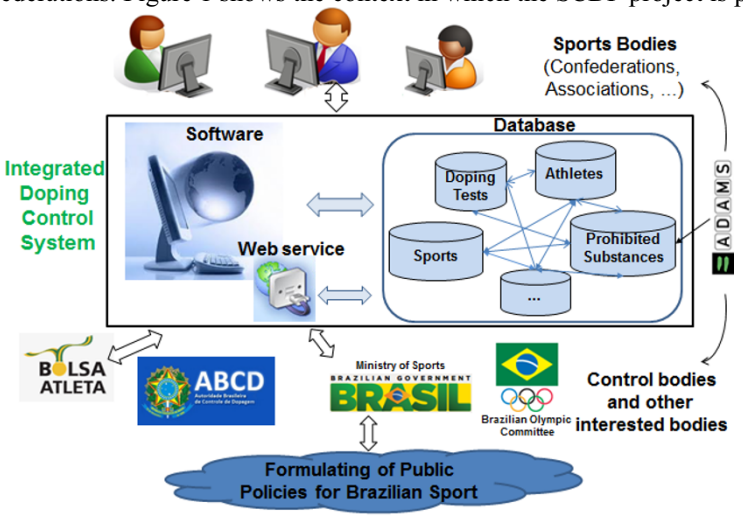


Figure 1. Context of the Doping Control System

3 Methodology Used

This section describes the methods and techniques used to conduct this project.

3.1 Mapping the doping control of the Sports Bodies

An exploratory study was conducted to answer the following research question: How is doping control currently being carried out by sports bodies? Two researchers conducted this activity.

Initially the team contacted the Confederations based on contact information provided by COB. E-mails were sent to all confederations. In addition, some confederations were contacted by phone and eight confederations were visited in person. The techniques used for data collection were: i) interviews and ii) analysis of documents. The interviews were conducted at the headquarters of the Confederations with the officials responsible for doping control. Notes were made during the interviews and the conversations were audio-recorded. The purpose of these interviews was to gain a better understanding of the process that the Confederations used and the difficulties they face. During the interviews, documents were collected

such as forms, and test results. In addition, other documents available on the Confederations' websites were analyzed. These included sentences passed at hearings of athletes who were caught by the doping tests. The analysis of the information collected at this stage guided the next step, the purpose of which was to develop the system to support the Confederations as to doping control.

ABCD helped in this process by providing information about the actions that it was conducting with regard to doping control and to formalizing the researchers' role with the sports Confederations. Several confederations were examined in this process. However, since the Brazilian Athletics Confederation (CBAT, in Portuguese) is the exemplar model for Doping Control in Brazil, it was used as the main source of information and to validate the functionalities of the SCDP system.

3.2 Development Process

The Information System is being developed using Scrum [9], and follows PMBOK (Project Management Body of Knowledge) practices [8]. An interactive and incremental development process, called Business Requirement Agile Process (BRAP) was used [7]. The process is divided into four sub-processes that are repeated in each monthly cycle of development (Sprint), as illustrated in Figure 2: Backlog Management, Refinement of the Requirements, Coding (Development) and Conclusion. Each sprint includes a subset of functionalities (requirements) of the backlog of the project.

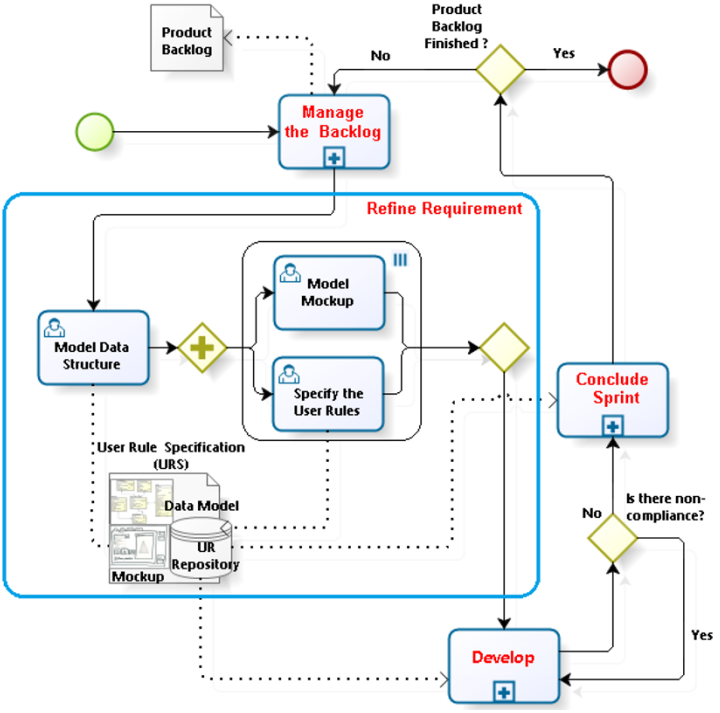


Figure 2. Development process used

To date, 14 people have been involved in the project: 1 coordinator, 2 researchers, 1 analyst, 4 programmers and 6 trainee students. However, not all staff worked throughout the project. BRAP was proposed in the PhD thesis of one of the project researchers who was responsible for supporting the team in how best to implement the use of process. The project coordinator is responsible for executive management, details what activities are to be done and monitors their implementation. Moreover, she is responsible for reporting information on the progress of the project to the project partners, whenever requested.

Managing the Backlog. Based on the face-to-face interviews in the confederations, the initial Product Backlog (PB) of the project was drafted. After validating the PB with CBAT, planning was conducted during which the requirements were distributed in Sprints in accordance with the priorities established by CBAT and ABCD. The project uses the Redmine tool to support management, thus controlling the demands allocated to the team.

Refining the Requirements. At the start of each Sprint, the structure of the database is modeled and includes all the requirements of the Sprint. Then, for each requirement, the mockups (proto-types of the interface with the user) are drawn up and the related rules are specified. These activities are conducted simultaneously by the analyst with the support of the CBAT users and the supervision of the researchers. When the refinement of a requirement is finalized, it is immediately made available for encoding.

The requirements are specified using the template defined in BRAP which links the user's rules, and the mockups and data structure with each other. The document is prepared in MS Word. The mockups are built on the Pencil tool and the data model is designed in the Astah tool.

Coding. This step is performed by the programmers and trainees. One of the programmers plays the role of a software architect and is also responsible for carrying out the weekly deploys. The programming language chosen to develop the software was Java, version 7, on the EE (Enterprise Edition) platform.

The software has a 3-layer architecture, following the Model-View-Controller (MVC) standard [5] of software architecture that separates the business logic from the interface with the user, as shown in Figure 3.

Within the Java EE platform, Java Server Faces (JSF) technology was used. The PrimeFaces library was chosen as an extension of components and resources for JSF. In the Java persistence API (JPA) layer, the Hibernate 3.5 framework was chosen in order to reduce the complexity of communication with the PostGreSQL 9 database that was used in the project.

Spring Security 3 was used as a security alternative of the Java EE specification, thus offering an authentication and authorization mechanism for the web application.

When the project was being developed, the testing team used the JUnit frame-work, which supports automated tests in Java. The management of project dependencies was carried out with Maven 3. By doing so, it was possible to manage the builds, standardize the development environment, and to simplify the creation and distribution of the project. For the control version of the source code of the application, the development team used the Apache Subversion (aka svn). The project runs on an Apache Tomcat 7 web server.

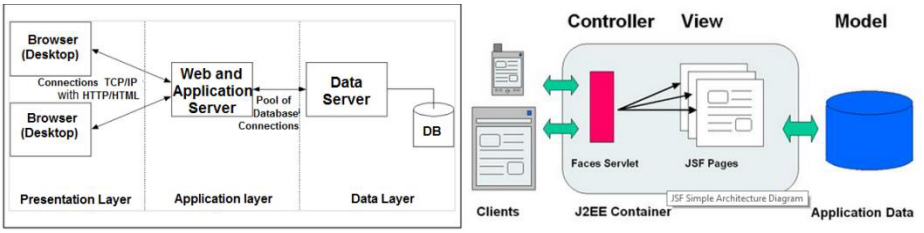


Figure 3. Architecture of the application

Conclusion of each Sprint. Every week, whenever a new version of the application is made available with new functionalities, acceptance tests are conducted. The non-conformities found are re-ported in Redmine and sent for correction in the specification or software. At the end of each Sprint, the application is made available for validation. Some functionalities have already been validated with CBAT and others with ABCD.

4 Evaluation of the Results

4.1 Current situation of Doping Control in Brazil

The doping control process currently carried out by the confederations was analyzed as was the level of transparency with regard to the disclosure of doping cases. In addition to the interviews with those responsible for doping control in eight Olympic federations, the sites of the Confederations were also checked to analyze the doping tests that were sent to the Upper Court for Sports Justice (STJD, in Portuguese) of the Confederations. These data were synthesized so as to make it possible to answer the research question of this study.

Of the 30 Olympic federations, 23 have information on the STJD, on their web-sites. Nonetheless, the absolute figures on the transparency of doping cases held in Brazil are alarming: among the fifty-two confederations analyzed, only eight make data available on their site that can be consulted efficiently. On the large majority of these sites, there is no access to case hearings held nor is there any mention of any control carried out in relation to doping.

During the survey conducted on the site of the Confederations, no information was found on any of these sites as to the number of tests carried out nor with regard to

negative results. The sites only held information on positive tests which had been sent on to the STJD. Even so, only 7 Confederations (all Olympic ones) held such information on their sites, a total of 116 cases, namely: the Brazilian Confederation of Cycling (35), followed by the Athletics Confederation (33), Football (21) and Equestrianism (21). Canoeing appears with 4 cases disclosed and Basketball and Shooting with just one each, as shown in Table 1. None of the other confederations showed any information on doping cases referred to the STJD on their sites at the time of the survey (until February/2015).

Table 1 - Doping tests sent on to the Sports **Tribunal** (up to February/2015)

	2007	2008	2009	2010	2011	2012	2013	2014	Sum
Athletics			6	5	2	5	6	9	33
Basketball						1			1
Canoeing							1	3	4
Cycling	1	1	9	3	5	10	1	5	35
Equestrianism			4	3		5	7	2	21
Football						2	12	7	21
Shooting							1		1
									116

The WADA anti-doping code sets deadlines for organizations responsible for doping control deadlines by which to disclose the results that must be made public. However, the results of the analysis carried out on the site of the Confederations demonstrate the need to improve the transparency of this information. The identity of the athlete who violated a rule can only be revealed after the test result has been confirmed and the athlete's defense has been heard. Nevertheless, it was noted that the confederations do not even provide quantitative information on the tests.

It should be pointed out that there are cases of Confederations that did not have records on their websites of cases on which sentences have been passed and reported in the mainstream media. These include the Confederations of Jiu-jitsu, Water Sports, Gymnastics and Motoring. This group includes sports that receive federal incentive programs such as the Athlete scholarship.

Besides few confederations making information available, there are also limitations as to the quality of information. Data are very often incomplete and disorganized, with decisions and legal remedies not being shown together, for example. In most of the Confederations, there are not enough details about the hearings. Very often there is not even access given to the report of the defense offered by the accused. Moreover we identified that some Confederations do not disclose the substances found in the tests but only the final decision and the penalty. Some Confederations claim that the high costs involved make it impossible to conduct and control doping tests.

In all the confederations analyzed, the absence of an information system to support the professionals involved was noted. Except for CBAT, there is an alarming need to systematize the doping control process. Another challenge identified is the need to improve the transparency of reporting the legal hearings and outcomes of doping tests.

In order to validate the understanding of the doping control process, a flow chart has been drawn up to describe the activities involved throughout this process [10]. This flow chart is one of the contributions of this article. It is hoped that it will serve

to guide the Confederations as to how to systematize their procedures on doping control. CBAT has validated this flow chart.

4.2 Functionalities Made Available by the Information System

Figure 4 illustrates the 7 modules (Administrative, Configuration, Access Control, Doping, Statistics, Sports Justice and General Use) that make up the system and the Webservice which is being developed to make the confirmed doping tests available. To date, the Product Backlog (PB) has 133 functionalities including registrations, queries and reports.

The webservice being developed will enable integration with other programs, for example, the Athlete Scholarship, thereby ensuring not only that the award is not granted to athletes who are under suspension due to doping but also that it is cancelled immediately after the final confirmation of a positive test.

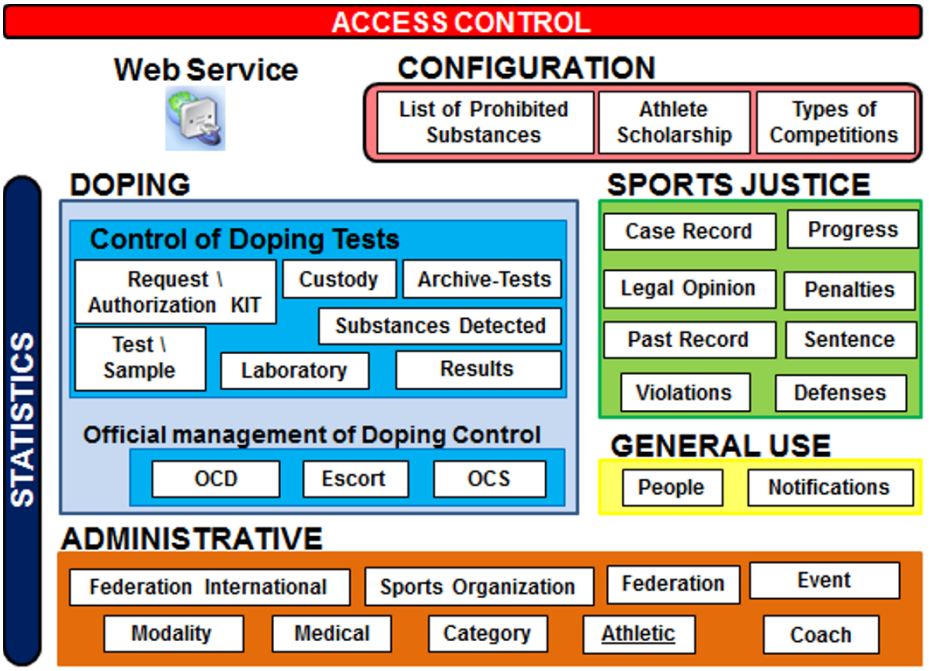


Figure 4. Modules of the System

Some examples of actions that can be taken with the help of the data analysis provided by SCDP are:

- Increasing the conduct of anti-doping tests in the sports in which the number of tests conducted is low;
- Investigating the good practices that are being applied with regard to anti-doping control of the sports in which the rates of testing are high;

- Investigating the reasons for the high incidence of positive tests in certain prohibited substances;
- Investigating what the age groups, gender, categories, cities, regions of the country are that need tighter awareness-raising monitoring.

Table 2 shows the current number of functionalities by module and by status.

Table 2 - Functionalities by Module and by Status

Module	Functionalities
ADMINISTRATIVE	30
DOPING	42
SPORTS JUSTICE	20
GENERAL USE	10
CONFIGURATION	15
ACCESS CONTROL	6
STATISTICS	10
TOTAL	133

Status	Functionalities
Concluded	71
Being tested	8
Being implemented	10
Being corrected	14
Allocated to the next Sprints	30
TOTAL	133

5 Conclusions

This research involved designing an Information System that can support the Confederations to implement doping controls with regard to their athletes by feeding a database with integrated information, which hitherto has not been done in Brazil. With this information, managers of sports organizations will be better prepared to make strategic decisions and to formulate public policies aimed at improving anti-doping measures in Brazil. It is hoped that the system will contribute to raising athletes' awareness of the harm that doping can cause to their health.

This project also served as a case study to validate and optimize a new process (BRAP) created to specify requirements in agile projects. As to future research, we plan to evaluate the possibility of integrating this system with ADAMS. In addition, it is intended to provide a game for mobile devices that can in a fun way help athletes to keep themselves informed about what substances are prohibited.

Acknowledgments. This research was supported by CNPq (The National Council for Development, Science and Technology) by Notice 91/2013, nº 487777/2013-1, to whom we are grateful for making it possible for us to have the resources needed to carry out this project.

We thank the Brazilian Confederation of Equestrianism for being our partner for the submission of the project; the Brazilian Athletics Confederation for providing information and validating some functionalities of the system; the Confederations of Baseball, Boxing, Canoeing, Snow Sports, Fencing, Rugby and Taekwondo who took part in face-to-face interviews; and finally, the Brazilian Anti-Doping Authority (ABCD) for the institutional support needed to conduct this project.

References

1. ABCD. Activities Report 2012/2013. Available at: http://www.esporte.gov.br/arquivos/ascom/publicacoes/RelatorioABCDAtividades2012-2013PortuguesIngles.pdf. (2013)
2. Adams. Anti-Doping Administration & Management System, Release 4.0. Available at: https://www.wada-ama.org/en/what-we-do/adams. (2015)
3. Athlete Scholarship Program. Lei nº 13051 de 8 de dezembro de 2014 que inclui a não violação de regras anti-doping para o Programa Bolsa Atleta do Governo Federal do Brasil. Available at: http://www2.esporte.gov.br/arquivos/snear/bolsaAtleta/leiN13051.pdf. (2014)
4. COB. Brazilian Olympic Committee. 2015. Olympic, Bound and Recognised National Federations. Available at: http://www.cob.org.br/pt/Confederacoes. (2015)
5. Fowler, M. 2003. Padrões de Arquitetura de Aplicações Corporativas. Editora Bookman.
6. Lipicer, S. K. and McArdle, D. National law, domestic governance and global policy: a case study of anti-doping policy in Slovenia, International Journal of Sport Policy and Politics, 6 (1), pp. 71-87. (2014)
7. Medeiros, J.D.R.V., Vasconcelos, A.M.L. and Silva, C. Integration of Agile Practices: An approach to improve the quality of software specifications. XVIII CIBSE Ibero-American Conference on Software Engineering – Doctoral Symposium. Lima, Peru. Pp.859.865. (2015)
8. PMI. A Guide to the Project Management Body of Knowledge (PMBOK® Guide). Project Management Institute. Fifth Edition. ISBN13: 9781935589679. (2013)
9. Schwaber, K. SCRUM Development Process. OOPSLA'95 Workshop on Business Object Design and Implementation. Austin, Texas, USA: Springer-Verlag. (1995)
10. SCDP. Flow Chart – Doping Control Process. Available at: Available at: https://drive.google.com/open?id=0B-Nlp0nCynhJdGFBOE9Kal9PZTQ. (2015)
11. WADA. 2015. The World Anti-Doping Code - Prohibited list. https://www.wada-ama.org/en/resources/science-medicine/prohibited-list. (2015)

A Framework to Assess Information Security Quality of Service Based on a Communicative Action Way of Thinking

António Gonçalves[1] , Anacleto Correia[2], Rui Matos[3] and Bruno Fragoso[4]

[1]INESC-ID,
1000-029 Lisbon , Portugal
[1]Instituto Politécnico Setúbal,
2910-761 Setúbal, Portugal
[1]antonio.goncalves@estsetubal.ips.pt,
[2] CINAV,
2810-7001 Almada, Portugal
[2]cortez.correia@marinha.pt
[3]Business Research Unit - ISCTE-IUL
1649-026 Lisbon, Portugal
[3]rjms1@isctec.pt
[3]Business Research Unit - ISCTE-IUL
1649-026 Lisbon, Portugal
[4]Instituto Superior Técnico, UTL, Lisbon
1049-001 Lisbon, Portugal
[4]bruno.fragoso@tecnico.ulisboa.pt

Abstract. Several types of research suggested that the quality of service is a trade-off between customers' expectations and concrete delivered service. However, a gap between the customer´s belief and perceived service is usually found. In order to measure the gap in quality of service, a set of activities should be implemented. This paper presents a specific method for providing guidelines for quality of service set up and assessment. This method integrates preceding work regarding measurement theory. Unlike other solutions that emerge from task oriented perspectives, this approach adopted a human-oriented perspective. For this purpose, the DEMO framework is used. DEMO provides a coherent understanding on how communication among people takes place on an organization, based on the systemic notion of enterprise ontology. This paper also reports the instantiation, in the information security domain, of the measurement inception, the first activity of a set belonging to an overall proposed method.

Keywords: Information security, Enterprise Ontology, Activity Theory Measurement, Quality of Service.

1 Introduction

According to ISO/IEC 27001 the aim of information security services is to protect valuable organization information assets [1], i.e., to preserve information from

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_36

unauthorized access, use, modification, recording or destruction. For an organization, it is important to measure the effectiveness of information security services, i.e., the information security quality of service.

The perception of service quality, in general, can be ensured by measuring the gap between: first the clients' expectation; and last the perception attained after service delivery, in a number of criteria previously specified [2].

However, the proposed measures, should demonstrate whether they actually express the attributes they intended to characterize. Furthermore, it also requires the validation of measures throughout a grounded approach.

This paper details a method to assess and improve the quality of information security service based on a set of capture relevant measures. The rational is the quality of information security service, can be measured through a set of internal and external measurable attributes as well as the relationships between them. Similar approaches have been taken in other domains, namely in process quality and software quality.

The measures' derivation approach, should answer questions concerned with the information security quality of service on different phases of its life cycle, such as:

- Initial assessment of information security, namely the elicitation of strengths and weaknesses (e.g. the frequency and density of certain types of security leaks);
- Quality of Information security design, with definition of the measures concerned with internal characteristics of information security (e.g., number of open, closed and parked vulnerabilities);
- Best-practices implementation, by providing a rationale for techniques adoption (e.g., impact measurement of adoption of a certain technique for preventing breaches in information security).

The outline of this paper is as follows. Section 2 presents related work with the topic under study. Section 3 overviews DEMO, a modelling framework used to draw the proposed method. Section 4 describes our approach for measures' elicitation. Section 5 instantiate of the first step of the proposed method: the inception measurement phase. This phase is illustrated by a case study in section 6. We conclude with recommendations, based on the results and the problems found, as well as future work, in section 7.

2 Information Security Quality of Service Work

Baker et al. [4] elaborated a benchmarked regarding how organization manage information security by implementing several controls. Therefore, control implementation and quality implementation were discussed in detail.

Zhilin et al. [5] provided a deep insight into service quality instrument involving: usability, usefulness of content, adequacy of information, accessibility, and interaction. The study focused on measuring the service quality by analysing web portals and portal managers.

Parasuraman et al [6] specifically developed a conceptual model of behavioural and financial concerns of service quality. The portion of the model regarding quality intentions was empirically studied at the customer level in an organizational context.

GesKus and Dietz [7] evaluated DEMO for the purpose of developing Quality Management Systems (QMS), as well as applying DEMO to QMS on real-world experiences. They described the hindrances on defining high-quality services

deliveries of a company. They conclude that using DEMO results in an increase of commitment from subjects.
Pitt et al. [8] describe The SERVQUAL service quality model. The authors initially recognized ten components of service quality, but later, these were grouped into five components: reliability, assurance, tangibles, empathy and responsiveness. SERVQUAL measures both the customer expectations of service quality and their perceptions regarding what was received.
Gordon et al. [9] describe a model that determines the optimal investment to protect information. They observe the vulnerability of the information to a security breaks and the possible damage should such a break happen.
Finally, Arkin et al. [10] focused on the topics of software security and security risk. They acknowledge that the broad objective of tests in organizations is ensuring that software application fulfills its functional business requirements. They also point out that security testing doesn't directly fit into this approach.

3 Summary of the DEMO Theory

DEMO is a communicative action approach used to provide a means of dealing with the complexity of the definition of security services information [11]. DEMO can offer firm, broad, concise and accurate models through an ontological model of a service, which emphasizes its essential definition, without details regarding people or technology. Using DEMO leads to reductions of over 80% in models' complexity (i.e. in terms of the size of produced services' models) when compared with other approaches [11].
DEMO uses different concepts to show a service. Central parts are actor roles and transactions. Transactions among actor roles are described in the social interactions patterns between people. Once a transaction is completed, something new, named a production fact is formed. A distinctive subject in an organization can match one or more actor roles, but one actor role is in charge for a single production fact. One transaction contains several process steps: request, promise, execute, state and accept.
DEMO is supported on Ψ-theory (Performance in Social Interaction) that describes organisations primarily as social systems [11] and is based on the theory of Communicative Action of Habermas and on Speech Act Theory [11].
The Ψ-theory defines human communication as the essence of information and (social) action, and consequently of an organisation, of which the elements are human beings, presented with appropriate authority and bearing the corresponding responsibility. According to the Ψ theory, through social interactions, people engage in obligations. The obligations are concerned with actions to be taken, related to agreed results for actions. Social interactions occur via acts of coordination through language that can be understood as an action.

3.1 DEMO Model to Derive Information Security Measures

To define measures for information security quality of services (i.e., the source of data in the measurement process) goals were formulated using the DEMO model, presented in figure 1. The suggested DEMO model is grounded in measures'

definition and validation framework proposed by Correia for process models measurement [12].

We undertake that measures derivation is capture across a set of four transactions: from T01 to T04 that has the following description (fig 1):

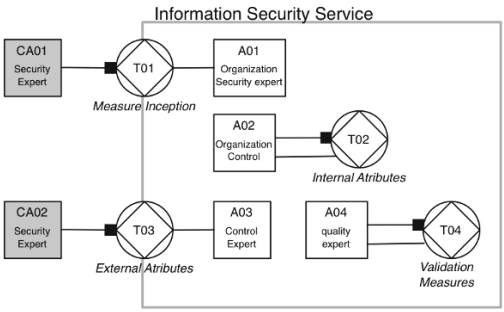


Fig. 1. DEMO model to derive information security measures for quality of service.

- **T01 - Measurement inception.** The objective is to capture from experts, measures' goals based on their knowledge concerning best practices of information security services. Driven by measurement goals, a set of intuitive suggestions is established in order to emphasize the relation between internal attributes of service (internal security practices) and external attributes of the same models (visible evidence of security breaks). For instance, for predicting an information security measurement goal regarding the unavailability of assets, an approach could be conjecturing the association between the time needed to test assets' security and the criticality of those assets;

- **T02 - Definition of central measures for internal attributes.** This transaction assesses the fitness of central measures for assigning the internal attributes features of a specific service. Internal attributes define issues that are presumed to have a relationship among external attributes. Internal attributes are described by a set of mathematical characteristics. The proof of a central measure is a prescribed method to validate a measure, concerning the properties as generic as possible of internal attributes. Reinforced by those properties, central measures are well-defined, as well as the measurement method that must be achieved over an established of predefined information security characteristics. For instance, the time spent on software systems maintenance, patching security vulnerabilities, is an internal attribute of an information security service whose base measure could be defined by the percentage of data breach occurred regarding the total of security incidents;

- **T03 - Definition of indirect measures for external attributes**. The external attributes are property features of a specific service apply to an asset (e.g. measures to prevent sensitive information from attainment the incorrect subjects, while making sure that the right people can obtain it). Those are the qualities that a service should convey when they are in use, namely by experts either for documenting sake or for service enactment. This transaction must assess whether the indirect measures adequately capture the external attributes;

- **T04 - Experimental validation of measures**. The intuitive hypotheses give way to grounded empirical hypotheses. The experimental hypotheses are confirmed by the measures defined for the internal and external attributes. The empirical hypotheses are a refinement of the intuitive hypotheses by providing a detailed meaning for the association between central and indirect measures used to build the prognostic model. The level of statistical meaning of results defines the suitability of the predictive model.

We state that secure service quality model is a result of an engineering process that can be analysed as a set of transactions described using DEMO model. This model can be used to capture the best practices of the service, such as subject collaboration, social rules, a division of work and tools).

4 Scope of the Work and Description of Method

A DEMO transaction (figure 2) denotes that the acts performed by agents occur only in universal standards steps of coordination and production acts and results in a creation of a coordination and productions facts [11]. The default transaction consists of the following coordination acts: request, commitment, statement and acceptance. It features two actors, each with a distinct role: The initiator, who initiates and completes the transaction; and the performer, who performs the act of production. Fig. 2 presents all steps of transaction T01 of measurement inception, the one this study is focused on.

According to DEMO, it is possible to interpret T01 measurement inception as consisting of both action and interactions. An action that brings about a new measurements goals. These measurement goals result of interactions (i.e. communications acts) directed at negotiations and commitments by the initiator and executor actors.

For that purpose, they need responses to questions regarding the information security quality of service. Since it is also needed a specification for the interpretation of the collected data, the derivation of measures should occur from explicit goals. For this reason, we choose to use the Goal Question Metric (GQM) [13] approach.

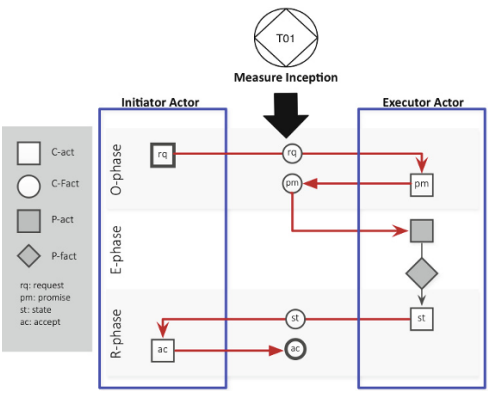


Fig 2 Model of a Transaction

4.1 Goal Question Metric

GQM is built aiming to fill the break among goals and measures in a prepared way by means of questions and models. GQM reinforce that the measurement goals should be graded, such as observed significance to the middle goals, and their feasibility regarding the building of a prediction model. GQM delivers a pattern and rules to describe measurement goals and enhance them into tangible and truthful issues, which afterward lead to the characterization of measures. According to the GQM goal template, measurement goals have a perspective, a purpose, and an environment.
The outcome of the use of the Goal Question Metric method application is the description of a measurement system targeting a particular set of topics and rules for the explanation of the measurement data. The resulting measurement model has three levels (figure 3): conceptual level; operations level and quantitative level.

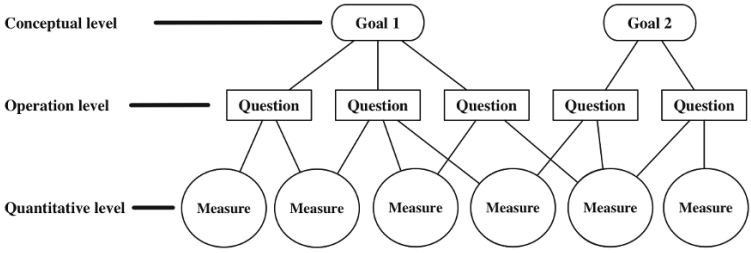


Fig. 3. GQM approach.

4.1.1 Capturing measures

A GQM model is established by recognizing a group of quality goals. From those goals and based upon the security concepts, questions are derived as completely as possible. For characterizing the service with respect to a group of quality concerns (e.g., integrity, communication, etc.), a quality model must be derived for manage those matters (e.g., access, identity, etc.). Questions try to define the service process to be measured, regarding a selected quality issues, and from a particular perspective. The next step consists in specifying the measures that are required for answering those questions, and to track the conformance to the goals. Once the measures have been quantified, we need to acquire the data collection artefacts, including proof and examination. A set of data is related with every question in order to answer it in a measurable manner.
It is the key to ensuring a settlement on the base set of properties that the perceptive measurement procedures of common internal attributes should have. This will assist researchers subject to use the same vocabulary when developing their measures. The intuitive measurement artefact defines the truth on which measurement is development, common sense and understanding of the service models' attributes under measurement.

5 Running an Experiment

For the purpose of applying the study to a real case, a survey to information security experts was conducted. The experts have a wide range of expertise providing information security services.
In the following, a set of business goals of an organization, defined at conceptual level guided the derivation of aligned security services' measure.

5.1 Measurement Goals

Two measurement goals were defined for this case study: *reliability* and *communication*. Service reliability encompasses service availability required by customer (accessibility); service uninterruptedly over the desired duration (continuity); meeting the customers' expectations (performance). This is an important goal since, inevitably, at some point real service can be less disposal. Thus, the challenge is to tolerate failures as it occurs and recover from its effects.

Reliability:	
Analyse the:	Delivered service
For the purpose of:	Understanding
With respect to:	Reliability and its causes
From the viewpoint of:	Security service team provider
In the following	Pen testing service

Service communication helps to coordinate subject work. This is a major goal due to the fact that the practice of work constitute part of the tacit knowledge and is carried out with the aim of contributing to the satisfaction of needs [14]. Beyer [15] states that understanding how people work is not so simple. Given the overwhelming complexity of the work, when people have to describe what they do, they simplify.

Communication:	
Analyse the:	Development process
For the purpose of:	Understanding
With respect to:	Effectiveness of reporting
From the viewpoint of:	Security service team provider
In the following context:	Pen testing service

5.2 Questions addressed

The reliability goal will be attained by answering the following questions. Detailed questions focusing the practical aspects of the project are specified during the survey: **Q.1:** What are the controls for the execution of secure information service? This question centres on recognizing concrete figures related to the service, when associations between all involved elements are well defined and values accessible; **Q.2**: What are the characteristics of an organization asset, in order to obtain an optimal effect of a service? This question focuses on the definition of criteria that define whether an expert will obtain the required effects and will give an answer to which characteristics a certain organization should hold in order to result in a specified result of a service; **Q.3**: What is the quality acceptance criteria after a service? This question focuses on the possibility to identify if an evaluated asset has an acceptable quality level. Therefore, it should be investigated whether criteria can be defined to which the performance of an asset must be met in order to identify an acceptable quality level. This question is answered when the possibilities for such criteria are understood, and when possible values to those criteria are known; **Q.4**: Are experts usefully and efficiently training organization's subjects? This issue is addressed when all learning skills have been recognized, and their results can be quantified.

The communication goal will be attained when answers can be given to the following questions: **Q.1:** What are the characteristics of a service provider must have, in order to obtain optimal communication with members of diverse knowledge workforce in order to respect differences and help achieve organizational and individual goals? This question centres on recognizing objective and countable numbers that are connected to the service, when the associations, related to the service, between all involved elements are well defined and values are accessible; **Q.2:** What are the characteristics of the communication patterns in order to design virtual workspaces for customers that have people in several places? This question centres on recognizing what are the adequate communication means to transfer information from service provider to customer. It should have several forms related to the service, such as intrapersonal and bulk communication; **Q.3:** What are the characteristics of a communication in order to understand the difference between customer expectations and service provider perceptions of customer requirements? **Q.4:** What is the inconsistency between the requirements for communication and actual communication delivery service? This question centres on recognizing how customer and provider function as a team and accomplish their goals by allowing members to participate in decisions and share group's success.

The selected measures should be the best representing the factors that lead to increase results in care; improved customer, operational, and financial performance; and objective data to support claims of quality.

5.3 Data collection and Interpretation

For data collection, a survey with a set of questions, using answers following 5-point Likert scale [16] was used, with a value of 1 representing a very low trust level and a value of 5 meaning a very high trust level. 25 interviews were collected. The final feedback session for this measurement programme took four months since inception.
The posed questions resulted in the following direct measures for the reliability goal: M.1: The number of resources unavailable; M.2: The ratio of successful service over total services in a customer; M.3: The number of complaints from group customers; M.4: The number of outages; M.5: The number of successful attempts that are completed within a specified period of time; M.6: The number of services successfully initiated; M.7: The total delay time during service, during setup, after setup and distortion.
For the communication goal, the following direct measures also resulted: M.1: Number of vulnerabilities that require priority attention; M.2: Number of vulnerabilities that are closed; M.3: Number of vulnerabilities that are open; M.4: Number of vulnerabilities that are close by customer and open again by provider; M.5: Number of customer requests that cannot be fulfils.
The two goals of the measurement activities were to understand product and process reliability, and the effects of reuse. The results of the measurements were not only presentations of empirical data regarding these subjects, but also conclusions where of actions taken by project team members based on measurement information.

6 Conclusions

This work addresses the measurement of information security quality service. Since information security is such a broad domain, the work was focused on the specific topic of information security named penetration testing.
DEMO was used do describe the main steps of a model for measures derivation, detailing the first step of measurement inception. The main objective of measurement inception was the capture experts' knowledge about the information security quality. This knowledge was expressed into organization measurement goals that establish the threshold for quality of service.
In this work two measurements goals were addressed: *reliability* and *communication*. Reliability is important since, during service provisioning, it can fail. So, quality of service relates the client's tolerance to failures and the capability of a provider to recover from its effects. C*ommunication* is also important because it contributes to improving work coordination and understanding the complexity of people's work. The measurement of the two goals enables the assessment of business continuity and business damage minimization and the prevention and minimization of incidents' impact.
DEMO method allowed outlining the steps of the framework through the description of main transactions involved in the capture of service quality measures and the delimitation the study to the specific domain of information security. On the other hand, GQM contributed to bridge the gap between goals and measures and mitigation the difficulty of specifying security in measurable terms.

References

1. Fenz, S., Goluch, G., Ekelhart, A., Riedl, B., Weippl, E.: Information security fortification by ontological mapping of the ISO/IEC 27001 standard. In: Dependable Computing, 2007. PRDC 2007. 13th Pacific Rim International Symposium on. pp. 381–388. IEEE (2007).
2. Brown, T.J., Churchill, G.A., Peter, J.P.: Improving the measurement of service quality. J. Retail. 69, 127–139 (1993).
3. Goncalves, A., Correia, A., Fernandes, J.: Service elicitation of non-functional requirements: An approach using activity theory. In: Information Systems and Technologies (CISTI), 2015 10th Iberian Conference on. pp. 1–7. IEEE (2015).
4. Baker, W.H., Wallace, L.: Is information security under control?: Investigating quality in information security management. Secure. Privacy, IEEE. 5, 36–44 (2007).
5. Yang, Z., Cai, S., Zhou, Z., Zhou, N.: Development and validation of an instrument to measure user perceived service quality of information presenting Web portals. Inf. Manag. 42, 575–589 (2005).
6. Parasuraman, A., Zeithaml, V.A., Berry, L.L.: A conceptual model of service quality and its implications for future research. J. Mark. 41–50 (1985).
7. Geskus, J., Dietz, J.: Developing Quality Management Systems with DEMO. In: Aalst, W., Mylopoulos, J., Rosemann, M., Shaw, M., Szyperski, C., Albani, A., Barjis, J., and Dietz, J. (eds.) Advances in Enterprise Engineering III SE - Lecture Notes in Business Information Processing. pp. 130–142. Springer Berlin Heidelberg, Berlin, Heidelberg (2009).
8. Pitt, L.F., Watson, R.T., Kavan, C.B.: Service quality: a measure of information systems effectiveness. MIS Q. 173–187 (1995).
9. Gordon, L.A., Loeb, M.P.: The economics of information security investment. ACM Trans. Inf. Syst. Secur. 5, 438–457 (2002).
10. Arkin, B., Stender, S., McGraw, G.: Software penetration testing. IEEE Secur. Priv. 3, 84–87 (2005).
11. Dietz, J.: Enterprise Ontology: Theory and Methodology. Springer (2006).
12. Correia, A.C. e: Quality of process modeling using BPMN: a model-driven approach, http://run.unl.pt/handle/10362/12205, (2014).
13. Basili, V.R.: Software modeling and measurement: the Goal/Question/Metric paradigm. (1992).
14. Polanyi, M.: Tacit Dimension. Peter Smith Publisher Inc (1983).
15. Beyer, H., Holtzblatt, K.: Contextual design. interactions. 6, 32–42 (1999).
16. Boone, H.N., Boone, D.A.: Analyzing likert data. J. Ext. 50, 1–5 (2012).

A Business and IT Architecture Model Supporting Public Organizations Introducing Language Technologies

Martin Henkel, Erik Perjons and Eriks Sneiders,

Department of Computer and Systems Sciences
Stockholm University
Forum 100, SE-164 40 Kista, Sweden
{perjons, martinh, eriks}@ dsv.su.se

Abstract. Language technologies and tools, such as text mining, information extraction, and question and answering systems, are becoming mature and should be ready for deployment in public organizations. However, it is not obvious how these technologies can be applied for improving customer service and case handling processes as well as supporting an organization's pro-activeness and strategic decisions. In this paper, we present a business and IT architecture model. The model introduces an overview of the roles, information and IT systems commonly used in public organizations for citizens' interaction. We furthermore extend the model to show how language technologies can be used for supporting operational and strategic processes in public organizations. The model and its extension are based on and exemplified by cases from Swedish public organizations.

Keywords: language technology, business architecture, IT architecture, business cases, eGovernment, business intelligence

1 Introduction

Many different requirements are facing public organizations of today. First, they need to provide high quality services for citizens and private organizations. Second, they need to be efficient in order to use public resources in a responsible way. Third, they need to be open [1], meaning exposed to public scrutiny; accessible to everyone from different communications channels; and responsive to new ideas and demands. Forth, they need to handle formal cases in a fair way. Therefore, public organizations employ a wide range of means, not at least IT systems. Examples of IT systems used in public organizations are case management systems for managing applications from citizens, workflow systems for efficient routing of documents, different types of web applications and e-services for interaction with the citizens, and business intelligence solutions for supporting strategic decisions.

The use of IT systems in public organizations is, however, not optimal. For example, citizens may need to wait for weeks and months for certain services; may need to wait for hours in telephone queues for asking basic questions; and may receive confusing and inconsistent answers from public officers. Moreover; public

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_37

organization may need to spend a large amount of resources to manage unstructured information, and may need to be reactive instead of proactive.

New technologies can address the described problems, if they are properly introduced in public organizations. One promising group of technologies that we focus on in this paper is language technologies. These technologies are now mature enough to have a significant impact on business processes and services. They can be applied as new IT systems or as part of existing ones, such as a case management system. Language technologies can also be combined in order to provide a more beneficial solution for an organization. In this paper we define language technology as a technique for processing human language, including semantic techniques (e.g. natural language processing and information extraction), statistical techniques (e.g. text retrieval and text mining), or a combination of these.

The large number of existing language technologies and solutions - stand-alone, combined, and integrated with other IT systems - makes it hard for both business and IT managers in public organization to understand "what" language technologies to use in a public organization, "how" language technologies can be used in full, and "why" language technologies should be used. In this paper, we present a business and IT architecture model supporting business and IT managers to choose an appropriate mix of language technologies in a public organization. The contribution of the paper is:

- A high-level graphical business and IT architecture model of public organizations showing roles, main information flows and IT systems. The model focus is on describing the interaction with citizens in form of customer services and case handling.
- An extension of the model to show how language technologies fit into the model, and how language technology can be used to address existing problems.

Note that a full description of language technologies is not included in this paper, a full description of the state-of art regarding the language technologies use cases presented in this paper can be found in our previous paper, see [2].

The model and its extension is based on an analysis of customer services and case management processes in Swedish public organizations. The analysis has been carried out as part of a research project, called IMAN2. The IMAN2 project's goal was to develop innovative e-government solutions for customer service and case management processes by the use of language technologies, with the aim to simplify and improve the interaction between public organizations and the actors they serve, such as citizens and organizations, both private and public. The project is a collaboration between researchers in language technology at Stockholm university, Sweden, Royal Institute of Technology, Sweden, the business intelligence company Gavagai, the process improvement company Visuera, and the IT consultant company Cybercom. Moreover, the project includes a number of Swedish public organizations on national as well as local level: the Swedish Transport Administration, the Swedish Pension Agency, and a number of local governmental organizations: the municipalities of Klippan, Kungsbacka, Nacka, and Söderhamn. These public organizations need a well structured way of managing citizen services and case management processes. They have all seen language technologies as promising solutions. The role of these public organizations in the IMAN2 project is to provide research issues to the project based on analysis of their citizen services and case

management processes, and to participate in design of solutions based on language technologies. These organizations will also act as test beds for designed solutions, i.e. software prototypes that the project aims to develop. In this paper we also include some experiences from a previous research project, IMAIL, in which the Swedish Social Security Agency participated [3].

The paper is structured as follows: Section 2 and 3 describes the research methodology used and related research. Section 4 presents the business and IT architecture model. Section 5 presents how the use of language technologies impacts the architecture. Finally, Section 6 concludes the paper.

2 Research Approach

The research methodology used in the research presented in this paper is design science research. Design science is carried out to change the state of affairs by designing and using an innovative artifact. Commonly, the design science process consists of several activities that lead to an artifact. We use the activities presented by [4]. *To identify current problems* and the *scope of a solution* we engaged the project participants in process modeling workshops, where existing business practices and IT systems where discussed and problems identified. The next step in the research project was the *design and development of the solution* in form of the architecture model. The artifact presented in this paper, that is, the business and IT architecture model and its extension are mainly based on actions and discussions going on in the IMAN2 project, including all participants: researchers, system developers, business and IT consultants and managers within public organizations. The model and its extension were *demonstrated* by presenting real case example(s) and how it relates to the model. These examples were based on a process analysis and the design of the use cases in the participating public organizations in the IMAN2 project. In this paper, the *evaluation* is presented in form a so called informed argument, where the researchers discuss if the model solves the identified problem. An evaluation where business and IT managers in public organization are asked to express their opinions regarding the model is planned to be carried out at a later state.

3 Related Research

The work in this paper relates to *models of e-government* and *ICT architectures* for case management in public organizations. Generally, e-government refers to the use of ICT to improve public organizations. The improvement can be in the form of several "functions", such as efficiency, improved interaction with citizens and transparency [5]. Models of e-government explains how e-government can be performed and how to improve e-government. An appropriate architecture of ICT systems helps to fulfill the promises of e-government.

Several theoretical *models for e-government* have been proposed, the most well know being the four stage model as proposed by Layne and Lee [6]. These models commonly describe how e-government can progress from an initial web presence into

the ICT supported interaction between citizens and public organizations [6]. In this progression, ICT is seen an enabler that improves efficiency and administration capabilities [7]. However, ICT development within e-government programmes has been criticized for the use of generic "universal strategies" when trying to reach efficiencies [8]. In this paper we do not apply a specific prescriptive e-government development framework, we rather examine and describe the current practices with regards of case handling in public organizations. Furthermore, we avoid prescribing universal strategies by focusing on concrete issues and means to overcome them (in the form of language technologies). The contribution of this paper, the business and IT architecture model, can be used as a concrete part of an existing e-government framework, or as a standalone tool.

Even though there exist numerous commercial systems that especially target case management in public organizations, surprisingly little research have been done into how these systems are used in practice. However, several authors have suggested IT architectures that may help public organizations. Dias & Rafael [9] suggest a division into a front-office and a back-office system, serving the same purpose as we have found in the form of Web forms and Case handling systems. Another example is Salhofer & Ferbas [10] that proposes an architecture that allow the use of process descriptions, this is similar to what existing commercial case handling systems are offering. Moreover some guidelines existing for governing the utilization of e-government service platforms [11]. To the best of our knowledge, there is no previous research describing the business and ICT architecture of Swedish public organizations. Our contribution is to firstly examine what type of systems are in use, and which roles that are actually using them. Secondly we suggest an extension to this architecture model by suggesting how several issues could be solved by the introduction of language technologies.

4 The Business and IT architecture of Public Organizations

Public organizations handle different types of incoming request form the citizens, ranging from small routine request for information to complex cases that require extended interaction. The case handling in public organizations are managed by having clearly defined roles for the actors involved, as well as having IT support for case handling. Based on our experience within the IMAN2 project we have identified two main types of case processes, and a number of supporting IT systems that are used.

Generally, the two types of requests can be distinguished are; *general questions* and *formal case requests*.

A *general question* is a request for information about the public organization and its services. For example, a citizen can ask which plans exist to build block of apartments or highways in the neighborhoods of the citizen, or how to apply for a driving license.

A *formal case request* is a request for access to certain services that require some form of formal investigation at the public organization. For example, a citizen can request a permission to build a house on a certain property, or request extra support at home for a person that is not able to manage cocking and cleaning. This type of

request is regulated by national and/or regional laws and/or rules. This type of request commonly starts a formal case process in which an officer investigates the request and checks if it is compliant with the national and/or regional laws and rules, and then make a decision about the citizen's right to access the service.

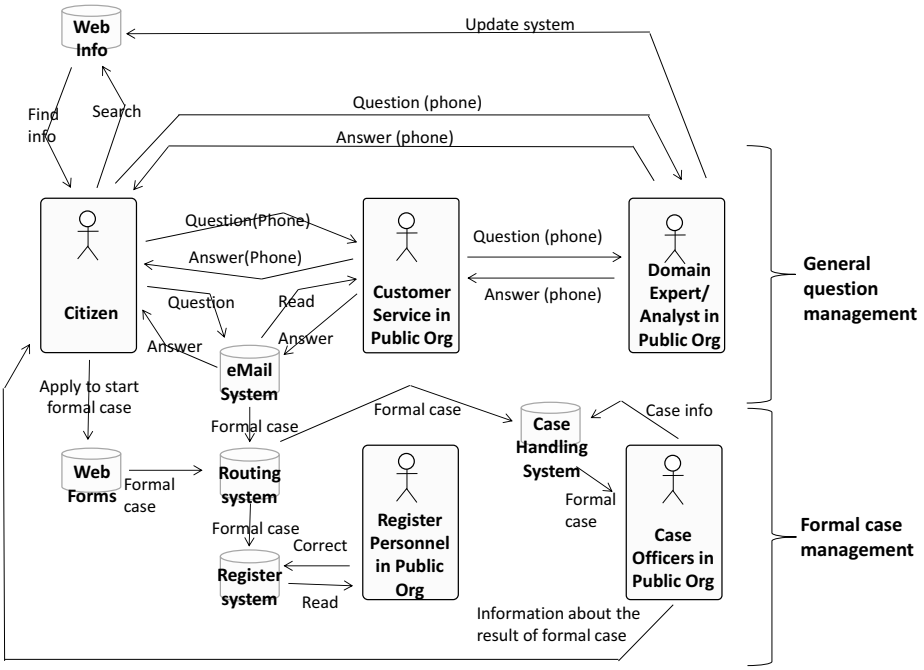


Fig 1. Overview of the case handling in form of general questions and formal case request, roles, and IT support systems

These two types of requests need to be managed by public organizations. Figure 1 describes somewhat simplified how a traditional public organization manage these two types of request. General questions are often managed by a customer service in the public organization. For example, a citizen contacts the customer service via telephone. The service officer at the customer service can answer the question, or make use of domain experts in the public organization if the service officer does not have the skill set to answer the questions. In many organizations, the citizens can also contact the domain expert directly, often via a telephone operator that direct the citizen to the right expert. Some general questions result in a formal case requests, see Figure 1. The citizens can also directly contact the public organization for a formal case request, via phone or mail. Formal case request are registered in a register system of the public organization, and the management of these formal request are usually supported by a case management systems. Formal cases are often carried out by case worker, a role that can be played by the same person as is playing the role of domain expert, mentioned above. The case worker will also contact the citizen via phone and

mail to inform the result of the formal request. The process of managing formal cases is described in Figure 1 as well.

The management of the two types of requests in a traditional public organization, described above, is not optimal. Different type of IT solutions can be introduced for a more effective management of the requests, see Figure 1:

- **Web Info.** A public web site with info, for example Frequently Asked Questions, can give the citizens easy access to answers of often asked questions. An example of a web info system is the extensive information that the Swedish Tax Agency has published on their web site.
- **An eMail System.** Questions from citizens can be sent to the customer service via email. These questions via email can be forwarded to a domain expert. For example, the Social Security Agency receives requests on issues related to parental leave and sickness leave via mail.
- **Web Forms**. Web forms on a public web site can be used for formal case requests. For example, tax declarations can be filed to the Tax Agency by using their online forms.
- **A register system.** This system is used to have a formal registry of all formal cases that are handled. Usually, each case is given a unique case number that is public. All Swedish public organization are required to have a registry that contains the formal cases.
- **A case handling system.** This system supports the handling of the cases, for example by providing workflow and/or content management support. For example, most Swedish municipalities, such as Klippan and Nacka, has a case handling system that support the operational handling of cases.
- **A routing system.** A routing system can be introduced to integrate the web forms, the register system and the case handling systems, so that a case can automatically be registered in the register system as well as automatically be started in the case management systems when a citizen post a formal case request via a public web form. This type of system is more seldomly used, instead routing is done manually. For example the Transport Administration performs manual routing of 2000 request per month.

When introducing new technologies, such as language technologies, the existing roles, way of working and the IT systems may be affected. In the following section we will examine how the use of language technologies may affect the existing IT systems.

5 Operational and Strategic use of Language Technologies

This section describes a set of use cases, each use case describing a possible use of language technologies in public organizations. The use cases can be used by business and IT managers in order to better understand what language technologies can be applied in their organizations, and how they affect the presented architecture. Note that we in this paper focus on the language technologies impact on the architecture,

for technical details about language technologies state of art please refer to [2]. The business cases impact on the business and IT architecture are visualized in Figure 2.

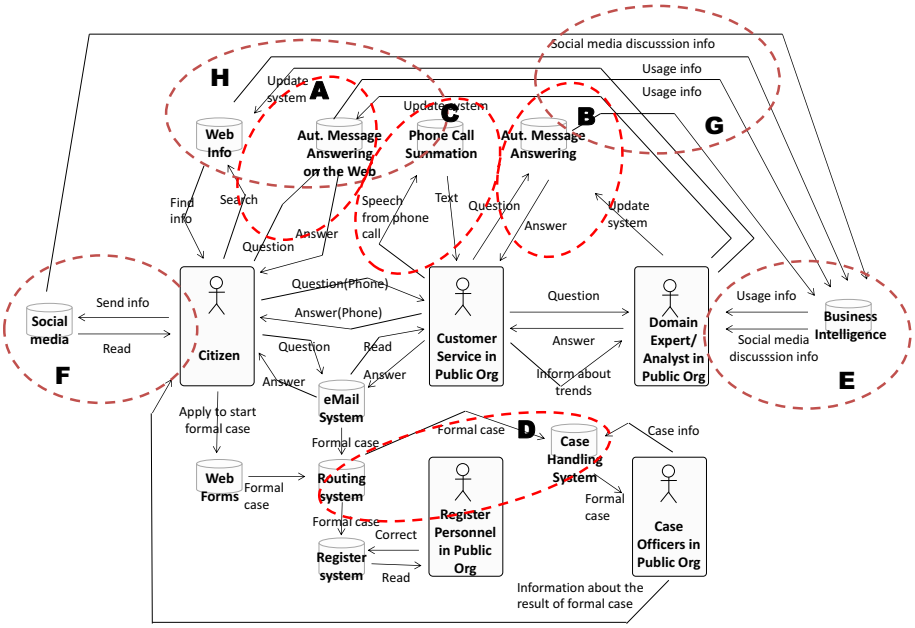


Fig 2. Language technology businesses cases, positioned in the architecture

5.1 Automatic and Semi-Automatic Message Answering

Automatic message answering is a business case in which citizens' requests for information are managed automatically by a system sending back answers instantaneously without human involvement (see A in Figure 2). Such a system can also be used by customer service agents (see B in Figure 2). A semi-automatic message answering system is a system suggesting answers to the users which can choose among different suggested answers and/or can edit the suggested answers.

Effects on IT system types: Modules for automatic message answering can be connected to the *e-mail* and *web forms* systems that public organizations use. The benefit with using this use case in combination with web forms is that the citizen immediately can get an answer on the web, and based on this decide to send a new request or not. The use case, when applied in an ACM setting as described above, can be used in tandem with a *case handling system*.

Real Case Example: The Swedish Pension Agency estimates that it takes around 10 minutes to answer an email. They want to lower that time to 7.5 minutes with the introduction of a semi-automated message answering system. The message answering

system will suggest templates to the service agent with different answers given the type of questions in the email. The service agent will then choose a template and adapt it given the question from the citizen, before sending the answer to the citizen. The Swedish Pension Agency are in the state of introducing the system, and estimates to create around 25-30 templates to be used in the system. The goal is that these templates should be able to be used in 10-20 percent of all of the email questions from citizens. An important part of the semi-automated message answering system is to maintain the templates. However, no organization has been designed for that yet in the agency, but at least one employee will be responsible for maintaining the templates.

5.2 Phone Call Summation

Phone call summation is a business case in which a telephone conversation between a public agent and citizens or employees in private organization is automatically transformed into a written summary by a system, thereby providing a documentation of the conversation in text form (see C in Figure 2).

Effects on IT system types: A natural point for integrating of a call summation system would be to integrate it with the system being used while a case agent has a conversation with a citizen. Based on the system types identified earlier, a call summation system would fit well with a *case handling system*.

Real Case Example: The Swedish Pension Agency handles request via both mail, e-mail and phone. Particularly elderly people are inclined to ask questions via phone. With the use of call summation it would be possible to extract structured information from the phone call and use that before, while and after handling the requests. For example, one type of case that the pension agency handles is applications for housing supplementary allowances. While in contact with an agent, the system could aid the case handler to document what is being said. Today this kind of documentation is done manually and partially after the conversation has ended. With support for text summation it would be possible to perform the documentation automatically, allowing the agent to focus on the conversation. The Swedish Pension Agency might implement such a solution in the future.

5.3 Case Routing

Business case description: Case routing is a business case in which a case is automatically routed by a system to an expert with the right knowledge to handle the case (see D in Figure 2). The categorization can both be based on meta-data, such as the form used for the request, and on free text contained in the request.

Effects on IT system types: Case routing provides the means to build, or extend an existing *routing system*. Based on the experiences of the organization participating in the IMAN2 project, it is however likely that language technology based case routing will extend existing *case handling* systems.

Real Case Example: The Swedish Transport Administration handles about 2 000 written request per month. The agents handling as well as the requests are divided into customer services and case handling officers. The customer service handles request that can be quickly resolved, for example, requests regarding the current highway

status, temporary routes. The case handling officers handles cases concerned with a number of sub-categories: railway, highways, ferries, transport logistics and large projects. One possible use of automatic case routing would be to first sift out the "small" cases that the customer service can handle promptly. The remaining cases could then be routed to a case handling officer. The category "large projects" are an example of a category that is changed often, and thus an automatic categorization must be updated to cover new projects as they are planned. An example of a project in the domain of the transport administration is the creation of a new turnpike. The creation of a new turnpike could cause a lot of questions from the citizens.

5.4 Citizen Intelligence Analysis

Business case description: Citizen intelligence analysis is a business case in which external information that affects an organizations activities are collected. This information is analyzed to make long-term strategic decision and short-term resource reallocations. Analysis can be based on sources such as newspapers, TV and radio channels, and on information from social media. Figure 2 shows how information is gathered via the public organizations agents' interaction with the citizens during telephone calls, and email communication (see G in Figure 2), and then analyzed in a business intelligence system (see E in Figure 2). BI can be defined as an umbrella term that is commonly used to describe the technologies, applications, and processes for gathering, storing, accessing, and analyzing data to help users make better decisions [12]. In this example, text summation is a useful tool for supporting the analysis, since telephone calls can be easily analyzed when transformed into text. Moreover, analyzing the public use of automatic and semi-automatic question answering system (see H in Figure 2) can also be used for better understanding the interests and needs of citizens. Finally, social media (see F in Figure 2) can be used to identify trends that can influence the public organization.

Effects on IT system types: Intelligence analysis does not fit well with the initial system types identified in the IMAN2 project. The reason is that the system types used are mostly focused on the operational perspective, that is, they support day to day activities. However, software for intelligence analysis would fit well with a business intelligence system, see E in Figure 2.

Real Case Example: The customer support at the *Swedish Pensions Agency* is highly dependent on its environment in the form of traditional and social media. For example if a minister make an announcement about desired changes in the pension system, the customer support will immediately get a lot of phone calls about how this affect the individual retiree. By the use of business environment analysis it is possible to monitor traditional press and social media to early discover if a debate is rising. This would allow the pension agency to allocate the necessary resources to their customer support.

5.5 Sentiment Analysis

Business case description: Ordinary categorization of cases gives a structured way of sorting and analyzing data based on what the case contains. However, when using traditional categorization it is easy to firstly miss how customers express values and

opinions about offered services. Secondly, by using pre-defined categories it might also be easy to miss details in the cases. Sentiment analysis is a business case in which customer views and sentiments are collected during the interaction with customers (See G and F in Figure 2). Existing language technologies can support sentiment extraction from text that is aimed at expressing an opinion, such as reviews, but also from a more general text that is not focused on expressing an opinion, but still might do [13].

Effects on IT system types: Sentiment analysis software can be interconnected with systems that store requests formulated in somewhat free form by citizens. *E-mail* systems, and *case handling systems* are appropriate sources for analysis if they contain the requests as formulated by the citizens, while a request that is made by filling in a standardized and rigid form in is not suitable for analysis.

Real Case Example: The *municipality of Kungsbacka* is interested to identify ongoing discussions in social media about services provided by Kungsbacka municipality, especially the citizens' value and expectation about the services, in order to become a more pro-active municipality. A first prototype of such a solution has been presented to Kungsbacka, and a discussion has been started to test the prototype in a real setting.

6 Conclusions

Public organizations are under the pressure to serve citizens request swiftly and with high quality. While many public organizations have, and are developing, online services that give citizen direct access to information there is still a need to improve how the handling of information requests are done. In this paper we highlight the possibility of using language technologies to improve operational and strategic processes in public organisations. We present a business and IT architecture model. The model introduces an overview of the roles, information and IT systems commonly used in public organizations for citizens' interaction. We furthermore extend the model to show how language technologies can be used for supporting processes in public organizations. Both the model and its extension are grounded in Swedish public organisations via the IMAN2 project.

The model and the extended model aim to be understandable and applicable. Introducing two common requests types (general and formal), as well as a set of roles and typical IT systems make it easy to discuss and describe a public organisations current way of working. Furthermore, by using the model it is possible to discuss how new technologies could be applied. The extended model describes how language technologies can be used in order to solve problems, thereby helping organisation to decide if they should apply language technologies or not. The model can be further extended by including new technologies.

Acknowledgements. The IMAN2 project is partially funded by the Swedish Innovation Agency (Vinnova). The authors would like to thank the participants of the IMAN2 project, in particular the participating public organizations.

References

1. EOP - Executive Office of the President: Transparency and Open Government, A Presidential Document by the Executive Office of the President. Document number E9-1777, Federal register of the United States of America. Available via https://federalregister.gov/a/E9-1777 (2009)
2. Henkel, M., Perjons, E., Sneiders, E., Karlgren, J., Boye, J., Thelemyr, A.: Language Technology for eGovernment – Business Cases. In New Perspectives in Information Systems and Technologies, Volume 1 (pp. 83--95). Springer International Publishing, (2014)
3. Cerratto-Pargman, T., Knutsson, O., Celikten, E., Sneiders, E., Dalianis, E.: User centered development of automatic e-mail answering for the public sector. In New Horizons in Creative Open Software, Multimedia, Human Factors and Software Engineering. LNCS, Springer, Berlin (2011)
4. Peffers, K., Tuunanen, T, Rothenberger, M.A. and Chatterjee, S.: A Design Science research methodology for information systems research. Journal of Management Information Systems. 24 (3), pp45--77 (2007)
5. Yildiz, M.: E-government research: Reviewing the literature, limitations, and ways forward. Government Information Quarterly, 24(3), pp 646--665 (2007)
6. Layne, K., Lee, J.: Developing fully functional E-government: A four stage model. Government information quarterly, 18(2), pp. 122--136 (2001)
7. Coursey, D., Norris, D. F.: Models of e-government: Are they correct? An empirical assessment. Public administration review, 68(3), pp. 523—536 (2008)
7. Dunleavy, P., Margetts, H., Bastow, S., Tinkler, J.: New public management is dead - long live digital-era governance. Journal of public administration research and theory, 16(3), pp. 467—494 (2006)
8. Cordella, A., Iannacci, F.: Information systems in the public sector: The e-Government enactment framework. The Journal of Strategic Information Systems, 19(1), pp. 52--66 (2010)
9. Dias, G. P., & Rafael, J. A.: A simple model and a distributed architecture for realizing one-stop e-government. Electronic Commerce Research and Applications, 6(1), pp. 81—90 (2007)
10. Salhofer, P., Ferbas, D.: A pragmatic approach to the introduction of e-government. In Proceedings of the 8th annual international conference on digital government research: bridging disciplines & domains (pp. 183--189). Digital Government Society of North America (2007)
11. Henkel, M., Perjons, E., Zdravkovic, J.: Towards Guidelines for the Evolution of E-Service Environments. International Journal of Public Information Systems, Vol. 3, pp. 183—200 (2007)
12. Wixom, B., Watson, H., Marjanovic, O., & Ariyachandra, T.: Educating the Next Generation BI Workforce. International Journal of Business Intelligence, 15(3), pp 26—31 (2010)
13. Pang, B., Lee, L.: Opinion mining and sentiment analysis, Foundations and trends in information retrieval, vol. 2 Iss 1-2, (2008)

A Reduced CRM-Compatible Form Ontology for the virtual Emigration Museum

Ricardo G. Martini[1], Cristiana Araújo[1], Giovani R. Librelotto[2], and Pedro R. Henriques[1]

[1] Algoritmi Research Centre, Department of Informatics
University of Minho - Gualtar - 4710-057, Braga, Portugal
[2] Programa de Pós-Graduação em Informática - Universidade Federal de Santa Maria - 97105-900 - Santa Maria, RS, Brazil
rgm@algoritmi.uminho.pt,decristianaaraujo@hotmail.com,librelotto@inf.ufsm.br,prh@di.uminho.pt

Abstract. In this paper we discuss the construction of a Reduced CRM-compatible form ontology for the virtual Emigration Museum based in the international standard for museum ontologies, CIDOC-CRM. To extract knowledge from the information of the virtual Emigration Museum when navigating through it, abstract data models should be used to conceptualize, the emigration documents stored in a relational database. In that way, resorting to an ontology (as abstract layer), the information contained in those documents can be accessed by the end-users (the museum visitors) to learn about the emigration phenomena. We also describe how we instantiate the ontology through a parser that automatically translates a plain text description of emigration data into RDF. Finally, we also discuss the choice of a triple storage system to save the RDF triples in order to enable the use of SPARQL to query the RDF data.

Keywords: Emigration Museum, Emigration Documents, Ontology, RDF, Triplestore, CIDOC-CRM

1 Introduction

The institutions holding cultural heritage – like libraries, museums, archives – are responsible for the technical treatment, preservation and dissemination of the documentary collections [1]. This kind of repositories is fundamental to comprehend History, contributing not just for the patrimonial wealth of a country but also for the council's history.

In the context of this work, we are particularly interested in bringing together the documentation about the emigration movement with the aim of creating a virtual Emigration Museum.

We discuss along the paper the digital preservation and exploitation of emigration documents via a web interface using an ontology.

In general it is known that libraries, archives, and museums hold many documents in paper. However, to consult and learn about the documents information

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_38

in paper becomes a hard task (since often the documents are old and handwritten). Moreover, the excessive paper handling causes a rapid degradation [1].

Those facts rise up the need to preserve all documents in digital repositories. Avoiding excessive paper handling and making its data available on the web, it is possible to consult, relate, and understand the information in an easy and interesting way. But to allow the data available on the web and extract some information of it, it is necessary to translate the data to a machine understandable format.

To handling this data, Semantic Web[3] technologies like Resource Description Framework (RDF) enable the creation of datasets on the web, so applications can consume the data and present them in an human-readable format [2].

The combination of different documental fonds related to the emigration movement like biographies, almanacs, passport application forms, passports, ship information, can bring a significant value to the existent data, and this bring to us the necessity of represent data and information (all kind of emigration documents) in RDF, because it facilitates, even in different schemas, the data merging [3].

The work here reported is a crucial part of a doctoral project that focus on the goal of automating the creation of web-based virtual Learning Spaces using ontologies and Domain Specific Languages to specify the virtual environment.

The main goal of the work reported in this paper is the creation, automatic instantiation through the translation of plain text to RDF notation, and exploitation of an ontology for the emigration phenomena in Portugal. We adopt the international standard for museum ontologies called International Committee for Documentation - Conceptual Reference Model (CIDOC-CRM[4]). Having the ontological view of the fond described in RDF, we consult the information using SPARQL Protocol and RDF Query Language (SPARQL).

In Section 2 is presented the Emigration Museum and its documental assets. In Section 3, CIDOC-CRM standard for ontology description is introduced and a Reduced CRM-compatible form ontology, to describe the emigration domain, is discussed. Section 4 discusses data representation alternatives in order to simplify the storage and query of the ontological triples (subject, property, and object). The development of a parser to convert the triples from a plain text description into RDF notation is described in Section 5. Finally, in Section 6 the paper is summarized, conclusions are drawn, and directions for future works are proposed.

2 Emigration Museum and its Documental Fond

International Council of Museums (ICOM[5]) defines virtual museums as "a logically related collection of digital objects composed in a variety of media which, because of its capacity to provide connectedness and various points of access,

[3] http://www.w3.org/standards/semanticweb/
[4] http://www.cidoc-crm.org/
[5] http://icom.museum/

lends itself to transcending traditional methods of communicating and interacting with visitors; it has no real place or space, its objects and the related information can be disseminated all over the world" [4].

The Emigration Museum is not an exception. It has cultural information extracted from a collection of documents inherited from a municipal archive to be exhibited to the public. Besides the backoffice archive, this museum has some thematic exhibition rooms [5].

In this paper we focus on the archive, because it holds the relevant documents to study and understand the emigration phenomena. The structure and content of the documents considered in this work were detailed in the paper [6].

3 CIDOC-CRM Ontology

The objective of CIDOC-CRM is to promote a shared understanding of the Cultural Heritage domain by providing a common and extensible semantic framework that any Cultural Heritage information can be mapped to. In this way, it can provide the semantic glue needed to mediate between different sources of information, such as that published by museums, libraries and archives [7][8].

To understand how CIDOC-CRM is organized, Figure 1 presents its core, showing the main entities and relations.

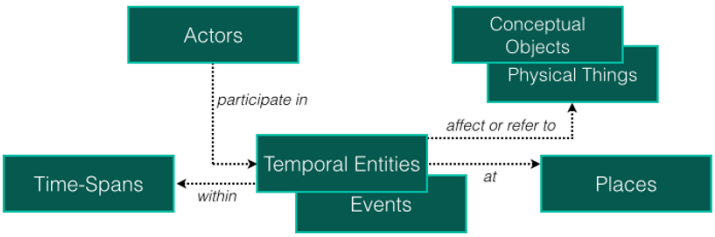


Fig. 1. Core Structure of CIDOC-CRM (adaptated from [8])

CIDOC-CRM is an event-based ontology where the main entities are related to *Temporal Entities* as depicted in Figure 1. As their name implies, *Temporal Entities* are concepts related to events in the past and because of this, they are related to a temporal length of events (period), so they can have date and time associated to the *Time-Spans* entity. The *Actors*, *Conceptual Objects*, *Physical Thing* and *Places* classes can not be directly linked to time (*Time-Spans*), so they need to be associated to events (*Temporal Entities*).

A *Place* can be anything that describes a location (geographical or e.g., in the bank of the Douro River or on top of Eiffel Tower).

Actors are entities that hold a legal liability. An actor can be an individual or a group; the first one is related to a person and the second one can be associated

to a company, for example. Actors interact with things (*Conceptual Objects* and Physical Things) through events.

A *Physical Thing* is something that can be physically destroyed and, case some part is preserved, it can be turned into something new. By other hand, *Conceptual Objects* can not be crashed. For instance, a physical thing like a smartphone, or a magazine can be destroyed, but the information (content) related to that physical thing can not. To destroy a *Conceptual Object* it is necessary to extinguish the source, i.e., anything that represents that concept, including people.

Things in CIDOC-CRM can have *Appellations*. They can be a name, an identification number, etc. Furthermore, different organizations have distinct classification types. In CIDOC-CRM, these classifications are called *Types* and they classify things. For instance, events can have diverse types like birth, marriage, race, earthquake, flood, war, etc. Both *Appellations* and *Types* can be related to any entity.

Besides, the CIDOC-CRM ontology has name conventions that should be followed. Any concept starts its name with the capital letter "E" (of Entity) followed by a numerical code (e.g. E39 Actor, E53 Place, etc.). The relations are no different, they start their names with the capital letter "P" (of Property) followed by a numerical code (e.g. P89 falls within, P131 is identified by, etc.).

Section 3.1 details how the emigration documents – held by Municipal Archive of Fafe – were described in CIDOC-CRM.

3.1 Onto ME, an Ontology for the Emigration Museum

After a CIDOC-CRM in-depth analysis, it was possible to correlate the compatible entities of the ontology with the emigration documental fond.

Thus, a compatible CIDOC-CRM based ontology was instantiated and reused. When an ontology is in accordance with certain rules imposed by the standard ontology, it is called *Reduced CRM-Compatible Form* [7].

To demonstrate how the emigration documents, that belong to the Municipal Archive of Fafe, fit in CIDOC-CRM, we show in Figure 2 an example of the previous ontology fragment instantiated with the information collected about the emigration movement of a person.

As can be seen in Figure 2, the main event is *E9 Move*, which refers to the emigration document that reflects a passport application form identified by the number *161*. *E9 Move* has four relations describing:

when the movement has occurred: described by *E52 Time-Span* named 'TS1', which in this case *(P78) is identified by* '1963-05-21', an *E50 Date*;

where the emigrant moved to: described by *E53 Place* named 'PL1', which in this case *(P87) is identified by* 'França', an *E44 Place Appellation*;

who emigrated: described by *E21 Person* named '2828624', an *E21 Person*, which in this case *(P131) is identified by* an *E82 Actor Appellation* 'José Carlos Magalhães'. *E21 Person* has a type to identify its role in *E9 Move*. So person '2828624' *(P2) has type* 'Emigrant';

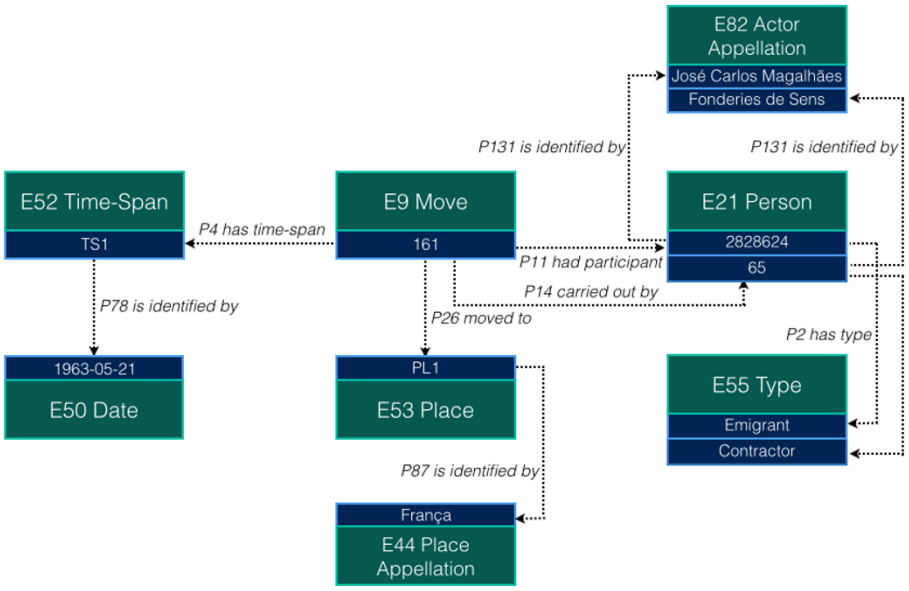


Fig. 2. Reduced CRM-Compatible Form instantiation example

who carried out [6]**:** described by *E21 Person* named '65', an *E21 Person*, which in this case *(P131) is identified by* an *E82 Actor Appellation* 'Fonderies de Sens'. *E21 Person* has a type to identify its role in *E9 Move*. So person '65' *(P2) has type* 'Contractor'. Notice that it is not possible to determine, from the sources, whether the contractor is a person or a company (*E74 Group*). So, it is always described as an *E21 Person*.

After describing the emigration documents using the CIDOC-CRM compatible form ontology, the need to represent the data in a machine-understandable format rose up. Section 4 presents the data representation formats used.

4 Data Representation

To define and use an ontology, an explicit representation should be adopted. There are several representation languages that can be used for that purpose, like eXtensible Markup Language (XML), RDF, Web Ontology Language (OWL), among others. They vary in expressiveness [9].

CIDOC-CRM ontology can be described in such languages, but usually RDF is the one chosen by the museum community. The creators of CIDOC-CRM have chosen RDF aiming at an easy understanding by both computer experts

[6] Notice that exist other objects related to this same property, with the difference in the *E55 Type*. In this project there are types like: who intermediates the emigration movement (the intermedary); who is calling the emigrant (the caller); etc.

and non-experts [7]. So in this work RDF is used to describe the knowledge present in the emigration documents.

As aforementioned in Section 3.1, it was crucial to verify if the ontology created adequately represents our documental fond. In a first step, presented in Section 4.1, to specify the triples representing the emigration assets, a description in plain text was created.

The flow depicted in Figure 3 shows the way to query in SPARQL the triples database starting from an ontology *described in* a specific notation (RDF).

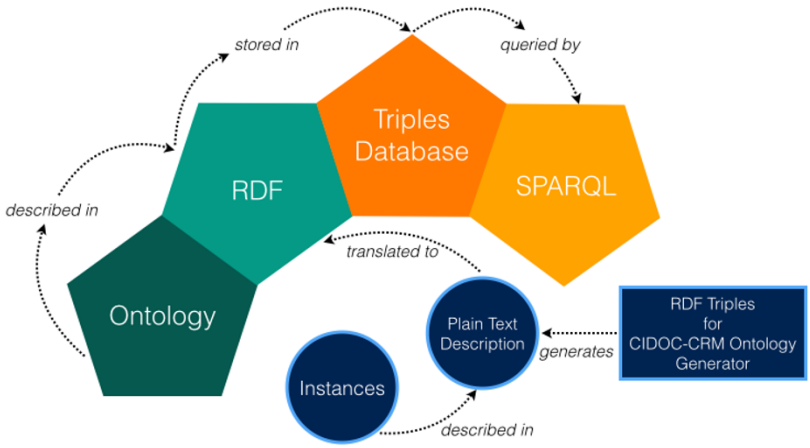


Fig. 3. Data Representation's schema

According to the flow of Figure 3, the ontology triples must be translated from the textual representation to RDF. This task was carried manually in a second step, as detailed in Section 4.2. This RDF description was stored in a triple database (Apache Jena TDB) to be queried through a SPARQL end-point (Apache Jena Fuseki).

Finally, and after understanding this manual process, it was automated by a compiler that translates plain text triples to RDF. The compiler was generated by ANother Tool for Language Recognition (ANTLR[7]) version 4; the process of translating the input (text triples) into RDF notation can be seen in Section 5.

Next sections describe the textual and RDF specifications used before storing the triples in a database appropriate to be queried by SPARQL.

4.1 Plain Text Triples

As mentioned in Section 4, to understand the structure and content of the emigration documents, we created a plain text description that follows the triples

[7] `http://www.antlr.org/`

concept (subject, predicate, object). An example of this plain text description can be seen in Listing 4-1.

Listing 4-1. Triples specified in the plain text description

```
1  161:E9 Move
2  P4 has time-span:TS1
3  P26 moved to:PL1
4  P11 had participant:2828624
5  P14 carried out by:65 .
6
7  TS1:E52 Time-Span
8  P78 is identified by:1963-05-21 .
9  . . .
```

This example describes exactly the same piece of knownledge previously shown in Figure 2; '161' is an *E9 Move* concept that has some relations described between lines 2 and 5. *E52 Time-Span* has relations specified starting at line 8. Notice that the "..." sign at line 9 indicates that exist other specifications (not listed) to describe the entire example of Figure 2.

This representation step is illustrated in Figure 3 by the node *instances* that are *described in* the *plain text description*. The plain text specification can be created in two ways: (1) simply using a text editor; or (2) using the *RDF Triples for CIDOC-CRM Ontology Generator* web application – which was developed by us and aids in the specification of the text triples (also depicted in Figure 3).

Having the plain text triples specified and the structure of the documents understood, it is necessary to describe them in a machine-readable format, so SPARQL can handle with it.

4.2 RDF Triples

Resources in RDF are identified by Uniform Resource Identifiers (URIs) and described with properties and property values, where: (1) Resources are subjects in RDF with a URI; (2) a property (a.k.a predicate) is used to describe the relations (e.g. 'is identified by', 'moved to', etc.) between the subject and the property values; and (3) a property value (a.k.a object) is an object that can be another subject or a literal. The aggregation of a Resource, a Property, and a Property value is known as a triple (subject, predicate, object), as already mentioned.

Thus, from the plain text representation, we can derive RDF triples to create our domain ontology. Listing 4-2 shows an excerpt of the RDF specification manually created to describe the example of Figure 2.

Listing 4-2. Triples specified in the RDF notation

```
1  <rdf:RDF . . .
2  <rdf:Description rdf:about="161">
3          <rdf:type rdf:resource="E9_Move"/>
```

```
 4          <P4_has_time-span rdf:resource="TS1"/>
 5          <P26_moved_to rdf:resource="PL1"/>
 6          <P11_had_participant rdf:resource="2828624"/>
 7          <P14_carried_out_by rdf:resource="65"/>
 8  </rdf:Description>
 9
10  <rdf:Description rdf:about="TS1">
11          <rdf:type rdf:resource="E52_Time-Span"/>
12          <P78_is_identified_by rdf:resource
                ="1963-05-21"/>
13  </rdf:Description>
14  . . .
15  </rdf:RDF>
```

Notice that the RDF file is describing exactly the same triples created in the plain text description (Listing 4-1).

5 Plain Text Description to RDF CIDOC-CRM (TXT2CIDOC)

Once understood how triples (both plain text and RDF) are specified, and the difficulty of manually describe the domain as a triple dataset in RDF, we feel the need to automate this process. With that in mind, we build a compiler TXT2CIDOC.

The first step in this case was to create a grammar in ANTLR that recognizes the language used by us to write the plain text description. A snippet of the grammar can be seen in Listing 5-3.

Listing 5-3. txt2rdfcidoc Grammar

```
1  grammar txt2rdfcidoc;
2
3  txt2rdfcidoc : (objectConcept NEWLINE (relationObject
       NEWLINE)* relationObject endStat)+ ;
4  objectConcept: object ':' concept ;
5  relationObject: relation ':' object ;
6  object       : OBJECT ;
7  concept      : 'E21 Person' | 'E53 Place' | 'E9 Move'... ;
8  relation     : 'P131 is identified by' | 'P2 has type'
9               | 'P26 moved to' | 'P4 has time-span'... ;
10 endStat      : '.' ;
```

For the sake of space, notice that at lines 7 and 9 there is a "..." sign indicating that exist other alternatives to identify a concept or a relation in CIDOC-CRM.

So, the main contribute here is the translation of the plain text to RDF notation. This translation process is represented by a *translated to* relation displayed

in Figure 3, that is used to illustrate that the compiler gets as input the textual description to be recognized according to the grammar and generates RDF triples.

This process is made by listening events thrown from a Java parse-tree walker. As shown in Listing 4-1, it is necessary to override some methods automatically created by ANTLR and used to visit each production of the grammar. These methods are called listeners and they work when the walker enters and exits a parse-tree node. Listing 5-4 shows the code of a listener to illustrate the approach (we use again the same running example).

Listing 5-4. A listener fired on entry in the node for the `objectConcept` production

```
1  @Override public void enterObjectConcept(
       txt2rdfcidocParser.ObjectConceptContext ctx) {
2          String object = ctx.object().getText();
3          object = object.replace(" ", "_");
4          instances += "\n<rdf:Description rdf:about=\""
               + object + "\">";
5          String concept = ctx.concept().getText();
6          concept = concept.replace(" ", "_");
7          instances += "\n\t<rdf:type rdf:resource=\""+
               concept +"\"/>";
8  }
```

The entry method of Listing 5-4 gets the text associated with the symbols `object` and `concept` and replaces any white space by the underline "_" character. After that, it concatenates the `object` and `concept` texts to the `instance` String, which should contain, after visiting all the tree nodes corresponding to the recognized grammar rules, the entire RDF description to be written in the final RDF file. This file is created when the Java walker visits the node for `txt2rdfcidoc` production by the last time (this is, on exit).

So, when the `txt2rdfcidoc` exit listener executes, the RDF file (as shown in Listing 4-2) is created.

After having the RDF file created, it should be stored and available in a triple database to be queried by SPARQL. In this work, Apache Jena Framework[8] was used to implement these tasks.

6 Conclusion

This paper presented a task that corresponds to one of the working phases of a bigger project that focus on the idea of creating virtual Learning Spaces to impart knowledge of cultural heritage information. The project here discussed aims at describing a documental fond of the Municipal Archive of Fafe (composed of emigration documents) in a machine-readable format in order to be possible

[8] Triple store (TDB): `https://jena.apache.org/documentation/tdb/` and SPARQL server (Fuseki end-point): `https://jena.apache.org/documentation/fuseki2/`

to extract the information about the emigration phenomena to build a virtual Emigration Museum. The basilar layer of the doctoral project – development of the digital repository – was already published in [6].

To achieve this, it was necessary to create an ontology based in CIDOC Conceptual Reference Model and automatically instantiate it through the translation of plain text to RDF. This compiler based translation was an important task, because manually creating the RDF triples is a time consuming and error-prone activity taking into account the RDF syntax.

As future work, this project can be extended to bring together the information not only about the passport application form, but another sources like biographies, letters, ships' route, etc. Thus, the final virtual Emigration Museum can be enriched with more knowledge about the emigration phenomena.

More information about this work can be seen in the TXT2CIDOC website at `http://www4.di.uminho.pt/~gepl/txt2cidoc/`.

Acknowledgements: This work has been supported by FCT – Fundação para a Ciência e Tecnologia within the Project Scope: UID/CEC/00319/2013. The work of Ricardo G. Martini is supported by CNPq, grant 201772/2014-0.

References

1. Young, S.F., of Illinois at Chicago. Library. Special Collections Department, U.: Don't Throw it Away!: Documenting and Preserving Organizational History. Special Collections Department, University Library, University of Illinois at Chicago (1995)
2. Shadbolt, N., Berners-Lee, T., Hall, W.: The semantic web revisited. IEEE Intelligent Systems **21** (2006) 96–101
3. : RDF 1.1 primer. Technical report, World Wide Web Consortium (2014)
4. Schweibenz, W.: The development of virtual museums. In: Virtual Museums. Volume 57(3). ICOM (2004)
5. Monteiro, M.: O museu da emigração e os "brasileiros" do rio: o público e o privado na construção de modernidade em portugal. Revista da Faculdade de Letras História **8** (2007)
6. Martini, R., Guimarães, M., Librelotto, G., Henriques, P.: Storing archival emigration documents to create virtual exhibition rooms. In Rocha, A., Correia, A.M., Costanzo, S., Reis, L.P., eds.: New Contributions in Information Systems and Technologies. Volume 353 of Advances in Intelligent Systems and Computing. Springer International Publishing (2015) 403–409
7. ICOM/CIDOC: Definition of the cidoc conceptual reference model. Technical report, ICOM/CIDOC (2013)
8. Oldman, D., Labs, C.: The CIDOC Conceptual Reference Model (CIDOC-CRM): PRIMER. International Council of Museums (ICOM) **1** (2014)
9. McGuinness, D.L., Harmelen, F.V.: Owl web ontology language overview (2004)

The Role of Information Technologies in Receivables Management

Lubos Smrcka[1], Dagmar Camska[2] and Jan Placek[1]

[1] University of Economics, Prague, Faculty of Business Administration, Department of Strategy, nam. W. Churchilla 4,
130 67 Prague 3, Czech Republic
{lubos.smrcka, jan.placek}@vse.cz
[2] Czech Technical University in Prague, The Masaryk Institute of Advanced Studies, Department of Management Sciences, Kolejni 2637/2a,
16000 Prague 6, Czech Republic
{dagmar.camska}@cvut.cz

Abstract. This paper is focused on receivables management and possibilities how to use available information technologies. The use of information technologies should make receivables management easier on one hand and on the other hand it makes the processes more efficient. Finally it decreases additional costs and losses connected with enforcing receivables when defaulting debts occur. The situation of use of information technologies is different if the subject is financial or non-financial institution. In the case of financial institution loans providing is core business and the processes and their technical support are more sophisticated than in the case of non-financial institutions whose loan providing as invoices is just a supplement to their core business activities. The paper shows use of information technologies in individual cases but it also emphasizes the use of general results for further decision making process. Results of receivables management are illustrated on the data of the Czech Republic.

Keywords: receivables management, registers of financial institutions, insolvency register, Czech Republic

1 Introduction

Receivables are one kind of enterprise's assets displayed in a balance sheet which are generated through enterprise's sales activities. Receivables are legally enforceable claims for payment. A customer does not pay directly because of using invoices but the payment is done within an agreed time frame. According to International Financial Reporting Standard (IFRS) 9 receivables are obviously a part of portfolio of financial assets measured at amortized costs [16]. Receivables have on one side their advantages, on the other hand they are also connected with many disadvantages [1]. Their advantages are based on the competition environment when payment conditions create one part of a competitive advantage and they enable another financial source

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_39

for the customer. The disadvantages are connected with risk of non-payment, late payment which has to be financed by other financial links.

There are many researches done in the field of enforcing of receivables which can exist in two main kinds - individual and collective enforcing. These researches focus especially on the level of satisfaction, recovery rate of receivables because forfeiture proceedings in the case of the individual enforcing and insolvency proceedings in the case of the collective enforcing are enforcing of the last instance. The recovery rate of receivables is very low in these special cases. When a creditor is not secured then the recovery rate is only in percents [9], [12] and [13].

During recent years our research team have taken attention especially to a theme connected with insolvency register and its efficiency leading to data processing and enforcing of receivables [14] and [15]. The main aim of these activities is to improve the environment and achieve higher recovery rates of receivables for creditors. Due to problematic receivables the affected creditors do not have revenues from their business activities. It could have a significant impact on their following running a business when they have to find additional resources for financing the problematic receivables.

This problem is much broader than only the last instance as forfeiture proceedings and insolvency proceedings. Therefore we have decided to turn our attention to the broader topic as receivables management. The task for management does not start with insolvency proceeding but it starts with signing a contract itself. On one side there is an enterprise which plays a role of a creditor. This enterprise is holding the receivables in its assets' structure. On other side there is a subject which plays a role of debtor who is holding payables in its capital structure. Further characteristics depend on the kind of the contract between these two parties. An object of the contract can be strictly financial as a loan, mortgage or leasing or based on non-financial business activities as selling services or products. Financial institutions use other approaches leading to signing the contracts than classical enterprises whose business model is based on the selling of products. The debtor can be natural as well as legal person, non-entrepreneur as well as entrepreneur etc. The paper will discuss on the next pages the role of information technologies in receivables management for different business parties and it will provide as well as suggestions and recommendations for better receivables management.

2 Receivables Management

Receivables management does not stand alone because it is a part of turnover cycle and working capital management which involves management of inventories, receivables, cash management as well as payable management [7]. Increased attention to working capital management has proven advantage during last economic crisis in the Czech Republic. It is proved in [11] that enterprises managing working capital cycle would have had a higher chance to overcome the last global crisis which was caused by external economic conditions. The general receivables management can be described by five steps as in [1], especially for non-financial enterprises. The first step is deciding the length of the payment period or discounts for clients paying in

advance, on the time of delivery or before the end of classical payment period. The second step is a decision about the contract itself because the classical contract can be accompanied by a guarantee as a bank guarantee, warrantor or securitization by tangible assets. The third step is an assessing client's creditworthiness which can be done by the enterprise itself or passing that to special parties as credit or rating agencies. The step four is establishing credit limits leading to minimization of problematic receivables but non-affecting flows from customers. When the payment has a delay or the customer does not want to pay or is not able to pay then the process of enforcing receivables will start.

These general five steps provide a basis for a decision making process in the case of each client. For each client the five step process should be done originally respecting the general limits decided for a whole enterprise. For small clients the beginning of the process can be done automatically and interventions come only in the case of troubles. For large clients the full process should be done carefully and not automatically because it is a decision problem which is not well structured. The use of the information technologies can be applied in each step but a range depends on the specifics of the contract and the product.

2.1 The Possibilities of Use of Information Technologies

The quality of receivables management and the level of the use of information technologies also depend on the situation if the creditor is systematic or non-systematic. In the case of systematic creditor the process would be more sophisticated and compliance. A specific case of systematic creditors are financial institutions which can play a role of banking or non-banking institution. The objects of their contracts are different kinds of loans as mortgage, consumer credit, credit cards, banking account overdraft or leasing etc. The financial institutions have the most sophisticated process of receivables management and the highest possible level of the use of information technologies in this process as well.

Financial institutions. The information technologies play their irreplaceable role in the assessing client's creditworthiness. The financial institution collects information about the client. First it is always the size of the asked loan. In the case of natural persons it would be age, marriage status, number of dependents, size of regular income, value of assets used for a guarantee etc. In the case of legal persons it is the length of history existence, field of economic activity, value of assets used for a guarantee etc. Worthy variable is a client's history. It is more profitable to enter into a contract with a party with which you have already had a common history. The client has had some kind of account or the client paid off the previous loan etc. Unfortunately there are many financial institutions on the market and the common history would lead to impossibility to get new customers. The customers would be 100% loyal to their financial institutions. The real situation in the market economy is different because the customers can choose or switch their financial institutions almost without limitations. It would lead without monitoring the personal situation that the customers have too many loans at several financial institutions. The financial institutions would not know the real situation of their clients and they would be exposed to a higher risk of late payments or even non-repayment of the loans. The

core business would be affected and financial institutions would have to ask higher interest rates to cover costs connected with enforcement of receivables or bad loans which have to be write off at the end.

The reaction to this possible situation is registers which contain clients' history about loan contracts. There are two main kinds of registers in the Czech Republic [10]. The first register is Banking Register set up in June 2002 by the enterprise CBCB – Czech Banking Credit Bureau, a.s. This register functions for banks and building banking societies. The second register is Non-banking Register set up in June 2005 by the enterprise Leasing and loan credit bureau, z.s.p.o. This register functions for leasing providers, factoring enterprises, credit companies and other entities having a relationship creditor-debtor. Since beginning 2006 both registers have started mutual exchange of information. Both registers are technically provided by the enterprise CCB – Czech Credit Bureau which is owned by the international group CRIF. CRIF is the leading provider in the continental Europe one of the biggest providers of credit registers and systems for credit decision making process in the world. Figure 1 proves that the solution used in the Czech Republic by CRIF is also usual worldwide.

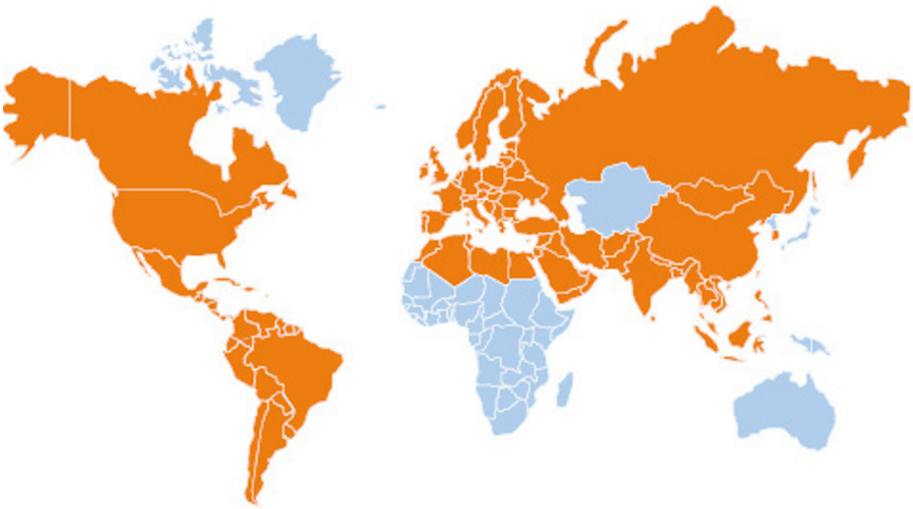


Fig. 1. CRIF in the world [5]

The both registers work on the same bases and assumptions. The main difference is that Banking Register contains all information about loan contracts in the banking sector because all banks operating in the Czech Republic are involved. On the other hand Non-banking Register contains only information about loan contracts entered at the register's partners. According to estimations Non-banking Register should contain between 80-90% about all non-banking loan contracts. It is caused by the situation that some financial providers are not members of register partnership. The reasons can be different as the size of loan provider or lower transparency of this provider.

Both registers work technically similar. The assessing of client's creditworthiness can be displayed by figure 2. The client asks for a loan. The financial institution sends a request to register which generates a credit report. The credit report contains a historical debtor profile. There is information about all available credits, size of month repayments and especially reports about late repayments. For good functioning it is necessary to upload and update data in the register regularly how it is showed in the part data processing on the figure 2.

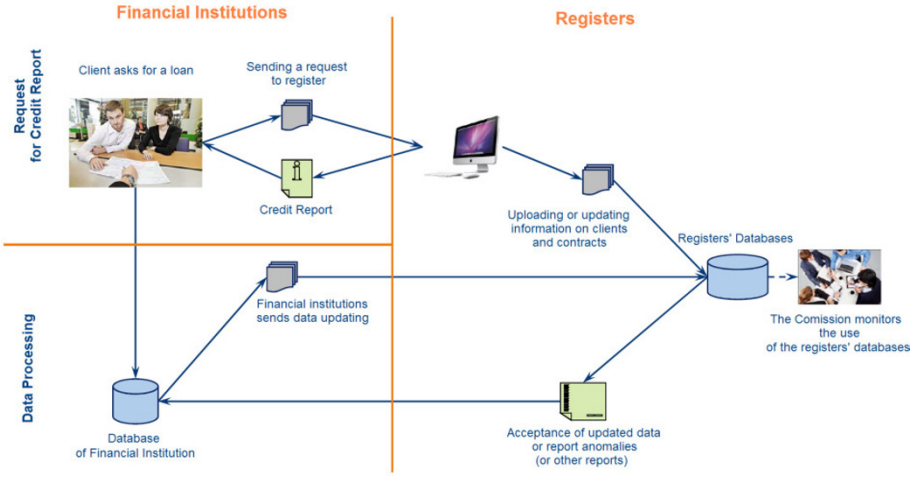


Fig. 2. Register functioning [10]

Non-financial institutions. The position of non-financial institutions is less clear because their business in the comparison with financial institutions is different. Receivables are generated in the connection with the main activity as selling goods, own products or providing non-financial services. The main business is not to provide this kind of short-term loans or in case of intensive investment units long-term loans but to provide the good, product or service. The payment conditions which set up the lending situation are part of the contract and they are reaction to business environment for creation or sustaining corporate competition advantage. The decision of non-financial institutions if they should provide a credit and for how long time depends first on the factor if they have already had a common history with the discussed business partner.

Common history means that these two partners already traded with each other and they have had common experiences in the past. The enterprise should have reports reflecting existence of payment with delays and other obstacles as paying other amount, losing invoice etc. These reports can exist in many forms. For a small and partly middle sized companies the records can be in the paper form or in the simple form of Excel sheet showing the payment history. In the case of large companies this thing has to be solved more sophisticated because the number of customers is rocketing with the comparison of small companies. The payment history is a part of corporate information system which connects invoice system, accounting, cash

management, ordering system, warehouse data and many other which are not directly relevant for our purposes.

If we come into contact with a customer without common history we are in the harder position because we do not have any experiences, any relevant data which would help our decision making process. Classical business enterprises do not have registers as financial institutions but they can use services of rating and scoring agencies. These services can be used only once for evaluating a specific business partner. Other possibility is that these services are used permanently as an access to the database which can be seen as an alternative to registers of financial institutions.

Evaluation done once means that the enterprise asks rating/scoring agency for assessing a specific business partner. The specialized credit scoring agency in the Czech Republic is Bisnode Česká republika, a.s. Worldwide active is company Dun & Bradstreet which is able according to information on its webpages to provide Industry standard report for moderate risk assessment for 409 $ [6]. These agencies take into account many variables and characteristics of the evaluating enterprise. The result is a report which contains a classification of the evaluating enterprise. The classification can be done by rating scale (AAA-D), by colors of traffic light (green means make a deal, yellow is not clear, red is a danger and contract should not be closed) or by a percentage on the 100% scale which shows the security.

The scoring of these specialized agencies is based on the use of information technologies. These enterprises collect data about other entrepreneurial entities and then they evaluate it using different models. With an effort to convince customers the enterprise Bisnode Česká republika, a.s. illustrates its scoring with used variables [2]. These variables and questions are if the evaluated enterprise does not have debts, how the enterprise pays its invoices, if it has assets, what the values of cash liquidity and financial ratios are, how the comparison with the last time period is, if the enterprise generates profit or loss, the regional impacts, the industry branches impacts, the enterprise's history, existence of subsidiary company in troubles, who the owners and management are, the company's size and results from the insolvency register. These factors are collected and processed in a system by a scoring model. Unfortunately these models are not publicly known because they are part of company's know-how. It is not clear which approach is used, how the criteria are measured, weighted together etc. The scoring does not use only financial information derived from financial accounting statements but also qualitative data which characterize enterprise's management, environment, product etc. Processing these large amounts of data is now possible thanks to available information technologies. Without these technologies the approaches for assessing could not be so sophisticated and using multivariate approaches.

Other possibility is to have permanent online access to a corporate database. This kind of corporate database usually contains financial accounting data and payment specification (on time, delay or even insolvency/bankruptcy). This database can have a supplement as the traffic light (or similar evaluation) which evaluates each enterprise by colors according the level of risk. The traffic light is based on the agency's model which takes into account some factors which we have already discussed. This supplement does not have to be always included. It means that final evaluation has to be done by the company itself based on the data displayed in the database.

2.2 The Results of Using Information Technologies

Results of using information technologies in receivables management do not have only conclusions as the evaluation of specific evaluated business unit. The gained results can be more generalized. We can illustrate that by the figure provided by Bisnode. The figure shows the division of entrepreneurial entities among different classes of risk in the Czech Republic. Other division could respect regional or industrial disparities. The general results enable faster decision making process when we evaluates a new subject. We can use a faster evaluation for subjects from non-problematic regions and industry sectors. On the other hand we can take more attention to subject coming from problematic sectors or regions.

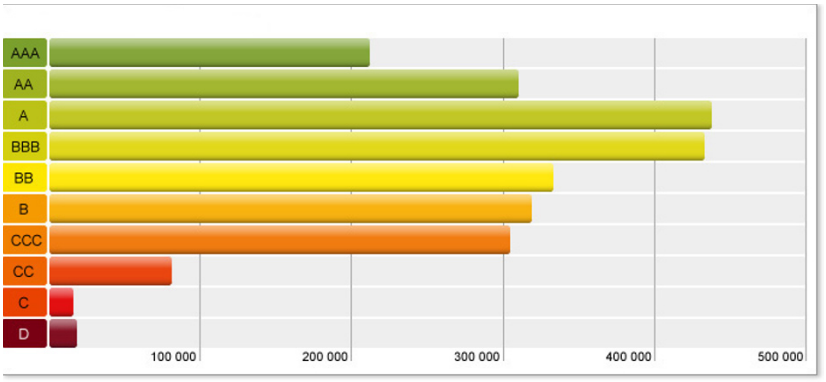


Fig. 3. The number of entrepreneurial entities according their level of risk in the Czech Republic [2]

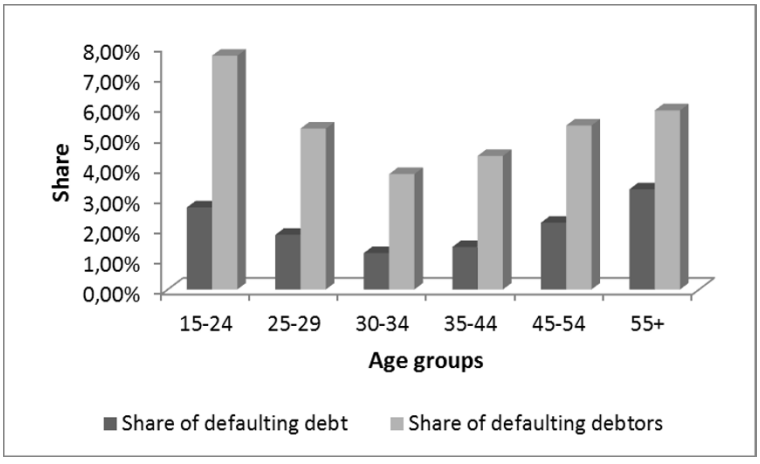


Fig. 4. Defaulting debts [8]

General conclusions can be got also from registers used by financial institutions. The results could be observed in the division according to regions, age groups, gender etc. Although the biggest group of bad debts is connected with age groups 35-44 and 45-54 (61% of debts in default and 59% of defaulting debtors from all age categories), these age groups do not have the highest level of default risk [8]. It is caused by the situation that these age groups use the debts the most. Another age groups have the highest level of risk - the youngest and oldest age group how it is proved by figure 4.

2.3 Recommendations

Using information technologies itself does not mean that there would not be mistakes in the business partners' choices. Management should respect following recommendations. On one hand we have available data and scoring reports on the other hand we have to respect results provided by the reports. These results have to be incorporated part of decision making process and they cannot be omitted due to specific conditions. In other words the information has to be use consistently. If the relationship between company and a new business starts the process does not finish with the evaluation at the beginning. The new business relationships have to be monitored and these data have to be collected for further use. The monitoring is especially important in the case that problems would occur and the business partner dos not fulfill conditions based in the contract and invoice. The company has to regularly monitor if the payment discipline of the business partner is not worsening. The monitoring is easier when the corporate information system enables connection of ordering system with invoices and banking account or cash register showed in financial accounting. If the company does not own a sophisticated IT solution as the corporate information system (especially case of SME) still the company should monitor the payment discipline of its customers. The worse payment discipline can cause serious troubles in operation management and it may result in secondary insolvency.

It does not matter if there is information system or just simple paper evidence but the outputs have to influence decision making. If the payment discipline gets worse there has to function alert which would warn the company. First the company can start a communication with a partner. The problem can be only technical as not arrived invoice, unreadable invoice or incorrectly entered payment. It also can be much serious as that the company does not want to pay or is not able to pay. Then the process of enforcing receivables starts. The alert function is also necessary for not starting new contracts with someone with bad payment discipline or for modification of conditions as paying directly and not using invoice time period.

2.4 Information Technologies in the Last Instance of Receivables Management

As last instance of receivables management it is meant the situation when all classical methods how to be paid failed. Classical methods are represented as phone calls, letters, personal meetings with a defaulting debtor. Classical methods are followed by last instance of individual or collective enforcement of receivables. In the case of

individual enforcement we do not connect with other entities who are also affected creditors because they do not exist or we prefer individual solution. It ends up in court which order forfeiture proceeding. The proceeding is done by a distrainer's office. Collective enforcement is also connected with a court trial but the process is usually much more difficult due to more affected creditors. The defaulting subject finishes in insolvency which is done by insolvency administrator.

The results of forfeiture proceedings as well as insolvencies should be publicly available because it can protect other entities to come into a business with an ailing defaulting partner. The insolvency register meets this condition although it has many shortcomings discussed by [14] and [15]. To get data about forfeiture proceedings is not easy because they are not publicly available for free as in the case of insolvency register. The environment is less transparent and clear for creditors who are not enough protected. Getting data about efficiency of executions is hard never ending work [13]. There are some registers/systems which work on the paid principle as Centrální evidence exekucí [3] and Centrální registr dlužníků [4]. In the case of Centrální evidence exekucí the each question is charged (60 CZK per piece) even when the answer is negative (the person is not included in register). When you realize that evaluated person is included you have to pay a new fee to get information about the specific forfeiture proceeding. That helps to create environment which is based on insufficient data and it protects more defaulting debtors than creditors.

3 Conclusion

This paper was focused on the receivables management and possibilities how to use information technologies for improving efficiency and results of this process. The specific situation was illustrated on the case of the Czech Republic. Firstly the importance of receivables management is emphasized. Then there are detected phases in which information technologies can be applied. Possibilities how to use information technologies differ if the business entity is a part of financial or non-financial sector. In the case of financial institutions the decision making process setting up the existence of receivables is more sophisticated, structured and regularly replicated and therefore also the use of information technologies is an obvious part of this decision making process. For non-financial institution the process setting up the existence of receivables is a part of broader activities. These activities are connected with the core business as selling bought goods, selling own produced products or provide non-financial services.

Monitoring of maturity of debts helps to sustain recovery rate of receivables on the highest possible level (of course in connection with evaluation business partner before running a common business). Reporting about maturity of debts enables to generalize recommendations which groups are more prone to default. These groups should be checked more before signing a contract. The groups can be characterized by the region, size, business sector, age, gender etc.

Acknowledgments. The paper is processed as one of the outputs of the research project “Research of insolvency practice in the CR, with the aim of forming proposals for changes in the legislation that would enable increased yields from insolvency proceedings for creditors, which would contribute towards increasing the competitiveness of the Czech economy”, registered at the Technological Agency of the Czech Republic under the registration no. TD020190.

References

1. Brealey, R.A., Myers, S.C., Allen, F.: Principles of Corporate Finance. McGraw-Hill/Irwin, New York (2011).
2. Bisnode, Bisnode Scoring, http://www.bisnode.cz/produkt/bisnode-scoring/
3. Centrální evidence exekucí, https://www.ceecr.cz/
4. Centrální registr dlužníků České rpeubliky, https://www.centralniregistrdluzniku.cz/
5. CRIF Lending Solutions, http://www.crif.com/site/en/Pages/default.aspx
6. Dun & Bradstreet, International Pricing List, https://creditreports.dnb.com/webapp/wcs/stores/servlet/InternationalPricingList?compCtry=CZ&custCtry=US&storeId=11154&catalogId=71154&categoryId=15053&intProd=intProd&parent=%5bobject%20Window%5d&popup=true&cmeid=IOS200549
7. Hyrslova, J., Klecka, J.: Ekonomika podniku. Vysoká škola ekonomie a managementu, Prague (2010)
8. Kislingerova, E., Richter, T., Smrcka, L. et al. Insolvenční praxe v České republice v období 2008-2013. C.H. Beck, Prague (2013)
9. Placek, J., Louda, L.: Research of interdependencies of some variables determining the quality of insolvency proceedings. In: Culik, M. (ed.) Managing and Modelling of Financial Risks 7th International Scientific Conference Proceedings (Part III.), pp. 648-656. VSB – Technicka univerzita Ostrava, Ostrava (2014)
10. Rajl, J. Jak si vybudovat finanční historii, http://ksg.vse.cz/wp-content/uploads/2012/11/Rajl.pdf
11. Scholleova, H.: The Economic Crisis and Working Capital Management of Companies. Theoretical and Applied Economics. 569, 79-92 (2012)
12. Smrcka, L., Schönfeld, J., Malý, T.: Results from Researching Insolvency Processes in the Czech Republic. International Advances in Economic Research, 1, 123-124 (2015)
13. Smrcka, L., Placek, J.: The Impact of Territoriality of Court Bailiffs and Its Qualification in the Czech Republic. In: Lee, G., Schaeffer, G. (eds.) 4th International Conference on Social Sciences and Society, pp. 189-194. Information Engineering Research institute, Bellflower (2015)
14. Smrcka, L. The Problems of the Insolvency Register in the Czech Republic from the Perspective of Information Technology. In: Rocha, A., Correia, A.M., Wilson, T., Stroetmann, K.A. (eds.) Advances in Information Systems and Technologies, 10 pp. Springer, Heidelberg (2013)
15. Smrcka, L. The Project of Electronic Monitoring of Insolvency Proceeding Results in the Czech Republic: Utilization of IT Reduced Information Asymetry among Economic Subjects. In: Rocha, A., Correia, A.M., Costanzo, S., Reis, L.P. (eds.) Advances in Information Systems and Computing, New Contributions on Information Systems and Technologies, pp. 317-327. Springer, Heidelberg (2015)
16. Strouhal, J., Bonaci, C.G., Mustata, R.: International Accounting Practices. University of Economics, Prague, Oeconomica Publishing House, Prague (2014)

Proposal of content and security controls for a CSIRT website

[1]Jezreel Mejía, [1]Mirna Muñoz, [1]Heltton Ramírez, [2]Adriana Peña

[1]Centro de Investigación en Matemáticas A.C. Unidad Zacatecas
Av. Universidad No. 222, Fracc. La Loma, C.P. 98068
Zacatecas, Zac., México
[2]Departamento de Ciencias de la Computación, CUCEI de la Universidad de Guadalajara,
Av. Revolución No. 1500, 44430 Guadalajara, Jal, México
[1]{jmejia, mirna.munoz, heltton.ramirez}@cimat.mx, [2]adriana.pena@cucei.udg.mx

Abstract. A CSIRT is a group of experts in information security which provides services such as alerts and warnings, incident handling, observatory technology, security audits, forensic computing, among others. Therefore, they have constant communication with the target audience via email, telephone or in a website. A website works as the main contact with the target audience, for this reason, when creating a website for the CSIRT, special care must be taken with technologies when using and applying security controls in order to avoid computer attacks that may jeopardize the reputation of the CSIRT. This paper describes a proposal related to content and security controls of the CSIRT website that must be considered.

Keywords: CSIRT, Systematic review, website, security controls, Wordpress.

1 Introduction

According to the Smart's CEO Mexican informatic security company, "attacks on websites were one of the most common risks that companies face in internet security in Mexico" and globally there are more than 35 groups of computer criminals active, which have anonymity and ubiquity to steal information and control gates [1]. This suggests that Mexico cannot escape as the target of computer attacks. According to the portal of the organization FIRST (Forum of Incident Response and Security Teams), in México there are only four CSIRTs, which is considered a small number compared to countries like the USA which have 70 CSIRTs [2].

Works like [3], [4], [5], [6] specify technological resources that are necessary for the operation, among which is the website. For many people, the first contact that they have for a CSIRT is done through the website [6]. On the website you will find information such as the mission, vision, services, contact information and safety warnings publications and manuals for computer security awareness [7]. It is even possible to put information security incidents on the same website through web forms, in which questions related to the incident are answered, so that makes it much easier to classify the impact and then to analyze it according to the CSIRT's internal process [5] In this context, up to now, the content and the security controls has not been

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_40

standardized and which should be taken into consideration during the development of the CSIRT website. Therefore, this paper proposes the content type, technology and the security controls for the CSIRT website, in order to establish a more secure website to avoid computer attacks which could jeopardize the CSIRT reputation. To establish the proposal, it has collected information through a systematic review, official websites FIRST portal inspection with a Web Scraping and extracting information from the same website with a web scanner.

This paper is organized as follows: section 2 introduces to the basic concepts, section 3 shows the contents of a CSIRT's website, section 4 shows how was the selection of website technologies, section 5 shows the systematic review about of security controls for a CSIRT's website, section 6 presents the proposed content and security controls to be taken in the CSIRT website and finally section 7 conclusions and future work are presented.

2 Basic concepts

Before presenting the proposal development, it is important to establish the main concepts used which are CSIRT, website, security controls and Web Scraping.

2.1 CSIRT

A CSIRT (Computer Security Incident Response Team) is a specialist team in information security dedicated to respond computer security incident [8]. The term CSIRT is typically used in place of the protected term CERT, registered in the US, by the CERT Coordination Center (CERT / CC) [3]. Several abbreviations for the same type of team are used:

- CERT or CERT / CC (Computer Emergency Response Team / Coordination Center, Computer Response Team / Coordination Center emergencies).
- CSIRT (Computer Security Incident Response Team).
- IRT (Incident Response Team).
- CIRT (Computer Incident Response Team).
- SERT (Security Emergency Response Team).

2.2 Website

A website is composed of several objects. An object can be a HTML, an image, a Java applet or a video clip. All web objects are linked using a single URL (Uniform Resource Locator), which is the most common way of identifying a Web resource. A URL identifies precisely and without ambiguity the hostname, port number and the full path of the object on the web server.

The website is indispensable in a CSIRT [3], [5], [6], [8] also contains multifaceted security requirements. However, many web browsers, servers, network protocols, extensions browsers and security mechanisms were designed without analytical

foundations. To further complicate things, the web continues to evolve with new browser features, protocols and standards.

2.3 Security controls

Also called safeguards for the Magerit methodology [8], the security controls are mechanisms of protection from threats, reducing the frequency of threats and limit the damage caused by them. The security controls may be good practice to define security controls for software or hardware.

2.4 Web scraping

Web Scraping is the process to automate the collecting of useful information from a website [9]. This is done by software programs, which simulate the navigation information extracted from a human being on the World Wide Web either by using the HTTP protocol.

Having established the basic concepts, the following sections describe how to identify the recommended content on a CSIRT website, how did it obtained technology usage for the development of the website and the relevant security controls to protect the website.

3 CSIRT website content

The purpose of this section is to show how the content elements of a website for CSIRT were obtained. To achieve this, an analysis of the content proposal using a Web Scraping and an analysis of 10 sites CSIRT/CERT officers was performed.

3.1 CSIRTs officials pages analyses

A tool to extract information from official pages of CSIRTs in the FIRST organization portal that have a lot of registered CSIRT was used. The tool is a web scraping which works collecting information from websites. Then in the Fig. 1 graphically represents the operation of the tool.

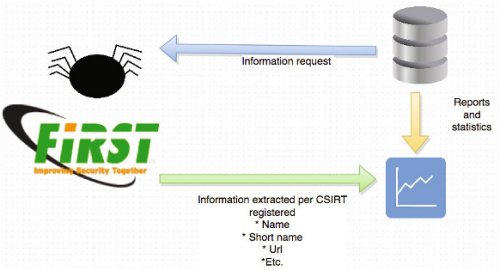


Fig. 1. The Web Scraping tool.

The content and functionality obtained by inspecting CSIRTs official websites that are listed in the portal FIRST are presented in the Table 1. The websites were SIRCC, CERT Australia, HR-CERT, ISIRT, CERTA, CERTBw, ID-SIRTII, among 300 official websites of CSIRT.

Table 1. Found elements.

Content	Functionality
CERT Info	News
FAQ	Site Map
Mission and objetives	Multilingual
Contact information	Search engine
Events	Vulnerabilities knowledge based
Documents	Indicentes reporting online
Tools	Restricted access area
Notices / Vulnerabilities	List distribution mail
News / Safety notes	Publications by RSS
Indicators / Statistics	
Links (related sites)	

3.2 Manually inspection of website Content

The results showed in Table 1 were reinforced by a manually inspection from the content of 10 CSIRTs/CERTs websites. The sites were chosen randomly considering they are registered formally into the FIRST portal. During the analysis were found another items, which complement the items shown in the Table 1. The results are listed in Table 2.

Table 2. Comparative analysis about 10 sites CSIRT / CERT.

Features /Website	INCIBE	UNAM-CERT	INFOTEC	CERT	US-CERT	CERT-EU	NCI	ENISA	TERENA	TF-CSIRT
CERT Info	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
FAQ	Yes	No	Yes	Yes	Yes	No	No	No	No	No
Mission and objectives	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No
Contact information	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Events	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Documents	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No
Tools	Yes	Yes	Yes	No	No	Yes	No	Yes	No	No
News / Vulnerabilities	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Indicators / Statistics	No	Yes	No	No	No	Yes	No	No	No	No
Links (related sites)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Security in your language / Tips	No	Yes	No	No	Yes	No	No	No	No	No
Blogs	Yes	No	No	Yes	No	No	No	No	No	No
Courses	No	No	No	Yes	No	No	No	Yes	No	Yes
Incident report	Yes	Yes	No	Yes	Yes	No	No	No	No	No
Alerts's subscription	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	Yes	No
Social networks	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	No

As shown in Table 2, the items that complement Table 1 are: Security in your language/tips, blogs, courses, alerts's subscription and social networks.

4 Technology selection

In order to identify the technologies, languages and tools used to create the website of a CSIRT, a census of the technologies used in official sites of CSIRT was obtained from the forum page of safety equipment and response to incidents (FIRST, Forum of Incident Response and Security Teams) [10]. As a result, 40 official websites of CSIRT to know what technologies are used with the WhatWeb tool version 0.4.8 [11] were analyzed. The goal of this tool is to answer the question "What is this website?" which identifies technologies including CMS, blog platforms, analyzes packets, javascripts libraries, web servers and embedded devices. Thanks to its 900 plugins, you can also identify specific versions of technologies, email addresses, and SQL errors [12]. The Fig. 2 shows an example of information that displays the tool as a result to inspect in a website.

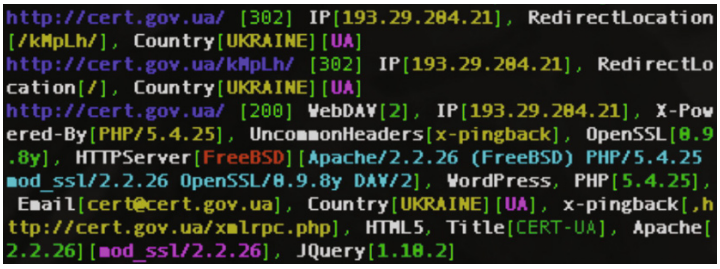


Fig. 2. Information extracted from cert.gov.ua website with WhatWeb tool.

The most prominent technologies cores were 18 sites using Apache as a web platform, 8 of them use ASP.NET, 25 of them are made in Wordpress and only 6 in Drupal, among other technologies. Therefore, it was decided that the platform should

use Wordpress, which is most used in the world [13] and Apache is a server to create the CSIRT's website providing it more specialized security.

5 Implementation of Security controls

Once the technologies and design used for CSIRT website have been already defined, as a result of the inspection of websites shown in the previous section, the specific security controls are proposed for Wordpress. Because Wordpress is the most popular CSM in the world, this attracts a lot of attackers, which objective is to penetrate the security system [13].

To identify the security controls, a systematic review is performed [14], [15]. It is a research method developed to obtain, analyze, and evaluate all the relevant researches of a particular research question or area. This method has 3 steps: planning, review and publication. The following main elements of the systematic review: the research questions, search string, result of the consultation and primary studies are described.

- **Research question:** What are the best security practices and technologies focused on protecting a website made with Wordpress?
- **Search string:** (Security && Wordpress)
- **Result of the consultation:** The search string was performanced in 4 formal sources for its search, which were IEEE, Springer Link, ACM and Google Scholar. Table 3 shows the number of results shown by source.

Table 3. Number of query results in formal sources.

Search string	IEEE	Springer Link	ACM	Google Scholar
(Security && Wordpress)	9	66	410	10900

- **Primary Studies:** The primary studies were obtained by executing the selection process. It consists of five steps: (1) Take the search string and adapt it to the data sources of the search engine; (2) Filter studies using the inclusion and exclusion criteria related to the following information:
    - **Inclusion Criteria:**
        - Studies written in English.
        - Studies not older than five years from its publication (eg, studies published within the period 2010-2015).
        - Studies whose title is related to the topic and containing at least two keywords or related terms, synonyms or abbreviations.
        - Studies whose keywords contain at least two terms or related key terms, synonyms or abbreviations.
        - Best practices related to the wordpress technology.
        - Security extensions or plugins for wordpress.
        - Attacks most commonly used in Wordpress platforms.

- Concept testing on wordpress security tools.

- **Exclusion Criteria:**
  - Studies that do not meet the inclusion criteria.
  - Studies where the summary (abstract) or the conclusion are ambiguous or personal opinion.
  - Considered obsolete version of wordpress.
  - Case studies of attacks without consider wordpress.

(3) Read the titles, abstracts and keywords, to identify potentially relevant studies. (4) Apply the remaining inclusion and exclusion criteria reading the introduction, methods, and conclusion and, if necessary, all the study; and (5) Select the primary studies.

As Table 3 shows, of 11,385 studies found after running the search string in the data sources, only 10 studies met all the inclusion and exclusion criteria. Once the primary studies were selected, the security controls were established as part of the proposal to CSIRT website security controls. The proposal is showed in the section 6.2.

6 Proposal

The proposal obtained by the tools and the systematic review related to CSIRT website contents and security controls are described.

6.1 CSIRT website contents

As mentioned in section 3, an analysis of official pages of CSIRT was performed using a tool and inspection of 10 websites. This analysis allows us to propose the following website content recommended for CSIRT website.

- **Home:** The home page of the CSIRT's website. This page aims to show an image that is eye-catching with a link to sections of incident reports and safety tips.
- **Safety Tips:** This section should show the tips and security alerts that will allow users to improve their security practices that are displayed.
- **Publications (papers):** This section contains several documents relating to research and security activities of the CSIRT that have been conducted, and which are available to read and download it.
- **Contact:** This section contains contact details and location of CSIRT.
- **About (mission, vision and objective):** This page displays information about the activities carried out by the CSIRT.
- **News:** On this page the news and latest security notes are presented.
- **Vulnerabilities:** This section displays the vulnerabilities and more recent incident.
- **Events:** This section contains the scheduled events displayed along with contact information related to computer security and computers.

- **Posts (publication, vulnerability, news, incident, event, tip):** This page is really a generalization of the different types of publications that will be made on the site, such as security tips, news, events, events, publications and vulnerabilities.

6.2 CSIRT website security controls

As a result of the systematic review addressed in section 5, the security controls recommended on a website created with Wordpress are described.

Cache memory: A cache is a type of optimization that is used frequently to save memory, processing and able to speed time to load a website considerably. Wordpress, by nature, is slow, because are adding more utilities, themes or complexity to the site also the programming language that works with Wordpress (PHP) is inefficient. Any website can suffer massive traffic (slashdotted) so it causes the website to stop responding, this is a consequence of insufficient cache storage. The solution is cached pages, this is to keep static copies of files in hidden directories and redirect incoming visits to these pages, in addition to speed things up for visitors, also significantly reduces CPU use [16]. Unfortunately Wordpress cache has not been included yet, but it has different caching options. The website that was implemented was WP Super Cache, this works rewriting in the .htaccess file to redirect the Wordpress requests for dynamic pages saved in a hidden directory on the user installation static files.

Tracking performance problems: If the Wordpress site suffers performance problems and is not being attacked, it is very probable that it has a bad configuration with respect to the network, plugins, themes or Wordpress database. If the problem persists, use tools like Yslow [17], together with Firebug it can be utilized to verify that there are many images on the site or elements to boot. If not, the user can try a plugin called WP Tunner and visit the main page below it, it will be seen all queries to the database and so realizing if it comes to problems with the engine of the database. Another option is to disable plugins or change the subject by default to verify if it has better performance [13]. To lock login Wordpress there is a plugin called Login Lockdown, which works by blocking a range of IP after many failed attempts to access in a short period of time [16].

Remove the head generated tag: One of the things that wp_head () adds is the theme of Wordpress, it is a tag that shows the specific version of Wordpress being used, this helps developers to see how many versions of wordpress are there in the world, however, this can also allow to alert a hacker on which version of Wordpress that is being using on the site and find vulnerabilities. The following code is to remove the tag: *Remove_action('wp_head', 'wp_generator')*

Security in .htaccess and wp-config.php files: There are many ways in which hackers can use the .htaccess file maliciously. They could rewrite rules to redirect visitors to other sites instead of genuine. Another way to misuse the file is to write a file in a subdirectory of Wordpress full of SPAM links and use the directories PHP as auto_prepend_file or auto_append_file to include the file index.php theme file running. To protect this regard, we recommend placing permissions so that only the

administrator can edit the .htaccess file and that can also change the .htaccess file to ensure that only the administrator can view and edit the wp-config.php file.

Change location files: You can move your wp-config.php file and wp-content folder to a different location index.php. All this helps to minimize the attack by a directory exploit writable in predictable places. An important file to move is the wp-config.php because of their database passwords and other important data that are stored in it. You can move the file to a location outside the published Web server folder and Wordpress that automatically detect the new file. To move the contents of Wordpress, you must define all constants in the configuration file to plugins that require a specific route not stop working.

Database Security: You must choose a good credential (choose a good password) to the database as well as changing the prefix of the tables and making backups of the database regularly. To change the default prefix Wordpress is easy through the installation process, in Wordpress database setting and the option to change the prefix will be shown.

Backup database and files: Backing up your database is frequently essential if you intend to restore your site when a disaster occurs. This can be provided by your hosting company although it is always advisable to have your own backups. There are many plugins that help making backups, one of them is the WP-DB-Backup, once installed, it is possible to backup with tools menu. You can automate the process by using tools like rsync or FTP clients to synchronize, download and update copies whenever needed.

Monitor security issues: You must choose a good credentials (choose a good password) to the database and change the prefix of the tables and support database regularly as well. It is easy to change the default prefix Wordpress account through the installation process, in setting the Wordpress database, the option to change the prefix is showed. This works as a protection to SQLInjection basic attacks, but it does not stop it completely. This is useful when an attacker makes use of automated hacking tools for Wordpress sites.

Monitoring security problems: There are many plugins that keep safe installation of Wordpress. The following shows a list of the plugins [9], [18]:

• WP Security Scan checks the file permissions, passwords, database security and more. It provides tools to fix many of the problems identified.

• Wordpress Firewall monitors HTTP requests with a blacklist firms known as malicious and can send an email when something appears suspicious.

• Exploit Scanner searches in the database and files any malicious input, such as files full of spam links. Audit Trail is helpful to let you know when someone has attempted to access.

7 Conclusions and Future Work

There is currently no specific regulations on the content that is recommended to have in a CSIRT's website. However the CSIRT's website is vital because it allow the contact and communication between the CSIRT and the target audience through publish alerts, threats and to make people aware of the dangers of the Internet among other things. This paper concludes that not all official CSIRT sites have the same

structure, content or are made with the same technologies. Thanks to the research by the systematic review, the content and the security controls were obtained for one of the technologies most used for creating websites, which is Wordpress, according to the sample of 40 sites analyzed.

References

1. Chapela, G. (2014). http://www.dineroenimagen.com/2015-03-27/53161. From http://www.dineroenimagen.com/2015-03-27/53161
2. FIRST. (2015). FIRST. Retrieved 8 5, 2015 from www.first.org/members/map#MX
3. ENISA. (2006). Cómo crear un CSIRT paso a paso. WP2006/5.1(CERT-D1/D2).
4. National Cryptologic Center. (2013, Junio). centro criptológico nacional del gobierno de España. Retrieved Agosto 12, 2014 from www.ccn-cert.cni.es/: https://ccn-cert.cni.es/publico/seriesCCN-STIC/series/800-Esquema_Nacional_de_Seguridad/820/820-Proteccion_contra_DoS-jun13.pdf
5. AMPARO Project. (2012). Manual básico de: Gestion de incidentes de seguridad informática.
6. Penedo, D. (2006). Technical Infrastructure of a CSIRT. IEEE 0-7695-2649-7/06.
7. Software Engineering Institute. (2014). CSIRT Services. From cert: http://www.cert.org/incident-management/services.cfm?
8. National Cryptologic Center. (2013). MAGERIT - Versión 3.0 Metogolodía de Análisis y Gestión de Riesgos de los Sistemas de Información. Madrid, España.
9. Vargiu, E., & Urru, M. (2013). Exploiting web scraping in a collaborative filtering-based approach to web advertising. Artificial Intelligence Research , 2 (1).
10. FIRST.org, Inc. (1995). FIRST Improving Security Together. Retrieved 2015 from https://www.first.org: https://www.first.org/members/teams
11. Horton, A., & Coles, B. (2015). WhatWeb is a next generation web scanner. Retrieved 2015 from https://github.com/urbanadventurer/whatweb: https://github.com/urbanadventurer/whatweb
12. Morningstar Security. (2011). From: http://www.morningstarsecurity.com/research/whatweb. From:http://www.morningstarsecurity.com/research/whatweb: http://www.morningstarsecurity.com/research/whatweb
13. Onishi, A. (2013). Security and Performance. In A. Onishi, Pro WordPress Theme Development (pp. pp 297-332). Apress.
14. Mejia J., Muñoz M., Uribe E., Marquez J., Uribe G., Valtierra C. (2014). Systematic Review Tool to Support the Establishment of a Literature Review. New Perspectives in Information Systems and Technologies, Volume 1, V 275. Advances in Intelligent Systems and Computing. DOI 978-3-319-05951-8_17. Pgs., 171-181.
15. Kitchenham, B.A., Dybå, T. (2004). Evidence-based Software Engineering. In: Proceedings of the 26th International Conference on Software Engineering (ICSE 2004)
16. Leary, S. (2013). Performance and Security. In S. Leary, WordPress for Web Developers (pp. pp 125-140). Apress.
17. Yslow. (2015). http://yslow.org/. Retrieved 2015 from http://yslow.org/: http://yslow.org/
18. Allen, J. (2001). The CERT Guide to System and Network Security Practices.

Cloud Healthcare-Records Manager

Asma Sultan AlShamsi , Nabeel AlQirim

United Arab Emirates University, UAE
{200424736, Nalqirim}@uaeu.ac.ae

Abstract. Recently, cloud computing (CC) has attracted the attention of many researchers and professionals as it provides a variety of solutions for different types of technical problems. One of these solutions is storage services. Cloud storage (CS) is expected to meet health industry expectations for maintaining health records and data. The importance of this focus in this research is that many healthcare providers face many challenges in managing their healthcare services in general and in controlling their costs more specifically. They are further challenged by adopting suitable novel technologies that could improve the quality of health services without increasing the cost, i.e., of storage services. CS service is one such technology that promises to store health records remotely allowing access to such records ubiquitously. This research reviews relevant literature about CC as a management solution for deploying health records and maintaining patients' data. The suggested solution uses metadata to identify healthcare records in order to store and manage them. The research proposes an architecture that enables healthcare providers store and manage their data.

Keywords: Cloud storage, healthcare records data, metadata, Storage Management Architecture

1 Introduction

Due to the proliferation of many health information systems in hospitals, health data has increased exponentially. This raises the need for efficient and effective data storage and management systems. In addition, there is a plethora of local storage systems that are readily available to manage storing health records and health data. However, storing and managing health data in local storages is costly and inefficient and most importantly, minimizes the opportunity of sharing such data with other related stakeholders which could increase the overall health value. Indeed, many healthcare provides struggle in providing quality healthcare services, managing healthcare records, storing the huge amount of data, providing data communication among healthcare institutions, decreasing the ever growing healthcare budget related mostly to adopting new technologies that could manage such issues. In review of the literature [1,3,5,8,14,16], the main issues are summarized as follow:

a. Difficulties in exchanging healthcare data because the data are not unified.
b. Difficulties in managing healthcare records
c. Data communication issues between different health-care organizations

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_41

Cloud computing (CC) can be one vital solution for healthcare organizations that are seeking to improve healthcare services provided to health clients as it could decrease the cost of storing health data. The use of electronic health records (EHRs) in CC is one powerful application [1]. Healthcare industry is expected to spend $30 billion over nine years (2011-2019) [2]. CC allows healthcare organizations to facilitate the efficiency and scalability of system's management. However, not all organizations fully succeed in using CC as a storage and as a management solution due to many limitations. These limitations are related mainly to storage performance and data identification.

This research investigates using CC as a storage and management solution for healthcare industry. The rest of the research is organized as follows, the following section provides background information about health records and health terminologies and discusses background information about CC. The section then discusses different management solution for managing healthcare records in the cloud. The following section introduces the suggested framework to handle and manage healthcare records. This is followed by an evaluation of the suggested framework. The final section concludes with final remarks and suggesting future work.

2. Literature Review

2.1 E-Health and digital health records

The terms electronic health record (EHR), electronic medical record (EMR), electronic patient record (EPR) and personal health record (PHR) define a set of concepts, including records collection about patients, medicines and diseases. These records are collected in order to process the data for health services [8]. "EHR" or "EMR" is a systematic collection of electronic health information about an individual patient or population [8]. The collected data is generated and maintained within healthcare institutions to give healthcare providers, patients and physicians access to a patient's medical records [11]. Many processes can be done to the Digital records. It can transfer quickly from one place to another. Digital records allow the doctors to review the patients' health history and help the hospitals to get a complete picture of the patient case. Digital records open the door for new opportunities in analyzing treatments, decisions making. Digital Records and e-health improve the efficiency and effectiveness of the health services [16].

2.2 Cloud Computing: A New Economic Paradigm

The CC is getting most IT stakeholders' attention as it delivers on-demand services over the Internet in a more efficient and effective manner. Buyya [2008] defines CC as "A type of parallel and distributed system consisting of a collection of

interconnected and virtualized computers that are dynamically provisioned and presented as one or more unified computing resources based on service-level agreements established through negotiation between the service provider and consumers." CC includes four deployment models:

a. The private cloud: That is operated and managed by one consumer only.
b. The community cloud: that is shared by many organizations within a individual community.
c. The public cloud: that is owned by one organization which called service provider. Public cloud is available to all clients.
d. The hybrid cloud: that is a combination of two or more of the other cloud types.

In addition, CC has three main famous models [4]:

a. Infrastructure as a Service (IaaS): It provides on-demand services for infrastructural resources. Infrastructures services can be logical such as: virtual machines (VM) or physical such as: processors, storage and network access.
b. Platform as a Service (PaaS): It provides platform resources such as: operating systems and software development frameworks. By using PaaS the users can develop their own cloud-based applications.
c. Software as a Service (SaaS): It provides on-demand applications over the Internet. In SaaS the cloud provider owns the applications and the consumers pay a fixed subscription fee.

Different initiatives have been proposed and implemented in health domain to use CC as a management solution for deploying health records and maintaining patients' data. Patrick et al. [12] suggested a model of ehealth in the cloud to manage health care records in Ghana. The proposed solution was designed to manage patients' records into hybrid cloud, which is an integration of both Private, and Public Clouds. The researchers claim that storage of data depends on the data type as stored into many servers to handle data bandwidth. If the data includes sensitive information such as family medical history, tests results or medication, then it will be stored in the private cloud. Otherwise, it will be stored in public cloud. Data Management are also based on data types. Doctors can manage the private and public data. On the other hands, patients can manage their own data that is located in the private cloud only. The proposed model of Ghana solves performance by separating tasks into servers, which are distributed between private and public clouds. However, it is not clear if the proposed solution works well as there is no real implementation or lab prototype of it.

A different approach [9] also considered the case of e-Health in China. The China project deployed EHR system into the cloud. In this project a private cloud was set up within the hospital system based on the IaaS model since they does not need to investigate the hardware and software requirements for the system separately. It will allow manage and monitor their data and increase its stability by using the private cloud and ViDs (Village Doctors) systems that is equipping village doctors and allow them to collect individual patient's information by using Health Information Technology. The planned system is designated for rural areas usage by using ViDs. ViDs systems work without Internet access, which is ideal in rural areas with limited,

or no Internet access. In their proposed design, they solve the issue of disconnection and the availability of cloud however the data is updated in the servers only when there is a connection and there is no integration between different ViDs. Moreover, all the data are stored in servers without separation and administrators do the management remotely by accessing the system's web pages. Reddy et al. 13] proposes a design of a Cloud framework for Health Monitoring System (CHMS). It gathers patients' health data through data acquisition devices and communicating this data using communication systems like: 3G and wireless devices to Telemedicine Repository (TMR). In the TMR, which is hosted in the Cloud, the data is processed and store in EHR system that also located in the cloud. The proposed CHMS has a web portal that allows users and health care agencies to access the records whenever they want. The advantage of CHMS is that it supports remote consultation between patients and medical professionals. CHMS has been tested by experimenting the performance against the response time and the data throughput. However, there is no real implementation that reflects the efficiency of the proposed system. Moreover, the data management was not discussed in the proposed system. The system might face downtime issues as it is based on communication module that uses wireless and 3G.

CHISTER [3] is an approach that relies on Cloud to support EHR system. CHISTER designed to have a two level modeling approach for an EHR system. The first model consists of data storage that defines entities and represents the semantics for storing the data. The second model consists of an archetype model that represents domain level constraints and defines clinical concepts. The authors claim that this approach makes the system more manageable and robust, as a change in one model will not affect the other model. To evaluate the performance of CHESTER, a prototype and benchmark of the performance was made. However, the complexity of operations in files creations and in checking the semantic of files each time makes this scheme unscaleable.

Rodriguez-Martinez et al. [14] illustrate MedBook, a platform that supports exchanging health records and billing activities. It is a SaaS platform built on top of open source cloud technologies and running on the top of an IaaS platform. Web services and web applications are used to support placing new records for billing activities or for creating new accounts. Health records are stored in a collection of cloud resident relational database instances. Health care providers have control over their services. Records have IDs and based on append-only database. Whenever an entry enters the system, it updates all the associated records based on its ID. The authors argue that this design allow to have trace back for the entire medical history of a patient. It is already implemented but no performance test applied to the system. Medbook has limitation on its legislation status since its built using open source CC.

Thuemmler et al. [15] discussed how to manage e-health data records in the cloud. FI STAR architecture based on Hybrid Cloud and the approach used is to bring the software to data paradigm. The requested services will be downloaded to the health system that locates in private cloud. The data will not be allowed to pass from private to public cloud. It consists of 3 main parts: Provider Edge, a Consumer Edge and an Application Store. The Provider Edge based on Public Cloud and includes software and the services. The Consumer Edge will be a platform software which will be run on top of a Service oriented Architecture. To manage all the activities, the authors

claims that the single point between bridges (private and Public) will allow close managing to all the health records. No evidence provided to test the efficiency of the suggested approach. Table 1 summarizes the advantages and limitations of each of the above approaches.

Table 1. Summary of different CC as a management solution for deploying health records and maintaining patients' data.

Project	Advantages	Disadvantages
Ghana system [12]	Handle performance by separating tasks into servers	No real implementation No meta data for storing data
China System [9]	Solve disconnection issues by storing data into ViDs system	Data are updated only when their is a connection to cloud performance issues
CHMS [13]	Collect and store data even in remote places	bad data management - Scalability and mobility issues down time issues
CHISTER [3]	Solve performance issues – it capture meta data so better data management	Complex - scalability issues
MEDBOOK [14]	Data recognition based on ID	Performance issues - storage bandwidth issues
FI STAR [15]	Handle the growth of data bandwidth	no evidence provided

Managing health records in cloud is important and can be achieved through an effective storage solution and through identifying healthcare records. This mean, if the healthcare records are identified by metaData then it can be easily managed and exchanged. Identifying data helps to facilitate storing and retrieving tasks. Recent studies have showed that the performance is an issue in their proposed solutions. For example, some research reported limitations in data performance as all the data are stored in one repository [9, 14]. There are no separation between servers, which results in having bad data management. However, others [3, 12, 15] separate the tasks and health data into servers and into hybrid clouds but they fail to find a way to identify the data so it can be retrieved later on. Metadata can help as it could structure the healthcare records.

3 HealthCare Records Manager

In the proposed solution we will solve the challenges of managing healthcare data and enhancing the storage performance. The approach that we will use is to manage

healthcare data based on MetaData identification that are related to the types of healthcare records. For example [5]: patients' records, Audit log records and health library records. MetaData [10] is "data about data". It Provides two functions: First, it allows users to browse and find healthcare records because it provides a mechanism to identify the data based on its structure. Second, Metadata clarifies the relationships [6] that mean it can help to associate health terminologies because not all the healthcare institutions use the same terminologies. Moreover, to enhance the management of healthcare data, we need a mechanism to store and retrieve data in an efficient way. To do so, we suggest to use a module that helps to identify the best storage based on criteria like: storage space. Storing and retrieving healthcare data can be considered as direct indicator for an efficient management system [7]. Thus, taking this challenge into consideration is very important.

Inspired by the previous literatures review on managing data in clouds, and our own studies from healthcare data management, proposal architecture is described as shown in Figure 1. First we will describe the proposal architecture and then we will discuss the execution workflow.

3.1 The Proposed Architecture

Figure 1 shows the proposed solution, which consists of three layers: First layer is user access layer that has General interface which allows communication between healthcare institutions and system. Healthcare institutions and users of the system can access the general interface anytime and anywhere as long as they have access to the Internet and membership to the healthcare institution society. Second layer is management layer that performs the Meta data management services. It plays the role of middleware between user access layer and storage layer. The role of management layer is to integrate the data between storage layer and user access Layer. Management layer makes it easy for users who want to store data as it takes care of finding the optimal storage. Users don't need to know how and where the data is stored. Management layer checks the status of the storage and send the data to the optimal storage. The third layer is Storage layer that responsible of storing the data in cloud.

The architecture of the system provides the ability for healthcare institutions to store and manage their data in variety range of storages. The system allows the users to get benefits from managing the healthcare data by utilizing the Meta data as a solution for management. Management layer which is the core layer in the proposal, contains the following components:

a. Metadata Assigner: Data that enters the system needs to be assigned with Meta data for management purpose. There are two meta data proposed: The unified Meta data for all the records and the additional Meta data for each record's type, for example: For patients Records, the Metadata is Patient Account Number-Patient Last Name-Patient First Name-Date of Admission. For audit Log Records Metadata is: Who access data, which data, where, when, why. For Health Library Records Metadata is: How many copies in the library – who checked them – Location

b. Optimum Storage Locator: determine the optimum storage to store the data based on: size and types of resources to be stored, storage space status, and network speed
c. Pre-Processing Convertor: this component is responsible of preprocessing the data in case it needs to be converted to another form before it is stored in the storage.
d. CS Adaptor Bus: This component allows scalability as it connects all the storage. It stores the data to the CSs. By CS Adopter Bus, the healthcare institutions can add as much health data as they need.

The expectation from Healthcare Records Manager is as the following:

a. Improve the performance of storing and retrieving healthcare data Better data management by using the optimal storage locator
b. Allow better communication and data exchange be-tween all the healthcare institutions by identifying health records using Meta Data
c. Allow scalability of data storage as the CS adopter bus can add as much CS as the healthcare institution need

3.2 Management Execution Flow

The management execution flow starts when the users and health care providers transfer their data stored in their local systems and local devices to management cloud system to share them. Management cloud system determine the type of data transferred and provides a Meta data structure according to the type of the records. The user needs to fill the Meta data of the transferred data in order to make it easy for later on retrieval. The Optimal Storage Locator will determine the best storage for the data and its Meta data based on the selection criteria. It is important to notice that, the preprocessing module will act only if the data doesn't suit the needed format. Moreover, the users will not notice all the details steps such as storage selection and data conversion. Evaluation of the proposed solution: Expected Outcome/ contribution: Improve the performance of storing and retrieving healthcare data Better data management by using the optimal storage locator Allow better communication and data exchange between all the healthcare institutions Allow scalability of data storage as the CS adopter bus can add as much CS as the healthcare institution needs.

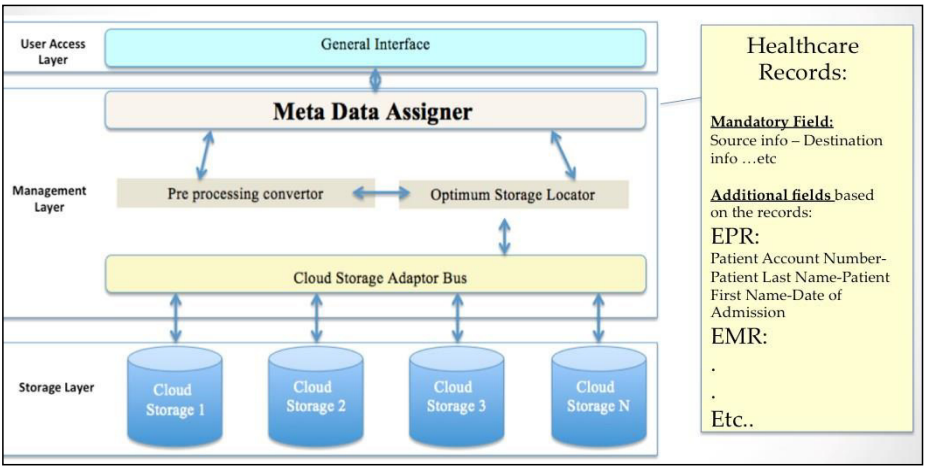


Fig. 1. Storage Management Architecture

4. Evaluation of HealthCare Records Manager

4.1 Prototype Implementation:

The system will be connected to many data servers that connected to the Internet. The user will access the interface to send healthcare data over the Internet to the data servers, which then manage the records in the optimal storage. When the user wants to retrieve the healthcare data, he or she will access the data server through a Web-based interface. The prototype will be built by using Google App Engine. We will create a class, which is the interface to manipulate health data to cloud. The language used for implementation will be java. We will connect to Google cloud by using Data store with JDO. The messages will be routing through the Message Routing that based on XML format. To access CS components, we will use CS API that is provided by Google.

4.2 Prototype Evaluation:

The evaluation of the proposal will be based on measuring scalability and performance of the data. An initial prototype is proposed in order to evaluate the efficiency of the proposed solution and to validate its possibility. First, it is important to test each component separately, in isolation, to make sure it's performing the

expected behavior. The testing can be done by using tools like unit testing. Measuring the followings will test the scalability performance:

a Speed vs. concurrent clients
b Speed vs. healthcare size (small 4kb – large files 100MB)
c Throughput scalability: scales up to bandwidth limit
d Metadata scalability

Moreover, different performance measurements will be illustrated to evaluate the performance. The test will include measuring the performance varies by uploading different size of health records to check the speed of the performance. Also, the network speed will be tested against the compressed health records and the normal health records. It can be predicted that the compressed health records will have better and faster transformation in the network than the normal health records and thus can help in health and clinical images transformation as it have large sizes. Also, the performance of the Optimal Storage Locator will be checked by measuring the storage space of each cloud and then if the Locator successes in determining the best storage cloud then its performance will be accepted. Also, the performance time of the Optimal Storage Locator will be measured by running sample to measure the time against the response. The goal of the heuristic algorithm is to find the optimal storage for healthcare data with minimum time. The expected result should show very fast response in less than 500 ms in a test environment.

5. Conclusions and Future Work

In this paper, we have proposed the Healthcare Records Manager in Cloud by using the power of Meta Data to identify healthcare records and also by using Optimal Storage Locator module, which allows finding the optimal storage for healthcare records. We have also proposed an architectural design for healthcare records in Cloud as a solution for managing and storing healthcare records in cloud by using the concept of Meta Data. Finally we suggested a prototype to evaluate the proposed Healthcare Records Manager by testing the scalability and performance. In the future, we plan to carry out some further activities, which could improve the performance of Healthcare Records Manager. First, we plan to Implement Evaluation prototype and also we plan to classify more Types of Healthcare records in order to include it in Meta Data structures. Finally, security issues will be addressed in the next phase of this research.

References

1. Abukhousa, E., Mohamed, N., & Al-Jaroodi, J.: e-Health Cloud: Opportunities and Challenges. Future Internet, 621–645 (2012)
2. Agha, L. The effects of health information technology on the costs and quality of medical care. Journal of Health Economics, 19–30.
3. Bahga, A., & Madisetti, V. K.: A Cloud-based Approach for Interoperable Electronic Health Records (EHRs). IEEE Journal of Biomedical and Health Informatics IEEE J. Biomed. Health Inform., 894–906 (2013)
4. Buyya, R., Yeo, C. S., & Venugopal, S.: Market-Oriented Cloud Computing: Vision, Hype, and Reality for Delivering IT Services as Computing Utilities. 2008 10th IEEE International Conference on High Performance Computing and Communications, 2008. *HPCC'08. 10th IEEE International Conference on*, pages 5–13 (2008)
5. DesRoches, C. M., Campbell, E. G., Rao, S. R., Donelan, K., Ferris, T. G., Jha, A., et al. Electronic health records in ambulatory care—a national survey of physicians. *New England Journal of Medicine*, 359(1):50–60 (2008)
6. Duval, E., & Hodgins, W.: Making metadata go away:" hiding everything but the benefits". In *International Conference on Dublin Core and Metadata Applications* (2004)
7. Heanue, J. F., Bashaw, M. C., & Hesselink, L. Volume holographic storage and retrieval of digital data. *Science*, 265(5173):749–752 (1994)
8. Jha, A. K., Ferris, T. G., Donelan, K., DesRoches, C., Shields, A., Rosenbaum, S., & Blumenthal, D.: How common are electronic health records in the united states? a summary of the evidence. *Health Affairs*, 25(6):w496–w507 (2006)
9. Lin, C.-W., Abdul, S. S., Clinciu, D. L., Scholl, J., Jin, X., Lu, H., et al.:Empowering village doctors and enhancing rural healthcare using cloud computing in a rural area of mainland china. *Computer methods and programs in biomedicine*, 113(2):585–592 (2014)
10. Mathes, A.:Folksonomies-cooperative classification and communication through shared metadata. *Computer Mediated Communication*, 47(10):1–13, (2004)
11. Oh, H., Rizo, C., Enkin, M., Jadad, A., Powell, J., & Pagliari, C. What is ehealth (3): a systematic review of published definitions. *Journal of medical Internet research*, 7(1), (2005)
12. Patrick, M., Laar D.: E-health dedicated hybrid cloud: a solution to ghana's health delivery problems (2012)
13. Reddy, B. E., Kumar, T. S., & Ramu, G.:An efficient cloud framework for health care monitoring system. In *Cloud and Services Computing (ISCOS), 2012 International Symposium on*, pages 113–117. IEEE (2012)
14. Rodriguez-Martinez, M., Valdivia, H., Rivera, J., Seguel, J., & Greer, M. MedBook: A cloud-based healthcare billing and record management system. In *Cloud Computing (CLOUD), 2012 IEEE 5th International Conference on*, pages 899–905. IEEE (2012)
15. Thuemmler, C., Mueller, J., Covaci, S., Magedanz, T., Panfilis, S. D., Jell, T., & Gavras, A: Applying the software-to-data paradigm in next generation e-health hybrid clouds. In *Information Technology: New Generations (ITNG), 2013 Tenth International Conference on*, pages 459–463. IEEE (2013)
16. Yamin, C. K., Emani, S., Williams, D. H., Lipsitz, S. R., Karson, A. S., Wald, J. S., & Bates, D. W.: The digital divide in adoption and use of a personal health record. *Archives of Internal Medicine*, 171(6):568–574 (2011)

IDENTIFICATION OF SEMANTIC FOCAL GROUPS FOR TOURIST PACKAGES BASED ON THE SEMANTIC ORIENTATION OF OPINIONS

Natalia Soledad Bustamante Sánchez[1], Susana Alexandra Arias Tapia[2], Silvia Elena Malo Martínez[3], Javier Sanchez Guerrero[4], Hernando Buenaño Valencia[4]

[1]Departamento de Ciencias Empresariales, Sección de Hotelería y Turismo, Universidad Técnica Particular de Loja, Marcelino Champagnat S/N, 1101608, Loja, Ecuador
Email:nsbustamante@utpl.edu.ec
[2]Departamento de Ciencias de la Computación y Electrónica, Sección de Inteligencia Artificial, Universidad Técnica Particular de Loja, Marcelino Champagnat S/N, 1101608, Loja, Ecuador
Email:saarias@utpl.edu.ec
[3]Departamento de Arquitectura y Artes, Sección de Teoría y Patrimonio, Universidad Técnica Particular de Loja, Marcelino Champagnat S/N, 1101608, Loja, Ecuador
Email:semalo@utpl.edu.ec
[4]Universidad Técnica de Ambato, Decanato Facultad de Ciencias Humanas y de la Educación
{jsanchez, edwinhbuenaniov@@uta.edu.ec}

Abstract. In tourism, marketing it is very important to take into consideration client opinions. The majority of this type of work focuses on textual classification. We have proposed a methodology that uses a semantic orientation of texts in order to identify: a) the classification of text-based opinions and, b) a semantic focal group in which textual opinion differs from polarity. For this reason, we have designed a mechanism that identifies levels of concordance between opinion and emotion in a text. When there is no concordance found between such variables, a focal group can be identified – the latter of which is very important for tourism operators. The results of our proposal are favorable in terms of identifying precision levels and they also help to provide conclusions and scope for future work related to the original proposal.

Key words
Tourism, Opinion, Tourism Package, Ontologies, Sentiments, Emotions, Polarity.

1. Introduction

Global tourism marketing strategies do not always take into consideration consumer needs during the elaboration of Tourism Packages (*TP*). The latter concept is essential to understanding consumer behavior. In fact, *TP*s are becoming more and more sophisticated today as consumers' needs become more demanding and more complex. A basic principle of marketing is to enable consumer markets to identify the precise nature of a product or service.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_42

In a similar vein, there are thousands of tourist destinations that are appealing to global travellers. However, many of these tourist destinations lack individual promotional strategies or do not have an established marketing campaign that includes *TP*s. In this sense, if a tourist operator is unaware of the needs of tourists, it is very difficult to create a suitable tourism package.

Generally speaking, many tourists seek travel experiences that include basic services and products that are available in one's own country. For example, Internet access, clean and safe accommodation, or just a cup of coffee-all of which are considered to be fundamental aspects of any *TP*. The majority of case studies that are used to help to identify a market segment are thus based on the actual requirements of the traveller. These normally consist of price, number of days spent travelling, the proximity to bus or train stations, and also basic services.

In fact, for tourism operators this is something that demands hard work and analysis, as well as good decision-making skills. [1]. Designing a *TP* also facilitates exchange and transaction. Indeed, it is often believed that this process should terminate with the sale of a *TP*. However, what is more important is that which occurs after the purchase. In other words, how we deal with information stemming from customer experience.

Our proposal primarily consists of identifying customer feelings after using a *TP*. The aim is to obtain a result – whether it is one of positive, negative, or neutral satisfaction. This will facilitate the improvement of marketing and services associated with TPs.

For this reason, we focused mainly on customer opinions obtained from written tweets about TPs, and also by applying text mining algorithms that identified the subjectivity of opinions and polarity scales (positive, negative, or neutral), which were associated with the service. Our main objective, however, was to identify the semantic orientation of texts, which lead to the semantic treatment of opinions for a *TP*. It is also necessary to highlight that client opinions were not extreme (0.1), but rather intermediate values that formed part of the neutral opinion value scale.

Our proposal thus consisted of individual elements that were examined together with the aim of taking into account the neutral values, which were rated as "normal" in terms of opinion. For this reason, we adopted the proposals of [2], which describe the level of pertinence in which it is possible to identify an emotion. However, prior to working with opinions, it was necessary to filter them by means of calculating the semantic orientation. In this sense, we only validated only those opinions that were semantically close to 1.

This helped to differentiate the normal clients (semantic concordance) from those without such concordance or those that are considered to be a semantic focal group. A semantic focal group is very important for tourism operators; it helps to identify whether clients provided accurate information or not about a product or service. In the following sections, we describe the State of the Art related to our research. This was done after proposing a methodology.

In the methodological section, however, we used text-mining definitions that enabled us to obtain semantic polarity and a semantic orientation of the subjective opinions of the *TP*. Finally; we tested the hypothesis with datasets so as to obtain the conclusions and to assess future research possibilities.

2. State of Art

The information that flows during the execution process of a *TP* is very important for tourist operators who need to improve their services. Consumer behavior in social networks was examined using text mining techniques, which helped to classify it according to customer preferences and to obtain information about client segments that preferred one *TP* over another [3]. With regard to customer opinions, we can also distinguish those that are spam [4].

Moreover, when they are processed as subjective opinions, they constitute noise in text mining process. Once the user's opinions have been validated, one can process the subjectivity and obtain classifications of tourist destinations (good, bad, average). The *VIKOR* model is used to classify tourist destinations according to user opinions, to filter irrelevant commentaries, to extract feelings or sentiments, and to quantify them, [5]. We used the *VIKOR* principle, but with Semantic Orientation (*SO*) values close to 1, since it was necessary for the opinions to be close to semantic management.

The multi-dimensionality of the model both enables the classification of places to be precise and aids the decision making process of the tourist operator and the consumer. The process of identifying valid opinions is very important in this study as it contributes to the semantic treatment of the data- making them a precise as possible for tourism operator consultancy. The customer opinions are not only used for text mining and for classifying a sentiment, but also for obtaining preferences.

When we examine social networks in relation to tourism and the evaluation of hotels, we aim to look at customer satisfaction and online management of the topics that are addressed in conversations with the clients [6]. This is an area that the clients consider to be of vital importance since it links the conversation and client opinion with the entity. For example, the extract the hotel was clean becomes a positive opinion regarding the entity 'Hotel' by establishing a semantic textual relationship.

These semantic representations have already been used for decision making in tourism. Combining semantics and information technology algorithms has thus enabled the classification of tourism documents [7] [8]. The design of semantic structures for tourism is related to consumer behavior, which is generally obtained by means of surveys that include measurements such as percentages, averages and standard deviations. These are also key aspects in tourism research.

In this case, we worked with text mining techniques for semantic treatment and proposed the usage of the fuzzy logic since the client opinions were between (0 or 1), or had intermediate values which were expressed in the text with phrases such as more or less and average - a definition, which in our proposal, is used to describe the neutral state of a client with respect to an opinion about an entity. The *PANAS* proposals and the levels of proposed pertinence in [2] are utilized in our research with the aim of identifying an emotion and its level of pertinence.

3. Methodology

One example of the text that we analyzed in this research study is that which has been compiled for the data set: *opinions_hote725721.*

> ***Old seattle getaway This was Old World Excellence at it's best. THIS is the place to stay at when visiting the historical area of Seattle. Your right on the water front near the ferry's and great sea food restraunts,and still with'in walking distance for great blues and jazz music. The staff for this hotel is e xcellent; they make you feel right at home. The breakfast was great.***

The above text is an example of an opinion about a hotel. The *hotel_72572* dataset contains more than 100 opinions about hotel services. Our proposal consists of identifying irrelevant opinions so as obtain an emotion and polarity of the text.

3.1. Irrelevant Opinions

Opinions have polarity. However, in order to construct a syntactical tree, one needs to have concepts and sentiments (feelings) linked together. This will enable us to create an affective space. By establishing these concepts, and by having sentiments (feelings) linked to this concept, we can use the polarity scale to calculate the valence of a concept. Moreover, because it is a dependency-based concept, it can transfer its valence to the rest of the concepts based on the proposed clauses or rules.

One should remember, however, that in order to obtain polarity, it is necessary to use dictionaries or lexis where the concepts are already related (which should be done in advance and should include a polarity and a related emotion). We can use Table 1 for this as it provides us with a polarity level. In addition, we can obtain the affective spaces, i.e. provided that we link each phrase of the text (entity) with a polarity. Moreover, with polarity, and through the incorporation of feelings and emotions, we can also apply a diffused classifier, *i.e. with the aim of allocating the affective space to the new opinions*. The following code can be used to carry out this process:

[1] http://www.cs.cmu.edu/~jiweil/html/hotel-review.html

```
from_future_import division
import urlib.request
import urlib
import json
from math import log
def hits(word1.word2--" ")
query = "http://ajax.googleapis.com/ajax/services/search/web?v=1.0&q=%s"
if word2 = = "":
results = urlib.request.urlopen(query % word1)
else:
q = urlib.request.quote(word1+""+"AROUND(10)"+""+word2)
print(q)
print(query % q)
results = urlib.request.urlopen(query % q)
json_res = json.loads(results.readall().decode("utf-8´))
google_hits=int(json_res[´responseData´][´cursor][´estimatedResultCount´])
return google_hits
def so (phrase):
num = hits(phrase."excellent")
#print num
den = hits(phrase."poor")
#print den
ratio = num / den
#print ratio
sop = log(ratio)
return sop
print (so("This is"))
```

Code 1. Semantic Orientation

In the above example, Code 1 can be used to obtain a semantic orientation (*SO*) of the phrase *"This is"*. Although there is a prior classification of the sentences, the previously created corpus[2] may also contain syntactic dependency trees (*syntactic n-grams*) and semantic dependency. All this helps to comprise the affective space. In our case, however, the previously built corpus is comprised of the opinions provided by tourism clients.

One may also use diffused classification. In this case, it is not only about obtaining semantic orientation, but rather about obtaining the level of valence based on polarity. The affective space may also be comprised of emotions that have an *"emotional level"* and that can be treated with diffused logic.

3.2. F-CLUSTER

What is important, however, is to relate the concept (phrase) with an emotion and polarity (range). *Lexis* is used as affective spaces. This includes affective phrases (taken from affective dialogue) in the same way that characteristics are included in the training grid. The algorithm *Fuzzy c* means (*f-cluster*), which is used to obtain groups based on a corpus. It is based on the function that helps reduce errors for each of the groups found in:

$$J_m = \sum_{i=1}^{N} \sum_{j=1}^{c} u_{ij}^{m} \left\| x_{i-c_j} \right\| 2 \quad , 1 <= m < \infty$$ [3]

As an example, we are going to apply the f-cluster classification to our series of data:

[2] *http://ajax.googleapis.com/ajax/services/search/web?v=1.0&q=%s*

[3] formula

Positive	Negative	Class
16	6	Sad
20	19	Sad
21	14	Neutral
7	7	Happy
56	35	Happy
1	1	Sad
2	3	Neutral
36	11	Neutral
29	19	Sad
17	35	Neutral
26	17	Sad

Table 1. Dataset polarity vs. emotions

Table 1 is related to the polarity of texts and the most repeated or most prominently experienced emotions in this study. The source code obtains the following f-cluster classifications:

```
mydata = read.csv("polarity-emotions.csv")
x<mydata
x<rbind(mydata$Positive, mydata$Negative,mydata$Neutral)
x<-t(x)
result<-cmeans(x,3,50,verbose=TRUE,method="cmeans")
s3d <- scatterplod3d(results$membership, color=result$cluster, type="h",
angle=55, scale.y=0.7, pch=16, main="Pertinence")
plod(mydata, col=result$cluster)
```

Code 2. Fuzzy Cluster

The results are shown below:

```
Iteration:   1, Error: 50.3540613909
Iteration:   2, Error: 49.7526506556
Iteration:   3, Error: 49.6991164048
Iteration:   4, Error: 49.6940199973
Iteration:   5, Error: 49.6935105661
Iteration:   6, Error: 49.6934576058
```

As a result, a high level of error is produced due to the small quantity of existing data in the dataset. The results of the centroids are as follows:

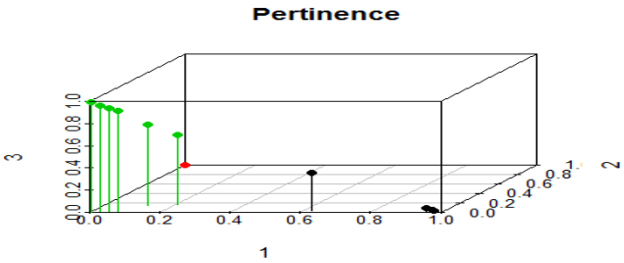
Fuzzy c-means clustering with 3 clusters
Cluster centers:

	[,1]	[,2]
1	5.251794	4.454648
2	54.603128	34.490338
3	24.680939	17.812261

Memberships:

	1	2	3
[1,]	0.6250245304	0.032016113	0.342959356
[2,]	0.0507703511	0.015156176	0.934073473
[3,]	0.0752179326	0.016467067	0.908315000
[4,]	0.9752722603	0.003077415	0.021650325
[5,]	0.0006287185	0.997643011	0.001728271
[6,]	0.9586845550	0.007202280	0.034113165
[7,]	0.9797492784	0.003307814	0.016942908
[8,]	0.1288100184	0.141782004	0.729407978
[9,]	0.0246805969	0.021375240	0.953944163
[10,]	0.2092354150	0.158457465	0.632307120
[11,]	0.0040567593	0.002121668	0.993821573

Here, for example, we find high values for the entries. We later observe the pertinence of the grouping as follows:



Below, we can see low values for cluster 1 (probable errors of the algorithm). Cluster 2 shows high values like those in cluster 3. The grouping of the entries per class are shown in the following diagram:

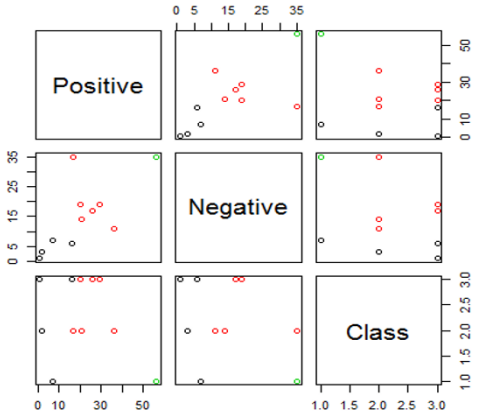


Figure 1. Distribution of emotions vs. polarity

Figure 1 shows that groups are created based on the distribution of emotions. For this example, the groups are homogeneous. What is interesting to note in this graph is that the groups do not mix with each other, which gives us the "preliminary" conclusion that emotions and polarity serve as mechanisms to identify client groups and valid opinions. In Figure 1, the affective spaces are shown, i.e. where each emotion is related to the text polarity. This has helped create more homogenous groups.

However, for the time being, and for the purpose of this study, they are not mixed. The level of emotion is reflected in the level of pertinence for each class. The emotional levels of [2], from 0 to 4 are taken into account to identify the emotion in our research, e.g. by placing a 0 where the emotion does not exist and a 4 when the emotion is found at its highest semantic level. When referring to the semantic level, it is important to highlight that the relationship with polarity must be precise.

Thus, where an emotion has a high level of polarity, then the positive or negative polarity must also be high.

3.3. Analysis of emotion and polarity

In this study we used dictionaries that enable us to obtain a semantic correspondence of opinions, that is, once they had been filtered via SO. These dictionaries are described as follows: a) ElhPolar, this dictionary relates the word to the level of polarity. (For example, a_ciegas (blindly): negative) [9]. This dictionary is currently available in Spanish. Moreover, with this dictionary, we can emulate the proposals by [10] with *SenticNet*, and

b) *EMS* relates words with emotions. *(For example, 'victimized': 'cheated')*. This dictionary is available in English.

In order to provide a more concrete example, the words were translated into Spanish[4]. With this particular dictionary, we can emulate the proposal provided by [10] such as with *WNA* (Affective Spaces). Code 2 helps us to obtain a correspondence between an emotion and the polarity of a text. If there are no coincidences, there is a problem in terms of consumer opinion. Therefore, one may obtain focal clients for the tourism operators.

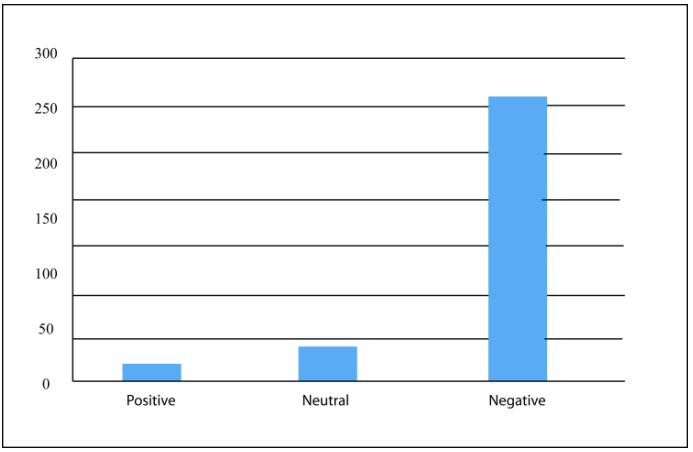


Figure 2. Semantic correspondence

Figure 2 shows the semantic correspondence of a dataset of opinions. The negative polarity is the most common, which corresponds to the emotions of *Angry and Sad*, namely those emotions that that possess an emotional classification. For example, a specific client may be said to have valid opinions and consequently they may be taken into consideration by the tourist operator in decision making. Therefore, when this concordance does not exist, we have a focal group that must be studied in detail as shown in the Code 3.

4. Experimentation

During this stage, we worked with the dataset_72572 with the aim of corroborating our methodology. The results are shown below:

[4] EMS can be obtained from: https://pythonism.wordpress.com/2013/06/16/elementary-sentiment-analysis-on-a-text-using-python/#more-1256.

TP	TN	FP	FN	Precision	Recall	F1Score
21	15	8	**4**	**0.72**	**0.65**	0.68

Table 2. Valid opinion selection

Table 2 shows that our methodology is precise. In other words, it is capable of identifying the valid opinions of the clients. For this reason, we took the 25 positive values with the aim of identifying their semantic correspondence. The values obtained by the *F1Score* indicate that there is equilibrium in the results.

```
1.      from ems import em
2.      from pol import po

3.      def analyse(e):
4.      w=[]
5.      for x in em:
6. if x in e:
7. w.append(em[x])
8. return w
9.def analysep (e):
10. w= []
11. for x in po:
12. if x in e:
13. w.append(po[x])
14. return w

15. outfile = open('corpustourism.txt', 'w')
16. fichero = "hotel_72572.dat"
17. infile = open(fichero, 'r')
18. contador = 1
19. linea= ""
20. for line in infile:
21. if contador == 2:
21. linea = linea + line
23. contador = 1
24. else:
25. contador = contador + 1
26. linea = linea + "."
27. outfile.write(linea)
28. infile.close()
29. outfile.close()
30. a=open('corpustourism.txt')
31. b=a.read()
32. c=b.split('.')
33. a.close()
34. q=[]
35. for x in c:
36. q.extend(analyse(x))
37. r={}
```

Code 3. Semantic correspondence

The results are shown below:

TP	TN	FP	FN	Precision	Recall	F1Score
16	2	2	**5**	**0.88**	**0.5**	0.64

Table 3. Semantic correspondence

The precision value in Table 3 is very important for our research. Apart from identifying concordance, it helps us to obtain a high level of precision in the focal group. However, the Recall value is considered to be low here. In addition, the error level should be reduced. Indeed, our methodology does not take into consideration certain opinions that form part of the focal group. We also analyzed the level of pertinence that was obtained with fuzzy logic. Table 4 shows the results obtained with fuzzy logic:

TP	TN	FP	FN	Precision	Recall	F1Score
42	9	7	12	0.85	0.56	0.67
50	**12**	**4**	**4**	**0.92**	**0.75**	**0.82**
37	8	8	17	0.82	0.5	0.62

Table 4. Identification of Emotions: Polarity vs. Emotion

Table 4 shows that the proposals by [2] function better for our experimentation stage, that is, with an F1Score value of 0.82. Three emotions are highlighted in the experimentation stage: Sad, Happy and Neutral. For neutral emotions, the important point was to determine that *neutral* may result in an opinion. For this stage, only some certain opinions were taken into account. The results from the experimentation stage are shown below:

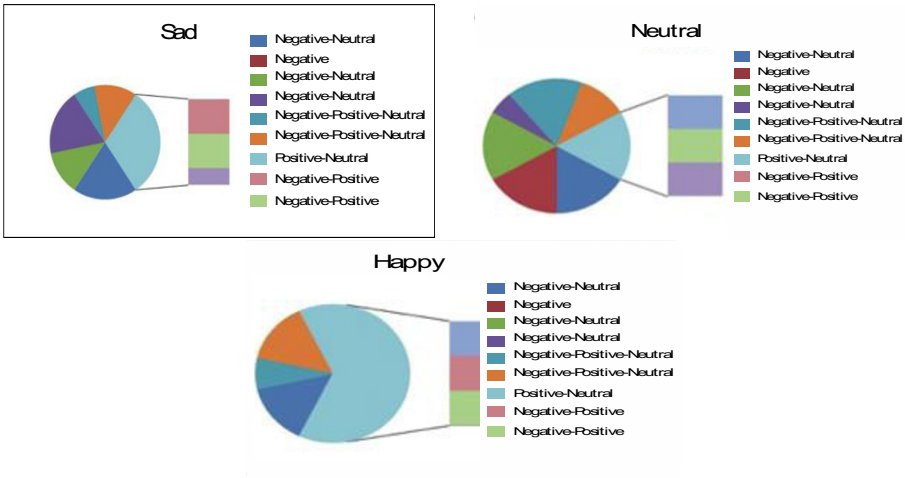


Figure 3. Emotion vs. Polarity

Figure 3 shows that a sad emotion may exist in a text –e.g. where there is a neutral negative-positive and a neutral-negative polarity. This implies that there are incoherencies in consumer opinions, which should be taken into consideration for the focal groups. In fact the emotions that are displayed are sad – despite that fact that they are found to be positive. The same result occurs for the happy emotion. For neutral, there is only the Positive –Neutral scale, which indicates that those that show a neutral polarity are more positive in written texts, and are consequently not that *neutral*.

5. Conclusions and future work

In this study, we described the semantic treatment of tourist opinions. We began by validating opinions using text mining techniques, i.e. with the aim of identifying the semantic correspondence and semantic focal groups. The semantic and focal classifications are important for tourist operator since they help us to identify which

clients should be focused on when proposing a new *PO*. The results show that our proposal is precise and that we can carry out a group classification and selection of opinions.

In other words, where the different values for neutral opinions demonstrate that there is a neutral-positive or a neutral-negative polarity. This constitutes one of the most important findings of our work, which is linked to the identification of a focal group. However, it is not complete. We need to improve the recall values since the methodology does not take into account values that correspond to valid opinions. In a future publication, we will try to improve the error margin and design ontologies that include various classifications.

With this new methodology, we can assess the relationships between entities and semantic treatment. This will be very important not only for group classification, but also to establish relations between different *PO*.

References

[1] M. E. Escudero Aragón, Marketing en la actividad comercial, Madrid: Editex, 2014.

[2] K. Bakhtiyari y H. Husain, «Fuzzy Model on Human Emotions Recognition,» *Recent Advances in Electrical and Computer Enginnering,* 2014.

[3] P. Aurchana, R. Iyyappan y P. Periyasamy, «Sentiment Analysis in Tourism,» *International Journal of Innovative Science, Enginnering & Technology,* 2014.

[4] E. Choo, T. Yu y M. Chi, «Detecting Opinion Spammer Groups Through Community Discovery and Sentiment Analysis,» *Lecture Notes in Computer Science,* pp. 170-187, 2015.

[5] A. Abirami, A. Askarunisa, K. Gayarathri y M. Jeyalakshmi, «Social Media Analysis for TamilNadu Tourism Places using VIKOR Approach,» *Artificial Intelligent Systems and Machine Learning,* 2015.

[6] M. Schickert, X. Liu y R. Law, «Hospitality and Tourism Online Reviews,» *Travel & Tourism Marketing,* 2015.

[7] C. Namahoot, M. Bruckner y N. Panawong, «Context-Aware Tourism Recommender System Using Temporal Ontology and Naive Bayes,» *Advances in Intelligent Systems and Computing ,* pp. 183-194, 2015.

[8] R. Prasath, V. Kumar y S. Sudeshna, «Assisting web document retrieval with topic identification in tourism domain,» *Web Intelligence and Personalization on Social Media,* pp. 31-41, 2015.

[9] X. Saralegi y I. San Vicente, «Elhuyar at TASS 2013,» de *XXIX Congreso de la Sociedad Española de Procesamiento de lenguaje natural*, Madrid, 2013.

[10] S. Poria, A. Gelbukh, E. Cambria, A. Hussain y H. Guang-Bin, «EmoSenticSpace: A novel framework for affective common-sense,» *Elsevier,* pp. 108-123, 2014.

[11] B. Giffard, M. Laisney, F. Eutasche y B. Desgranges, «Can the emotional connotation of concepts modulate the lexico-semantic deficits,» *Neuropsychologia,* 2009.

[12] E. Ascher, V. Sturm, B. Seider, S. Holley, B. Miller y R. Levenson, «Relationship satisfaction and emotional language in frontotemporal dementia and Alzheimer disease patterns and spousal caregivers,» *Alzheimer Dis Assoc Disord,* pp. 49-55, 2010.

[13] B. Torres, R. L. Santos, M. F. Barroso , J. Simoes, M. Moreira, T. Belfort, R. Dias y C. Nascimento, «Facial expression da expressao facial na doenca de Alzheimer: um estudo longitudinal,» *Arq. Neurosiquiatria,* 2015.

[14] D. Sidtis y R. Wolf, «Pragmatic verbal repetition: review and application of a new method of quantification,» *Text & Talk,* pp. 263-287, 2015.

[15] B. Agarwal, S. Poria, N. Mittal, A. Gelbukh y A. Hussain, «Concept-Level Sentiment Analysis with Dependency-Based Semantic Parsing: A Novel Approach,» *Cognitive Computation,* pp. 487-499, 2015.

[16] S. Poria, E. Cambria, G. Winterstein y G.-B. Huang, «Sentic patterns: Dependency-based rules for concept-level sentiment analysis,» *Elsevier,* pp. 45-63, 2014.

[17] M. Minsky, «The Emotion Machine: Commonsense Thinking,» New York, Simon & Schuster, 2006, pp. 344-350.

Large Project Management in the Automotive Industry: A Flexible and Knowledge Based Approach

Filipe Ferreira[1], Ana Luísa Marques[1], José Faria[1,2], Américo Azevedo[1,2]

[1]*CESE / INESC TEC, Campus da FEUP, Porto 4200-465, Portugal*
[2]*Faculdade de Engenharia, Universidade do Porto, Rua Dr. Roberto Frias, Porto 4200-465, Portugal*

filipe.d.ferreira@inesctec.pt, ana.l.marques@inesctec.pt, jfaria@fe.up.pt, ala@fe.up.pt

Abstract. This paper presents a novel approach on flexible and knowledge intensive process management, driven by a large automotive industry case study. The automotive company in analysis requires a very dynamic behaviour, based on high flexibility of both people and equipment. Market has been imposing a decreasing of automotive products life cycles, increasing the number of line adaptations during the entire value chain, resulting in an increased complexity from product design to production. To handle this complexity, new knowledge-based methods and technologies to model, simulate, optimize and monitor planned and existing manufacturing systems are required. Existing large Enterprise Information Systems impose totally structured and predictable workflow, while knowledge intensive processes are flexible and unpredictable, involving high amount of human-decision and interaction. This lead to the need of development of highly specialized applications. This paper presents a novel hybrid approach, including work, information and communication management, to support knowledge intensive processes. The application of the new solution in the automotive engineering process management proved to be very effective and efficient, leading to significant savings.

Keywords: Hybrid Process Management; Knowledge Based Engineering; Collaborative Engineering; Product Design and Development; Manufacturing Planning.

1 Introduction

Nowadays, automotive industry is driven by mass-customization and high quality and productivity standards. Time to market is critical due to the imposed shorter life cycles of the products, increasing the number of facelifts and respective production line adaptations during the entire value chain. This implies a fast reaction and proactive production system based on product, process and human resources flexibility [1] [2].

The presented use case is based on a flexible multi product assembly line that produces three car models. This paper is focused on the planning stamping processes, which involve high levels of collaboration, communication and human decisions. These kind of processes require a very forceful and dynamic behaviour, which is achieved through qualified and motivated people, continuous improvement and innovation.

The company has a specific Business Unity (BU), dedicated to dies construction, together with other four tool shops, supports die constructions as a core technical

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_43

business worldwide. With a workforce around 230 employees, equipped with modern milling machines and try-out presses, this BU is able to follow-up several die-sets projects from analysis phase till the process validation phase.

Every time a new car model is launched, a new die-set project is raised for stamping, been managed by a dedicated team that has to handle a huge amount of information flowing through the different stakeholders and during several phases of project. Having the right information at the right moment, to make fast and well based decisions is usually a challenge planners and managers have to face.

After analysing the as-is processes, it was possible to assert that the continuous updates on each die-set (DS) status were consuming a considerable amount of time and resources, turning the decision making process more reactive instead of the desired pro-active approach. It was also possible to see that valuable information is spread by numerous departments and specialists. This approach represents a severe concern since it can be the cause of wrong or slow decisions due to misinformation in a process that is very time dependent.

This show us that this process can possibly generate high amounts of information that need to be searched, organized, reported, kept, tracked and stored for future projects causing the concerns regarding the reaction times and reliability of information.

The current state of the process weaknesses can be summarized and identified in the following list:

- Transversal and hierarchical projects involving several departments and objectives within the organization;
- Human intensive processes with high level of improvement and feedback loops;
- Processes dependent on individual expertise;
- The number of people involved and information's storage formats are incompatible with a pro-active approach;
- Management based on individual trust;
- Low capacity for knowledge capture and reuse;
- Lack of standardized knowledge based databases fed by past experience and personnel knowledge;
- The current storage method for data makes it difficult to gain access to it;
- Ad-hoc communication flow;
- The reliability of the data is compromised because of the communication methods and data formats;
- Time dependent processes that do not allow on-time/online monitoring;
- High risk of misinformation.

Having analysed the as-is state in detail by considering the process mapping it is possible to understand that all the weaknesses can be eliminated by providing means to have a proactive approach in the die-set manufacturing process.

This paper presents a complete solution to support collaboration in knowledge intensive work environments in the scope of automotive engineering and planning, including integrated work, information and communication management.

2 Approaches and state of the art

Knowledge intensive processes are not suitable for traditional automation and enterprise information systems and new knowledge-based methods, technologies and tools are required [1].

It is observed that in many cases the existing information and communication technologies tools are not capable to manage the daily activities due to the lack of flexibility regarding dynamic and changeable environments [3] [4]. Large enterprise information systems impose structured and predictable workflow, while projects are flexible and unpredictable, involving high amount of human-decision and interaction [3] [5]. Moreover, many times, large enterprise information systems are not able to manage the communication and information inherent to the knowledge-based process itself [4] [6]. Thus, during the project execution, team members are forced to use office productivity tools such as spreadsheets and text editors as well as shared folders and internal email and phone to manage processes in flexible and unpredictable work environments [3].

This lead to the need of development of small and highly specialized applications with few features, available in any alternatives (Tablets, Phones, PC) and cross linked in order to support the product designers, process planners, and shop floor managers in their daily activities with a special focus on supporting collaboration in knowledge intensive work environments [3].

Process management research tends to focus on situations that are responsive to formal analysis and modelling. However, in several domains, it is not possible to structure or model processes using formal notations. The total flow of so called semi-structured processes is not known a priori and many times, only the high level phases are defined [1] [8].

The characteristics of a structured process include:

- The scope is totally defined and all the activities are known;
- It is possible to identify the initial state, the final state, and all potential transitions;
- The process is suitable for fully automation.

Despite the apparent simplicity of the above characteristics, many companies try to completely automate this kind of processes with no success due to the fact that a full definition of a knowledge based process is not possible [6] [8] [9].

In fact, humans are better than computers for non-structured and ambiguous situations [1]. On the other hand, computers tend to be better than humans for full structured processes. This situation lead to a more difficult decisions where companies need to determine when a process should be fully automated or not [10] [11].

Some important implications of non-structured processes include [10] [13]:

- Inputs may not be completely definable;
- A priori optimization is not definable since optimization implies the use of rules;
- Increased flexibility, since a non-structured process cannot be fully described.

The case presented in this paper falls into these two extremes and when a new car project starts, the top management defines only some milestones that are controlled in an automatic way. However, the work to be done between each milestone cannot be

automated once it relies on human intensive knowledge and decision tasks, even if the final results are known. The combination of these structured and unstructured activities are equally important in terms of leading the project to its success [10].

In summary, decision making involve two types of processes: a structured process is a process that can be reduced to fully-defined rules leading to high efficiency but low flexibility (typical workflow management systems), while a non-structured process is not reducible to fully defined rules, leading to high flexibility but low efficiency and control (typical ad-hoc managed processes). We call a process as semi-structured when it contains both structured and non-structured sub-processes leading to a flexible and efficient hybrid approach. This kind of processes are suitable to be supported for what we call Hybrid Management Systems, as depicted in Fig 1.

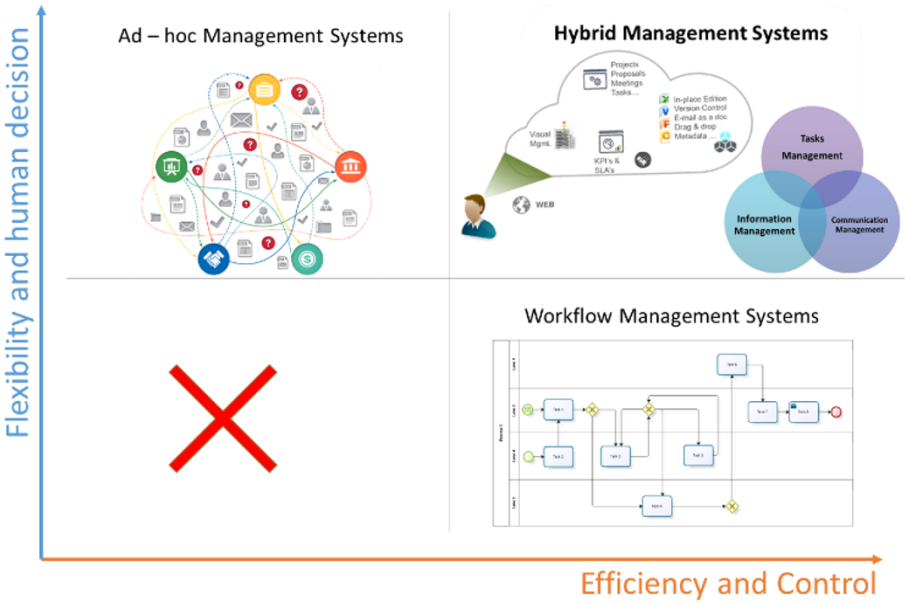


Fig. 1. Flexibility vs. Efficiency in Process Management

3 Detail analysis of the process

The die-set development process was split into three main stages: planning, machining and evaluation stages. In fact, each process instance can be deployed and implemented in partnership between the buyer and suppliers, or simply by the buyer or the supplier. Here, the decoupling point depends on the level of expertise of the buyer to deploy and control this process.

The planning is one of the most critical stage of the DS development process, since the outcomes of the activities involved can strictly affect the performance of the overall process execution. Based on the assumptions that the DS specifications have, the

following activities must be performed: Team Definition, Simulation & Feasibility Study, Capacity & Resources Allocation, Die Concept & Process Simulation and Components Design.

Starting from the team definition, each technician is responsible for a series of die-sets, distributed to a small number of suppliers (one or two maximum in order to enhance the buyer-suppliers relationship). Then it is necessary to execute the right simulations and feasibility tests, in order to understand if the technical specifications of each die-set are correct from a product and manufacturing point of view. After validation of the technical specification for each die-set, it is important to understand if the plant, where the die-set is going to be used, has the resources necessary to apply the die-sets designed. In other words, if the facilities have enough space to store the die-sets, during the "homeline" try out and production, as well as understand if there is any available press capable to apply, for instance, the forces and torque necessary. Known and validated the die-sets, as well as the necessary resources, it is possible to build a 3D model of each die-set, as well as plan the die-set construction, in terms of budget, time and quality. Here it becomes critical to specify the quality standards to be validated at the end of the process execution.

The following stage, the machining, is where the supplier has to transform the die-set 3D model into a final and usable die-set, capable to produce the parts as specified by the product owner.

The final stage must be focused on the evaluation and improvement of the die-set model built, towards the successful production of the idealized parts. Here, both company requirements and quality standards defined during the planning stage must be taken into account. Thus, as first action, technicians must build some prototype parts in order to validate if the dies are fulfilling the expected quality standards. After all product requirements being validated the manufacturing process is tested thought a pre-series evaluation. If minor problems are identified, then correction action must be taken in buyer's house, following an iterative approach.

Given this scenario, it is clear that managing a die-set program for a new car project or for a new car variant requires a holistic view of managing several hundreds of individual instances that depend on each other. When some decisions are being made individually it can affect other running projects. For example a decision in the development of one DS can have indirect consequences in other running DS development projects. Additionally, it requires managing several suppliers, stakeholders and documents that are being continuously updated into new versions due to improvements or unpredictable changes in the product development. The challenge is how to manage effectively the product development process when the information collected is dynamic, comes from multiple sources (stakeholders and software tools) and has dependences.

The process of dies manufacturing is highly complex and very human intensive (only highly skilled resources based on experience and expertise are chosen). It has a step-by-step methodology with a high level of improvements and feedback loops, through the lifecycle of the product development, demanding a very flexible and real time monitoring process.

Despite this, the complexity of the DS development process increases because each step can be performed by a different expert team with different goals. The existing interdependencies must be taken into account to avoid lack of consistency. Additionally, there is a huge amount of information and communication flow being managed.

The need to control these flexibility due to product development time constrains led to the development of a Hybrid Process Manager (HPM) application that is helping to control the several steps and sub-steps, tasks and activities of the process in terms of time, information and communication flow. Moreover, information generated along the different activities of the process life cycle, is classified and catalogued according to its relevance for the process execution, in order to optimize the time and effort necessary to make decisions.

The product development communication process was being made through the traditional support form of paper or e-mail, which was easily forgotten, lost or ignored when the work environment have excess of information. The developed communication functionalities allow connecting all stakeholders and interdisciplinary teams that are involved in the product development. This guarantee real-time communication, information regarding updated documents, problems or other issues, saving time and improving the decision making process.

As stated before, the product development process of building a new die, requires a lot of expertise, experience and knowledge that are valuable on solving problems and which were not captured, stored or re-used. The knowledge reuse process will be made through ticketing functionalities where the user can document in detail the problem of the part being developed, list of actions, method, solution, and verification and action plan. This information can be re-used when needed through a database with a problem-solution-result repository.

The product development process, as stated before, is very complex and requires the management of a high quantity of tasks with their problems and constrains. In order to keep track on the status of the tasks it will be monitored by an application which will allow the user to identify if a task has a delay.

Traditional process management is mostly mechanical, mono-causal and non-dynamic with a linear structure that is unsuitable to solve the above challenges. The flexibility desired due to the dynamic system of product development requires a new approach that will allow to breakdown the communication and collaboration barriers between the product-process-factory-production levels. The adoption of the developed tool supports the company in facing this challenge and enables a faster and a more efficient product development process.

4 Solution

The aim of the Hybrid Process Manager solution is to facilitate the flow of information among partners, making it more reliable and actual, allowing a closer control and fast reaction. Thus, it is strictly linked with planning activities on the stamping area, covering a special challenge related with the launch of a new model.

Working in cooperation with other departments or external partners, stamping planning department has to manage a pack of dies-sets (the tooling necessary to produce new parts for a new model), track the flow path, schedule, define milestones, handle project changes, evaluate risks and define actions, as well as control costs and capacities along the project development.

In order to successfully accomplish this mission, for each project this department need to collect and manage huge amount of information and knowledge, coming from inside and outside of the factory. Indeed, managing all this information not only is intensively time consuming, slowing down decision-making process, but also hinders project reliability, increasing its uncertainty.

Specifically, the aim of the solution is to manage the product development process. Currently these actions have been done manually using numerous physical, electronic files and calls. Therefore all the information needed and used in the process is spread around several departments, reducing the reliability of the entire process to a minimum. To solve this, a new approach and solution is needed.

HPM solution addresses the main challenges that are typical in this kind of semi-structured and knowledge intensive collaborative environments by implementing the following functionalities:

- Dashboard for holistic view of project status;
- Real time monitoring and control of the ongoing work activities;
- Totally integrated knowledge and documents management;
- Technical integration with Windows and Office tools, which are widely used by project teams;
- Integrated communication/messaging along the process activities in the scope of each project/phase/to-do, eliminating the internal and project related email;
- Problem solving support - tickets management integrated with all entities.

The HPM solution relies on an ASP.NET web application and takes advantage of Microsoft SharePoint foundation services. The application runs on Microsoft Windows Server on top of Microsoft SharePoint Foundation Server and its data model is implemented in SQL Server RDBM System.

LINQ-TO-SQL is used to enhance the connection between server side C# programming and database. Several libraries are used in order to integrate the application with native windows functionalities as well as Office tools, which are widely used by knowledge intensive workers. The process manager UI is a totally web-based HTML5 and JavaScript technologies enabled. Several control libraries such as telerik for AJAX.net and HighchartsJS were also employed in order to have a rich and high usable and flexible interface.

During the requirements elicitation process, it was clear that all stakeholders use Microsoft productivity tools in their daily work. Thus, it becomes obvious that a seamlessly integration with Microsoft productivity tools such as windows explorer, outlook and office tools is critically necessary.

Giving this context, is was decided to develop the application on top of .NET and SharePoint foundation frameworks in order to take advantage of its functionalities. Thus, the eApp is designed to run on windows server IIS using Microsoft SQL server and SharePoint Foundation services. Nevertheless, a Windows Communication

Foundation (WCF) RESTful API was developed in order to have an integration endpoint with any kind of application such as java EE, android, iOS and others. Moreover, MVC Frameworks such as AngularJS can be employed to develop customized GUIs for specific devices like smartphones or tablets.

5 Validation

During the process analysis and re-definition, a set of Key Performance Indicators (KPIs) was defined in order to measure the impact of the solution. Thus, for the successful implementation of the solution, the following KPIs were defined:

Overall Report Lead Time (ORLT): Required time necessary to create an overall report in hours is given by the equation 1.

$$ORLT = \frac{\sum(ReportTime - requestTime)}{\sum reports} \quad (1)$$

Overall Report Resources (ORR): Required resources necessary to create an overall report in persons is given by equation 2.

$$ORR = \frac{\sum(numberOfResources)}{\sum reports} \quad (2)$$

Reaction Time on Critical Status (RTCS): The Reaction Time on Critical Status KPI, measures the mean elapsed time between the problems raise moment till its closing, when they're solved. It's measured in hours and can be calculated using the equation 3.

$$\text{RTCS} = \frac{\sum(issueSolvedTime - issueRaisedTime)}{\sum issues} \quad (3)$$

Phase Lead Time (PLT): The Mean time between the start of a project type phase and the effective closing of that phase. This KPI is measured in hours and can be calculated using the equation 4.

$$PLT = \frac{\sum(EndPhaseTime - StarPhaseTime)}{\sum phaseInstances} \quad (4)$$

Project Schedule Variance (PSV): The variance between the project schedule and its real execution time can be calculated using equation 5.

$$PSV = \frac{\sum(RealEndPhaseTime - RealStarPhaseTime)}{\sum(EstimatedEndPhaseTime - EstimatedStarPhaseTime)} \quad (5)$$

The solution was evaluated in real engineering environment inside the company, by the stamping planning team, which involves eight planners and a manager for each project. During this evaluation phase, a specific project has been used to test and verify the functionalities implemented. Each stakeholder has a specific credential to access, test and validate the functionalities, giving feedback for continuous improvement.

It was possible to measure and calculate the KPIs previously defined and compare the results, lead to the savings that are presented in the following table.

Table 1. KPI values and savings.

KPI Acronym	Units	AS-IS Result	Actual Result	Savings (%)
TACD	minutes	30	5	83,0%
ORLT	hours	3	0,5	83,0%
ORR	persons	9	2	77,8%
RTCS	hours	20	5	75,0%
PLT	months	4	3,5	12,5%

6 Conclusions

As shown by the results of KPIs from previous section, the introduction of the Hybrid Process Manager in the automotive engineering collaborative environment prove to be very effective and efficient, leading to good results in terms of savings.

The introduction of the HPM made possible that managers avoid asking for reports and a lot of time and paperwork is now saved. HPM allowed planners to concentrate in important issues improving the product and avoid non-value added efforts and time on collateral activities. Other advantage is the data collection built in the solution storing historic and experience retrieval modules, allow access to expertize, knowledge and best practices collected from previous projects and available to incorporate in future as a factor of knowledge sustainability.

The comprehensive dashboard allows the real time report of the project status, leading to savings in reporting time and resources.

Due to integrated documentation and information management, team members have now instant access to the right information at the right place and in the right moment, leading to a reduction of time to access critical data.

The communication functionalities and issues tracking, involving the allowed key players to participate more actively and fostering the team spirit.

This solution has proven to be very effective and efficient when applied in hybrid work systems and in particular in the automotive engineering collaborative processes.

In summary, the project has improved the communication, the cooperation and trust the exchanged information, which are key factors for a successful project. In future, with the integration of suppliers, the solution aims to allow a chain reaction and a huge impact on speeding up the product development and time to market allowing also a faster response to external changes.

Acknowledgments. The research leading to these results has received funding from the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° 314156. The authors would like to thank INESC TEC for their support and the Apps4aME Collaborative Project for their inputs and contributions.

References

1. S. Kemppilä and P. Mettänen, "Innovations in Knowledge Intensive Services," in Innovations in Knowledge Intensive Services, pp. 22–25 (2004)
2. B. Weber, M. Reichert, and S. Rinderle-Ma, "Change Patterns and Change Support Features - Enhancing flexibility in process-aware information systems," Data Knowl. Eng., vol. 66, pp. 438–466 (2008)
3. C. Hill, R. Yates, C. Jones, and S. L. Kogan, "Beyond predictable workflows: Enhancing productivity in artful business processes," IBM Syst. J., vol. 45, no. 4, pp. 663–682 (2006)
4. M. Adams, A. H. M. Hofstede, D. Edmond, and W. M. P. Van Der Aalst, "Implementing Dynamic Flexibility in Workflows using Worklets," (2006)
5. R. Lu, S. Sadiq, and G. Governatori, "On managing business processes variants," Data Knowl. Eng., vol. 68, no. 7, pp. 642–664 (2009)
6. P. Mangan and S. Sadiq, "On Building Workflow Models for Flexible Processes," J. Aust. Comput. Sci. Commun., vol. 24, no. 2, pp. 103–109 (2002)
7. K. D. Swenson, Mastering the Unpredictable: How Adaptative Case Management Will Revolutionize the Way that Knowledge Workers Get Things Done. Tampa, Florida: Meghan-Kiffer Press, p. 337 (2010)
8. Bider, "State-Oriented Business Process Modeling: Principles, Theory and Practice," Royal Institute of Technology and Stockholm University (2004)
9. W. M. P. Van Der Aalst, M. Adams, A. H. M. Hofstede, and M. Pesic, "Flexibility as a Service," in Database Systems for Advanced Applications Lecture Notes in Computer Science, pp. 319–333 (2009)
10. Faria J., Silva J. and Marques H., "Supporting the Operation of Semi-structured Work Systems", in ENTERprise Information Systems, International Conference, CENTERIS 2010, Viana do Castelo, Portugal, October 20-22, 2010, Proceedings, Part II, pp 416-425 (2010)
11. Faria J. and Nóvoa H., "An Agile BPM System for Knowledge-Based Service Organizations", in Exploring Services Science, 6th International Conference, IESS 2015, Porto, Portugal, February 4-6, 2015, Proceedings, pp 65-79 (2015)
12. S. W. Sadiq, M. E. Orlowska, and W. Sadiq, "Specification and validation of process constraints for flexible workflows," Inf. Syst., vol. 30, no. 5, pp. 349–378 (2005)
13. W. M. P. van der Aalst, M. Weske, and D. Grünbauer, "Case handling: a new paradigm for business process support," Data Knowl. Eng., vol. 53, no. 2, pp. 129–162 (2005)

Part II
Organizational Models and Information Systems

IT GOVERNANCE - MODELS AND APPLICATION

Fernando Molina Granja[1], Raúl Lozada Yánez[2], Edison Fernando Bonifaz[3], Edmundo Cabezas Heredia[4]

[1]Universidad Nacional de Chimborazo, Riobamba, Ecuador
Facultad de Ingeniería, fmolina@unach.edu.ec
[2]Universidad Nacional de Chimborazo, Riobamba, Ecuador
Facultad de Ciencias de la Educación, rlozaday@unach.edu.ec,
[3]Universidad Nacional de Chimborazo, Riobamba, Ecuador
Facultad de Ciencias de la Educación, ebonifaz@unach.edu.ec,
[4]Universidad Nacional de Chimborazo, Riobamba, Ecuador
Facultad de Ingeniería, ecabezas@unach.edu.ec

Abstract: In a dynamic, globalized and uncertain reality, the Technologies of Information and Communication ICT, play a key role in the development of organizations from different fields such as technological, economic, financial, service and production among others, adequate critical is preparation and training from a corporate perspective, to focus on what we now call government Information Technology (IT Government), in order to give a response to the many needs of these, because beyond the purely technical and technological elements is important to recognize the organization of comprehensive, holistic with a synergy own that seeks the fulfillment of its objectives under increasing profitability and earnings maximum.

In this article the different IT Government developments are explored, the most used in the world and who have made a significant pattern in organizational development and model of e-government posed by the Ecuadorian government, is the purpose to examine Ecuadors e-Government model.

Keywords .-IT Government, ITIL, Cobit, Iso 2700, Models of IT government, e-government.

1 Introduction

For the operation and development, improve their efficiency safety and planning strategy meeting the challenges of today, every institution depends on information technology (IT)[1]. Due to the nature of the technology, in many cases other agencies declare their ignorance on the subject, which contributes to further isolate the IT area. THE difficulty most important of it Government is to align the strategic it goals with the Organization; the it areas are subject to different pressures because they must support the running of the business, support in addition regulatory pressures, technical and commercial. Quick response to these pressures can easily lead to lose alignment with the Organization and dedicate himself to solve punctual problems [2]. Produce the concept of governance and everything to do with it to achieve alignment and integration with the corporate governance has been a major effort of the Academy, consulting firms, research partnerships, regulatory bodies and standards organizations. Several efforts can demonstrate, to mention some, ITGI, ISACA and *Enhancing Corporate Governance in the Bank's Banking Organizations for International Settlements* (Basel Committee on banking supervision, 2005 & 2006) whose reports had origin, among others, by the Enron scandals [3], [4] and [5] where ultimately there had been fraud in information that corporations, shareholders and the world, taking advantage of the lack of control on information technologies.

This article shows an evolution of IT Governments, and its status in the Organization of private and public.

2 Conceptualization

According to the RAE- Royal Spanish Academy, governance is defined as "art or way of governing that he is proposed aimed at the achievement of sustainable economic, social and institutional development, promoting a healthy balance between the State, civil society and the market economy (RAE, 2005) and Government is the element that is to organize people with the purpose of achieving the objectives of the

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_44

community among which stand out the protection of the territory, the safety of its inhabitants and their integral development.

Several concepts have revolved around Government, corporate governance, according to ITGI [6] corporate governance is a set of responsibilities and practices carried out by the Board of Directors and executive management. According to the OECD (2004), corporate governance is the system by which companies are directed and controlled. CAF - Andean Development Corporation in its regulatory framework to improve business practices in the countries that comprise the region (Bolivia, Colombia, Ecuador, Peru and Venezuela), defines corporate governance as a set of practical, formal and informal, governing relations between administrators and all those that mainly invest resources in the company, shareholders and creditors.

Corporate governance and Government business are closely related, since the corporate delivery reports of an economic cycle and accountable on that information, it is necessary to control the execution of all processes that generate this information, which is the Government's business, where are the assets of the company and among those assets is the information technology i.e., the concept of IT Governance is within the Government's business, which is a dimension of the corporate governance and this takes years ago, i.e., does not come from the Cobit framework. Figure 1 shows the two dimensions of corporate governance: corporate governance and Government business.

Figure 1. - Government of the company in a broader way, with two dimensions: corporate governance and Government of the business [1].

The government information technologies integrates and institutionalizes good practices to ensure that the technologies of the Information on the company supports business objectives. It facilitates that the company make the most your information, maximizes the benefits, capitalizes on the opportunities and win competitive advantage [7].

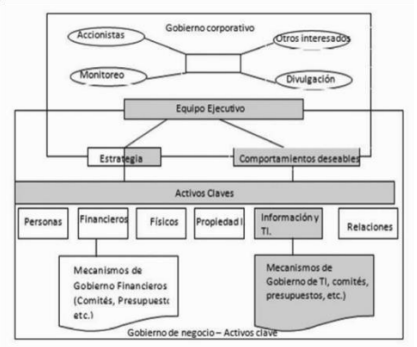


Figure 2.-adaptation of the model by Peter Weill and Jeanne W. Ross [8].

It could also be defined as: "Is the efficient use of IT resources to support the fulfillment of the objectives of the business [9]".

As well as good corporate governance is to ensure and to align the key business decisions, with the vision and strategy of the company, a good IT governance is critical to ensure that the decisions of IT are aligned to the objectives of the company [10].

The IT governance activities can be grouped into five areas of focus that are illustrated in Figure 3 (ITGI, 2007):

Figure 3.-IT governance focus Areas

One of the keys to the success of the performance of IT is the report IT *Governance Broad Briefing* of the ITGI (2003) optimal investment, utilization and allocation of IT resources (people, applications, technology, facilities, data) in the service of the needs of the company. The majority of companies cannot maximize the efficiency of your IT assets and optimize costs associated with these assets.
According to the IT BSC [11] there are four perspectives, each one designed to respond to a question about how to make the company's business, so that government information technology and business aligned. (Figure 4).

PERSPECTIVE	**Financial Customer**	Provide good return on the investment in the IT enabled business investments
		Manage the business risks associated with IT
		Enhance corporate governance and transparency
		Improve guidance and service to the customer
		Offer products and services competitive
		Establish the availability and continuity of service
		Create agility in responding to the requirements
	Internal	business change
		Obtain costs for service delivery optimization
		Useful/reliable information for strategic decision-making
		Improve / maintain the functionality of the business process
		Reduce process costs
		Provide compliance with external laws, regulations, and contracts
	Learning and growth	Provide compliance with internal policies
		Manage business changes
		Improve / maintain operational productivity and staff
		Manage business and product innovation
		Acquire / maintain personal skills and motivated

Figure 4.-perspectives according to the BSC to align the business with IT

3 The main trouble of IT Government

Insufficient available of the IT staff; problems with the delivery of service; and difficulty to check the value of the Information Technology (IT), [12], continue to be the main problems for executives in companies around the world according to a new report by the Institute of IT Government (ITGI for its acronym in English), an independent, not-for-profit institution.

ITGI commissioned a global survey of 749 executives from CEO/CIO level in 23 countries to determine priorities for Government and the problems with the you who have had to face. According to the *2008 IT governance Global Survey*, which is available for free download at www.itgi.org, 58% of respondents mentioned that the insufficient staff is a problem, compared to only 35% in 2005.

Likewise, 48% said that problems with the delivery of service continued to be the second most common problem and a 38% points to staffing problems with few skills. 30% of respondents reported problems in anticipation of the return of the investment outlay of IT.

The study is a follow-up to the 2003 and 2005 surveys and da monitoring trends in IT in the past four years. Many important advances in business IT-related are identified in the report, including:

a. 93% of respondents said that the IT are something very important within the corporate strategy - an increase of 6% compared to 2005.
b. IT are always present on the agenda of the Board of Directors, according to the opinions of 32% of those surveyed - compared to 25% in 2005.
c. 18% of respondents said that the IT Department always advises the company on potential business opportunities - only 14% reported the same in 2005.
d. Awareness of the framework objectives Control of information and technology (COBIT for its acronym in English) related to the IT Government exceeded 50%, almost doubling since 2005.
e. The use of COBIT doubled (from 8% in 2005 to 16%).

Areas for improvement include alignment - 36% of respondents reported that the alignment between the it strategy and the corporate is average, poor or very poor. In addition, the implementation of activities relevant to ITGovernment varies around the world. The percentage of organizations that are in the process of implementing or have already implemented practices of IT governance in different regions are:

• Latin America, 27%
• Asia, 44%
• Europe, 50%
• North America, 50%

In relation to Latin America, [13] considered that while the responses of those interviewed in Latin America show one lower percentage of implementation of practices of IT governance, with respect to other regions, the study showed that Latin America is the region considered most frequently as "very important" information technology, which confirms the great potential that is in this region to implement best practices of Government you like COBIT and Val IT.

"The point is that many organizations around the world are sacrificing money, productivity and competitive advantage unnecessarily to not implement an effective governance," said Lynn Lawton, CISA, FCA, FIIA, PIIA, FBCS CITP, International President of ITGI. "Companies with good governance have shown that provide a better return for investors and the same happens with the Government. Executives need to direct their IT for optimal advantage, manage IT-related risks and measure the value provided by them."

Throughout the literature is an important number of frameworks designed to support the implementation of various aspects of the IT governance; Each focuses on different aspects of IT Government priorities, making them largely complementary. However three main frames can be reviewed.

4 Models Standards and framework of reference of IT Government

4.1 Basic management model IT .- With the progress and investment in ICT in organizations, cadres and managers expect profitable results for the company, which put it at the forefront in the markets. However cases of everyday life examples such as: failures in the implementation of ICT solutions, inadequate or obsolete technology, incomplete processes, lack of vision, budgets exceeded etc. Paul Strassmann, known North American consultant, points out that a direct relationship between the companies in ICT investment and return that get that investment [14] there is. Fundamentally the management of ICT should point you to the following:

• The alignment of objectives with the objectives of the Organization
• Opportunities and generate greater profitability
• Use balanced, fair and equitable resources for ICT

• Risk minimization

According to the presented control frames shows the presence of standards that support the IT Government in any of them, that allow to realize the 'how' to different it controls.

4.2 The ISO standard dealing with corporate governance: ISO 38500 (ISO/IEC, 2008).- It was published in June 2008. It is based on the Australian standard AS8015:2005. It is the first of a series of standards on IT (ISO/IEC, 2008) Government. Its aim is to provide a framework of principles that organizations address used it to evaluate, direct, and monitor the use of the technologies of the information [15]. IT is aligned with the principles of corporate governance contained in the Cadbury Report [16] and in the principles of corporate governance of the OECD (OECD, 1999). The standard defines six principles of good corporate governance of IT: responsibility, strategy, acquisition, performance, conformance, human behavior. The model of governance presented by the standard positions three tasks areas: evaluate, direct, and control, as the key to give direction and monitor the performance of the roles of the management in the conduct of the Organization for the planning, implementation and operational use of IT [17]. Figure 5 illustrates the model.

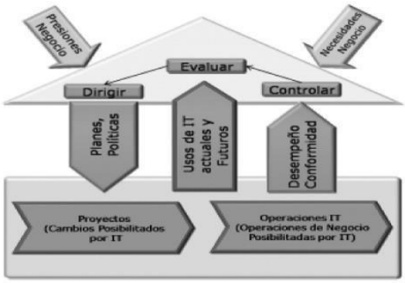


Figure 5. Model of Government IT ISO/IEC 38500 (Toomey,2009)

4.3 ITIL.-v3.- ITIL (Information Technology Infrastructure Library) is the set of concepts and best practices for the management of IT services (ITSM) for development and IT operations established by the Office of trade of the Government of the United Kingdom (OGC). ITIL postulates that support, administration, and operation is carried out through five processes: incident management, handling problems, configurations management, change management and management of deliveries.

4.4 ISO 20000.- Is recognized worldwide as a standard to certify the services management of companies and organizations, ISO/IEC 20000 (International Organization for Standardization) and IEC (International Electrotechnical Commission) (ISO/IEC, 2005a) (ISO/IEC, 2005b). The ISO/IEC 20000 standard emerges as a response to the requirements of customers who not only wanted to work with them certified consultants, but that also required that the companies were certified.

4.5 ISO/IEC 27002 (ISO/IEC, 2005 d) ISO/IEC 27000.-is a set of standards developed by ISO (International Organization for Standardization) and IEC (International Electrotechnical Commission), which provide a framework for managing the security of the information usable by any organization, public or private, large or small. Security can be seen as a measure of robustness of a system, with regard to a policy of safety [18]. This international standard establishes guidelines and principles generate them to initiate, implement, maintain, and improve the management of information in an organization security. Objectives of control and controls are recommended to meet the security requirements that have emerged from an assessment of risks [19] is a standard of good practice consisting of eleven domains, 39 control objectives and 133 controls for information security.

4.6 CALDER-MOIR.- There are several frames of work and standards for the Government of IT, but somehow, none provides the complete set of IT governance. When these frames of work and standards are used collectively, become very confusing and obstructing the main purpose of the Government's IT [20]. Many frameworks in existence, none is in itself a full IT government framework.

The frame of Government of the Calder-Moir IT is a metamodel for models and coordinating the Government of IT providing structural Guide to focus the Government of IT. Using this model, the

organization can get maximum benefit from all other frames of work and standards [10]. It is a simple tool to help organizations implement the ISO / IEC 38500 for the Government in the real world.

4.7 GTI4U Model

Designed since 2008 and published in 2010 by the team of researchers GTI4U, at the request of the sector TIC Commission of the CRUE; conceived as a model of the it governance adapted to the University System Spanish (SUE) especially based on the standard ISO 38500. The model GTI4U consists of 3 levels:

1. Elements of the ISO 38500 standard.
2. A maturity model MM for each one of the principles of the standard.
3. Different types of indicators related to the IT governance practices.

4.8 COBIT Model.- The need for ensuring the value of ICT, ICT risks management as well as the increase in requirements for control information, understood now as key elements of the Government of the company. The value and the risk is defined as the possibility that can demonstrate an adverse event, misfortune or setback a loss, hence critical control for the Government's ICT[2[11]]. The approach to processes of COBIT subdivided ICT into 34 processes according to areas of responsibility: plan, build, run, and monitor; offering a vision of end-to end of ICT. The concepts of enterprise architecture will help identify those resources essential for the success of the process, i.e., applications, information, infrastructure, and people. COBIT supports the Government's ICT, by providing a framework that ensures that: TIC is aligned with the business, ICT train business and maximizes the benefits, ICT resources are used responsibly and risks of TIC are administered properly.

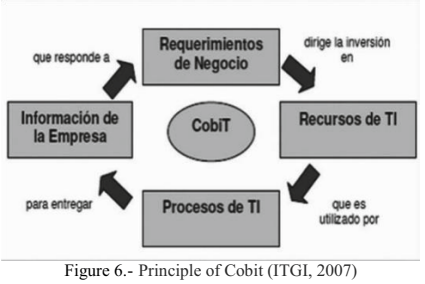


Figure 6.- Principle of Cobit (ITGI, 2007)

5 IT Government on the company

Currently technological in any modern organization dependence have a graph up, practically in all kinds or business process, employees are in contact with different devices and components of the universe of the IT, establishing a relationship close between these business processes and technology and, consequently, with its resources and associated infrastructure.

In 2012 the study "The future role of the CIO;" Digital Literacy', of CA Technologies company, pointed out that "87 percent of CIOS, s1 believed that ignorance of managers on the application of technology to business hampered business growth".

Indeed, in many organizations, public and private, business units do not perceive the multiplier effect of the IT or as these may improve the effectiveness and efficiency of its business activities. I.e., the value of the information technologies, is not known as there are, generally, not relative to the performance before and after application measurement: what labor is saved, how much the time of a process or activity limits are reduced, novel uses of information have been developed for the business, what new capacity is available. It's direct benefits for the performance and economic management of the business units; Therefore, those business units will be unique corporate departments ready to meet and measure the usefulness and the warranties provided by the use of the IT and are themselves who can lead the development of these services and systems, since, usually, the Department and the specialist personnel of IT impugn those data, indicators and measurements to calibrate the impact and cost-effectiveness of these services and systems. It seems clear, then, that are not technical departments who should be directed and controlled employment present and future technologies of the information of an organization. [22].

5.1 IT Maturity

Despite the omnipresent character of the information technologies in the professional environments, it is not difficult to find examples of projects and technological services that have failed after having generated great expectations. This circumstance, coupled with the lack of insight clear about the proportionality between it investments and the productivity of the workers has generated great mistrust by the governing bodies of the organizations; at the same time, the lack of methods enabling to properly align the IT with the business goals and then take measurements that demonstrate the benefits of a proper administration of the IT, to these governing bodies has caused a substantial delay in the positioning of these technologies within the organizations; and although many organizations have ignored their role and have avoided making decisions in administration of them due to these factors, today it is unthinkable to most of them that, in one way or another, have taken on the importance of a proper administration of the IT.

In recent years, these factors have accelerated the pursuit of solutions that allow you to manage the IT properly, getting metrics of measurement and valuation that obtained the confidence of the governing bodies and ensure that investments generate the corresponding value of business with minimal risk. Thus, little by little, have appeared concrete action frameworks in the form of methodologies, standards or models of good practices that have led to significant progress in this regard.

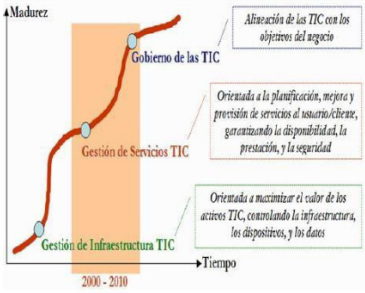


Figura 7: Evolución de la madurez de las organizaciones en materia de administración de las IT (Fuente CESEDEN)

5.2 Management Resources or Services

It is patent, therefore, as in the last decade the way of maturity when it comes to managing the information technology has led to all kinds of organizations, private and public, to the paradigm of management by processes with an undisputed service orientation. ITIL (library of the infrastructure of information technology), the main model of good practice for the management of IT services, born in the bosom of the public administration of the United Kingdom, said that the **resources** and **capabilities** constitute the **assets** of the service. Organizations use them to create value in the form of goods and services: **resources** are the direct entrance to the production start-up and become value through the management, organization, personnel and knowledge.

The capabilities represent the ability of an organization to coordinate, manage and implement resources in order to produce value.

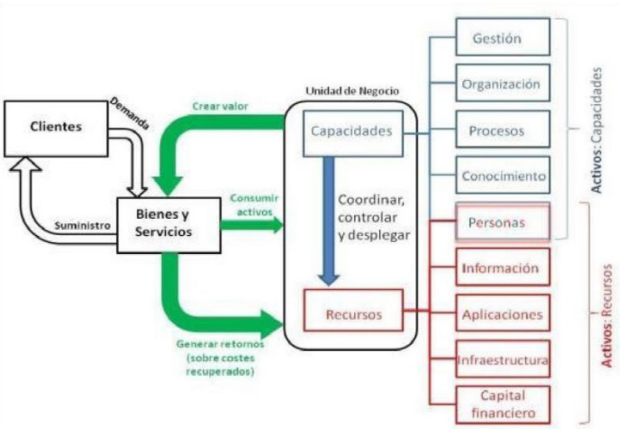


Figure 8: Resources and capabilities are based on the creation of value (source ITIL version 3)

The acquisition of resources is relatively simple compared with the acquisition of capabilities, but capabilities can not generate value, by themselves, without adequate resources. The combination of resources and capabilities form **the basis for the value of a service**. These are suitable assets to the provision of IT services:

- **Management**: is a system that includes leadership, management, policy, performance, standards and incentives; It promotes, coordinates and supervises other types of assets.
- **Organization**: are active configurations of people, processes, applications and infrastructure that implement all organizational activities.
- **Processes**: process assets include algorithms, methods, procedures and routines that facilitate the activities and interactions of implementation and management.
- **Knowledge**: these assets are an accumulation of achievements, experiences, information, perceptions and intellectual property related activities and specific contexts.
- **People**: people represent the capacity of creativity, analysis, perception, education, assessment, leadership, communication, coordination, empathy and trust.
- **Information**: these assets are collections, patterns and significant abstractions of data applied in the context of clients, contracts, services, events, projects and production.
- **Applications**: they can be of many different types and include artifacts, automations, and tools to support the performance of other types of assets; the value of the applications is derived from its relations with other assets.
- **Infrastructure**: the infrastructure assets have the peculiar property of exist in the form of layers defined in relation to the assets that give support, especially people and applications. Include, basically, software applications, computers, storage systems, telecom equipment, cables, wireless links, access control devices, systems of monitoring, buildings, electricity, air conditioning and water supply, without which it would be impossible that the people and the Applications could operate.
- **Financial capital**: economic assets are needed to sustain the property or the use of all types of assets.

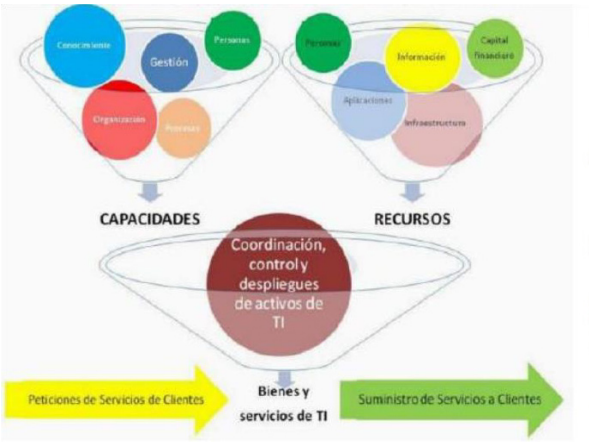


Figure 9: The management of resources and capacities of the ITIL framework

From the moment in which Richard Nolan introduced in 1973 his "model by stages" for the application of IT in organizations, there are many that have proposed models of gradual improvement. These models very soon became suitable instruments for developing quality improvement programs, thus helping organizations move up the ladder of maturity.

Existing frameworks of best practices and standards serve as guide organizations to achieve "operational excellence" in the IT services management. Thus, the "requirements of the management system of the service (SGS)", include the design, transition, provision and improvement of services to comply with the requirements of the service and, therefore, add value for the customer and the service provider. The supplier requires an approach based on integrated processes when you plan, establishes, implements, operates, controls, reviews, maintains and improves a system of service management. Integration and coordinated implementation of a SGS provides a continuous monitoring, as well as greater effectiveness and efficiency.

The service provider should define the scope of the SGS; create, implement and maintain a management plan; implement and operate the SGS for design, transition, provision and improvement of services; use the appropriate methods for monitoring and measuring of SGS and the services (internal audit and review the address); and maintain and improve the SGS, according to a policy of continuous improvement of SGS and the services. Minimum processes for the provision of the service are: to) level of service management, b) service reports, c) management continuity and availability of the service, d) preparation of budget and accounting services, e) capacity management, f) management of the security of the information, g) business relationship management, h) management of suppliers, i) management of incidents and service requests, j) management of problems, k) configuration management, l) management changes, and, m) delivery and deployment management.

5.3 IT Service Providers

Always within the scope of the management of services, other than that of good governance or the IT governance, from the hand of the cited standard, ISO 20000 has been introduced the concept of service provider: this organization or part of an organization that manages and provides one or more services to the customer. The ITIL reference model distinguishes three different types of service providers:

(a) type I, internal service provider,
(b) type II, services unit Shared and,
(c) type III, provider of Services

6 IT Government in Ecuador

In Ecuador, several institutions have been isolated in the process of TI efforts, the National Development Plan 2009-2013 provides a national long-term strategy, which seeks to diversify the productive matrix. On the other hand, the National Plan of development 20132017 plasma the strategy for the reduction of poverty, to support and facilitate these two great national interests, the State needs to improve its management and the quality of its services, for which the use of the Information and communication technologies (ICT) becomes a key factor.

Electronic State institutions generated several initiatives to improve governance, so each entity generated one or more projects to meet its institutional strategic objectives.

These isolated institutional efforts have contributed to some extent to the development of e-Government in the Ecuador. Fruit of these efforts have generated a set of systems, portals, applications and solutions

The efforts have left several lessons learned, which will allow to conceptualize the key projects of the Plan with a view to achieving the greatest possible success. The lessons learned are detailed below:

a. It is essential to involve the citizen / citizen initiatives and activities of e-Government so that outcomes are aligned to your expectations.
b. Necessary lifting, standardization and optimization of cross-governmental processes, before the automation of the same, even before the automation must be ensured that the rules and regulations are approved; This will prevent duplication of efforts and waste of public funds.
c. It is essential to establish a vision unique and shared by the public entities for projects and initiatives to produce the desired results.
d. In project management established knowledge management to ensure the transfer of the same and maintain projects regardless of the people.
e. Establish standards for project management and encourage its use with the objective of training public servants and implement projects based on the best practices to achieve the same success.
f. Implement centralized tracking and e-government projects investment control procedures to ensure the efficiency and effectiveness of the investment.

Implement a strategy of change management that allows the incorporation and institutionalization of new approaches.

In may 2014, the public administration National Secretariat, approves a Plan of e-Government and defined the model of e-Government for the Ecuador and the strategy for its implementation. This plan contains three strategic objectives which are near Government, open Government, efficient and effective Government. Additionally identify the resources necessary for the achievement of the goals, which constitute the 4 pillars of the Plan and are: regulatory framework; Services and processes; Information technologies and Communications; and, individuals. The development of these pillars seeks to evolve at the level defined by the UN e-Government maturity.

In this model of e-Government organizes ICTs in the most convenient way to improve the way of relating of the four main actors (Government, citizens and citizens, productive sector and public servants), thus eliminating the barriers of communication and strengthening relationships and alliances with stakeholders in a society increasingly interconnected and globalized. This is defined in relations G2C - Government for the citizen, G2G - Government for the Government, G2B - Government for the productive Sector (Business), G2E - Government and public server (employee).

A. Indicators of current situation of Ecuador in the context of global

At this point is the diagnosis of the country highlighting major data this is a composite indicator, which measures the willingness and the ability of Governments to use ICTs as tools to provide and make delivery of public services to this citizenship indicator is based on a survey of the comprehensive presence online of 193 States members of the United Nations, which evaluates technical Web sites as well as e-government policies and, in general, strategies through the technologies of information and communication for the provision of public services.

Evolution shows that the Ecuador has not submitted a homogeneous effort in development for eGovernment actions so there has been a setback in the ranking, however this does not mean that the country has not

produced progress in the different components, but if indicates that other countries have advanced at a greater pace than Ecuador.
Another indicator that should be taken into account is found in the Global Information Technology Report (GITR) and the Networked Readiness Index (NRI), prepared by the World Economic Forum. This is the result of several analysis assessing the influence and impact of ICT on economic development and work in a networked society.

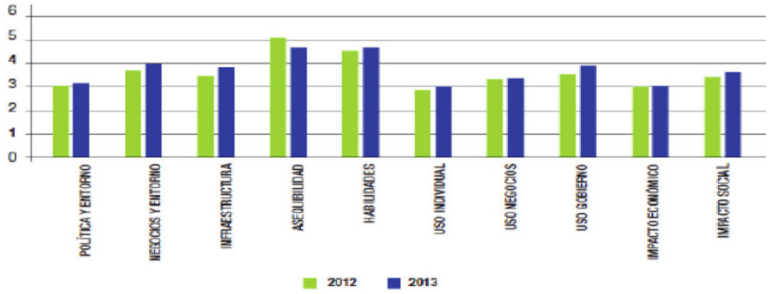


Figure 12.-situation in Ecuador according to GITR

The data placed to Ecuador in the 96 year 2012 position and position 91 in 2013. Despite this slight improvement the situation in the country is at a clear competitive disadvantage against other countries in the region like Colombia, which on average is 10-position above Ecuador.

B. Description of the model of ITgovernment of Ecuador

The e-government model is based on the use of modern management techniques to achieve the goals and objectives of the Plan. These objectives make the purpose and are the basis of measurement of a Government that is legitimized through results that provide benefits to citizens and society as a whole and which are measured internationally. This does not exclude that the results should be in tangible benefits for people, the productive sector, the State and administration, and any other related actor. The model articulates and sets the strategy, and this design leads to a strategic plan.

As e-government solutions are diverse, ranging from forms and methods of work, to complex computer systems interoperable, through regulations, laws, and regulations these strategic instruments acquired different forms. Strategic instruments are a means and ends to achieve goals and its conceptual design today is a requirement in any plan, since they define the potential space that validated any future action, which in this case are e-government solutions. These instruments reflect international successful experiences and requirements expected for the Ecuador. In some cases these strategic instruments are concepts or guiding ideas, technological means that grouped to others, are prerogatives contractors, or define an ecosystem of strategies. In any case, for the purposes of simplicity of this Plan, called les strategies.

Finally, the model of Government Complete electronic solutions, which have been called the Park of solutions in very broad terms.

Figure 13.-model of electronic Government of Ecuador

1. The e-government model has four elements: pillars, objectives, strategies and solutions Park. The *pillars* grouped to the enabling elements. They are understood as those resources that develop solutions to achieve goals, develop and mature e-Government. Figura 13.

The pillars are:

- Regulatory framework.
- Services and processes.
- Information technologies and Communications.
- People

2. The *objectives* are the ultimate goal of the e-Government plan, where are all the efforts.

3. *Strategies* are the means to achieve the objectives. The solutions leverage strategies, while more strategies apalenquen greater is its contribution to the development of e-Government and the achievement of the objectives.

4. The *Park of solutions* is the set of programs, projects and standards that leverage strategies to achieve the objectives.

The results of this assessment show the following points to consider: a) sparse presence of it governance processes, b) IT Government units boast a poor planning. c) the development and construction of software applications do not have control of the transition operation, d) it is noted that IT Government entities units are overturned to the operation and care of incidents, with poor preventive processes, and e) there is evidence of a lack of monitoring, evaluation and assessment for measuring performance, achievement of objectives and compliance with standards and controls developed it projects. Only 7.5% of institutions showed to develop these processes. This lack makes government institutions most exposed to risks associated with the failure to comply with regulation, leading it services do not meet the requirements of users and projects and investments of IT is don't end up in a timely manner and fail by the costs, delays, ill defined scope or changes to corporate priorities. [23].

7 Conclusions

In today's environment and competitive dynamics, the possession of technology doesn't itself a competitive advantage for organizations. It is the management of that technology that can give you a competitive advantage or a differential factor with special emphasis on the management of the risks arising from the use of information technology

Can be seen in the Ecuador there is an increasing trend of use of information and communications technologies; therefore required a boost suitable for the enhancement and development of ICT in pro generate progress in the country's economy. The importance that has the efficient use of ICT in the development of the country promotes to improve the quality of life of its population

Experiences in relation to the development of e-Government in several countries are evident and often respond to the "Millennium Goals". These advances have a low level of recognition in the Ecuador. Increasing innovation in technology, easy access to the Internet and the wide variety of mobile devices show that people are now more interconnected, so there is greater social demand for the Ecuador to accelerate the implementation of e-Government.

8 References

[1]. P. Weill and J.W. Ross. "IT Governance: How Top Performers Manage IT Decision Rights for Superior Results". *Harvard Business School Press*. 2004 (Weill, Subramani & Broadbent, 2002)

[2]. Bryce, r. (2002). Pipe dreams: Greed, ego and the death of Enro. New York, NY: PublicAffairs.

[3]. McLean, B., Elkind, p. (writers), & Gibney, a. (direction). (2005). Enron: The Smartest Guys in the Room [film]. Microsoft. (July 2010). Microsoft operations framework /MOF extended guidance. Recovered from: www. microsoft.com/mof.

[4]. Office of Government Commerce. (2007). ITIL V3 Service operation book. London: The Stationery Office.

[5]. Jeter, l. (2003). Disconnected: Deceit and Betrayal at WorldCom.

[6]. Carrillo, j. (2009). Defining the scope of the Government from you. Conference presented in the third Summer University course: the Government.

[7]. Palao, M. (2010). Reflection on the State of the art of good government ICT. Bogota: ISACA.

[8]. Ross, j., & Weil, p. (November 2002). Would Six IT Decision Your IT People Shouldn? t Make. Harvard Business Review. Recovered from: http://www. qualifiedauditpartners.be/user_files/ITforBoards/GVIT_Harva rd_Business_Review_Ross_Jeane_Weill_Peter_ Six_IT_Decsions_Your_IT_People_Shouldnt_ Make_2002.pdf.

[9]. Rolling Meadows. ITGI. (2008a). IT Governance, global status report 2008.

[10]. Garbarino, H. (2010). It governance. Organization, administration and control of the IT, a framing in SMEs. Retrieved from: http://www.ort.edu.uy/fi/pdf/investigaciontuteladagarbarinoort.PDF

[11]. Cram, a. (2007). The IT balanced scorecard revisited.Information system control journal, 1-5.
[12]. **Rolling Meadows, IL,** ITGI. (2008b). IT Governance, global status report 2008.

[13]. José Angel Peña Ibarra, international Vice President of ISACA

[14]. Strassmann, p.: "Getting better value from information management" Information Economics Journal, 2003.

[15]. Bosch, a. (2008). COSO - ISO 38500 Conference presented in the third summer course. The Government it

[16]. Cadbury, a. (1992). Report of the Committee on the financial aspects of corporate governance. London, England.

[17]. Toomey, M. (May 2009). A Framework for Governance and Management of IT.

[18]. Viega J.; McGraw, g., 2001, Building Secure Software: How to avoid security problems the right way,

[19]. Calder, a. (2006). Nine keys to success, an overview of the implementation of the standard NTCISO/IEC 27002. Bogota: ICONTEC.

[20]. Calder, a. (2008). The Calder-Moir IT Governance Framework. Recovered from: http://www.itgovernance.co.uk/ calder_moir.aspx

[21]. Pressman, r. (2001). Software engineering. A practical approach", 5a ed. McGraw - Hill.

[22]. Jesus Gomez wheels, (2013)
E-Administration, CIS, TIC, IT and other tags of modernity in the context of the Ministry of defence.

[23]. Republic of Ecuador, National Secretary of public administration, under Secretary of e-Government, e-Government Plan 2014-2017. Version 1.0. Available in
http://www.gobiernoelectronico.gob.ec/PlanGob iernoElectronicoV1.pdf

cloud computing as an alternative solution for south african public sector: a case for department of social development

Simon Motlatsi Maluleka[1,1], Nkqubela Ruxwana[2],

Abstract. The South African (SA) government adopted Open Source Software (OSS) with the aim to reduce ICT services cost, less dependencies on outsourced proprietary technology, skills and flexibility. However, the SA government was less successful in achieving this aim due to OSS implementation challenges such as support, funding, training, awareness and human factors. In the midst of the OSS challenges, a potential alternative to address the same objectives aimed by OSS is Cloud Computing adoption. Cloud Computing is the latest phenomena that promises better potentials especially ICT cost reduction, effectiveness and efficiency of IT services.

The purpose of this study was to explore the feasibility of Cloud Computing adoption in SA government as cost effective approach for ICT services. To achieve this purpose, the study applied mixed research methods, selected a single case study. A triangulation of data collection methods was used to promote validity and reliability of study findings, where primary data was collected using questionnaires, interviews, and document review. The Diffusion of Innovation (DOI) was employed as the underpinning theory that guided the study. Key findings reveal that Cloud Computing solution promise to be a cost effective alternative for ICT services. The study recommended Cloud Computing as a cost effective alternative for ICT services in SA government.

Keywords: Cloud Computing, Open Source Software, Innovation, Government.

[1] Financial and Fiscal Commission, Midrand, South Africa

[2] Tshwane University of Technology, Pretoria, South Africa

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_45

1 Introduction

The South African (SA) government adopted Open Source Software (OSS) in the year 2002 with the aim to achieve economic value since OSS is perceived as having potential advantage for affordable ICT solution [1]. This OSS adoption had several objectives such as costs reduction and less dependency on outsource proprietary technology and skills; further to provide affordable software for enterprise and government; as well as reliability and flexibility [1][2].

In spite of the efforts and investments injected on OSS the implementation by several departments within the SA government, it is sadly reported that the intended objectives have not yet been fully realized even after a decade since the adoption of OSS as a cost saving approach by SA government. This is due to challenges such as support, funding, training, awareness, and human factor [2].

In the midst of OSS challenges, one recent invention of ICT solutions promising even much better potentials, especially the realization of ICT costs reduction is "Cloud Computing" model. Cloud Computing offers the benefit of reducing costs, increasing flexibility and improving ICT's responsiveness to organizations [3], far better than that provided by OSS.

It is therefore important for a SA government to explore Cloud Computing as an alternative solution for a SA government. This paper presents Cloud Computing as an alternative cost reduction mechanism for ICT services in a SA government.

This paper discuss the notion of Cloud Computing, Research Methodology employed, present findings and results. The paper further discuss findings and make recommendations.

2 The Notion of Cloud Computing

Cloud has been used as a metaphor for the Internet. It has therefore derived from a depiction in the network diagrams as a sketch of cloud which represented transfer of information from one point to the other.

2.1 Defining Cloud Computing

Cloud Computing have been defined by different authors in various ways. Cloud Computing is defined as an innovation that takes technology, services and applications which have similarities to those on the Internet and turns them to a self-service utility [4]. Cloud Computing is a model for supporting unlimited, convenient,

on-demand network access to a shared pool of configurable computing resources i.e. networks, servers, storage, applications and services that can be rapidly provisioned and released with minimal management offered or service provider interaction [9].

2.2 Cloud Computing Models

According to National Institute of Standards and Technology Cloud computing is a model for enabling convenient, on-demand network access to a shared pool of configurable computing resources such as servers, storage, networks, servers, applications, and services) that can be rapidly provisioned and released with minimal management effort or service-provider interaction [4]. Cloud Computing model provide a cloud purpose and how cloud is located as on Fig. 1.

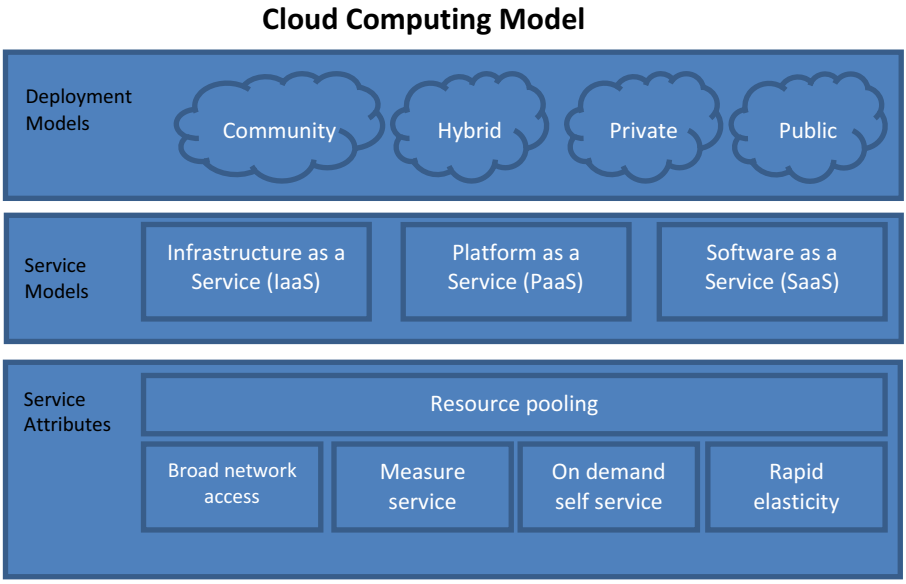


Fig. 1 illustrate three Cloud Computing dimensions, deployment models and service models.

2.2.1 Cloud Computing Deployment Models

Cloud Computing deployment models are categorized into four types which are Community Cloud, Hybrid Cloud, Private Cloud and Public Cloud [4].

Public Cloud is a set of hardware, networking, storage, applications and interface owned and operated by a third party for use by cloud consumer. This type of model is managed relatively repetitive or straight forward workloads such as electronic mail (e-mail) service where the cloud provider optimizes the environment so that it is best suited to support large number of customers [5].

Private Cloud is a model that the infrastructure is dedicated to one organisation. It is not shared with other organisations. Datacentre is hosted by the organisation itself or at a rented space (the same organisation the consumer belong to). The organisation owns and has a full control of infrastructure [6].

Hybrid Cloud is the model which when the organisation decides to combine both Public and Private Cloud, the service of Public and Private clouds are joint. This creates a backup where Private Cloud capacity is exhausted and there is a need for additional capacity [7].

Community Cloud model is also known as "vertical cloud", it caters for a group of organisations with a common set of requirements or objectives [8]. This means that, not everyone in the organisation has access to community cloud. This model is dedicated to a specific community within the organisation e.g. Community of Practice in the organization [9].

2.2.2 Cloud Computing Service Model

Cloud Computing service models explain different types of services the cloud provides. Service models are categorized into three service types which are Software as a Service (SaaS), Platform as a Service (PaaS), and Infrastructure as a Service (IaaS) [9].

SaaS is the way cloud users are first introduced to the cloud because is designed to implement a specific business process. Most business users are found that SaaS represent a more cost effective, flexible and secure alternative to traditional on-premises applications [5].

PaaS is an abstracted and integrated cloud based environment that supports the development, running and management of applications. Application components may exist in a cloud environment or may integrate with applications managed in private clouds or in data centres [5].

IaaS is the simplest of cloud offerings as it is an evolution of virtual private server offerings and provides a mechanism to take advantage of hardware and other physical resources without any capital investment or physical administrative requirements [8].

3. Benefits of Cloud Computing

Cloud Computing can significantly improve IT services in public sector [10]. Some of the benefits offered by Cloud Computing in the government are economic scale, flexibility, rapid implementation, and consistent service [8],[9],[11]:

Economic scale: Cloud Computing can cut out upfront or reduce capital expenditure as a result then reduce IT administrative burden [12]. It does not require a lot of capital

investment. It uses pay-as-you-use approach which you pay only for the services used [11].

Flexibility: Cloud Computing increases flexibility because of on-demand computing across technologies and reduces solution implementation times. There is no need to secure additional hardware and software as can add or subtract capacity as based on the demand and pay for only what is used [12].

Rapid implementation: Cloud Computing does not require to procure hardware, software licenses or implementation services and certification process. It also helps execution of projects within the required time frame [13].

Consistent service: Cloud Computing offers higher level service which is reliable and provide immediate response to emergency situations. The user can use variety of computer devices including portable devices. Network outage is sent to IT department for response [13].

4. Research Methodology

4.1 Research Approach and Design

According to [14] all research begins to a certain extent with existing knowledge and previous research.

Mixed Methods Research was used for this study to have a degree of depth validity and reliability which requires both approaches. In validating findings the researcher can conduct in-depth interviews and may find certain patterns exist in the data and set out numerical questionnaire to clarify the findings [15]. The purpose of using Mixed Methods in this study is to best fit the research problem by obtaining one data source which is significant, the results need to be explained, generalize exploratory findings. The secondary method (qualitative) was used to enhance the primary method (quantitative).

4.2 Research Strategy

A case study approach was adopted for this study to help explore how feasible Cloud Computing is and how it could be adopted as a cost effective ICT service approach in the South African government. Case studies design can be classified in two types: single and multiple case studies [16], [19]. Single case study is for corroborate or challenge a theory or may be used to represent a unique case [16].

In this study, a single case study was used, where The National Department of Social Development (DSD) was selected as a case because it was a key focus for OSS intended aim. The case was selected on the basis that it provides a condensation of specific in-depth issues as experienced in SA government, thus findings could

possibly be used to address other issues of this nature in other government departments [16].

4.3 Data Collection

A case study can use interviews, observation, questionnaires and documents techniques [17] among others. The primary data collection techniques used in this study were closed-ended questionnaires, semi-structured interviews, and document review to increase the credibility and reliability of data.

4.4 Sampling Design

A sample is a representative part of the target population selected [18]. For the purpose of this study Purposive Sampling was selected because is sample type used for people or other units that are chosen for a particular purpose [23]. The researcher choose this sampling type because was more appropriate to get participants that have knowledge and understanding of Open Source Software and Cloud Computing.

Population for this study were officials from Information Technology (IT) division within DSD. Participants include Senior Managers, Managers, Business Analysts, Developers, IT supports, IT specialists and consultants. Questionnaires were distributed to 28 officials plus 2 consultants, which makes a total of 30 but 28 were returned fully completed and considered in the study. 6 participants were interviewed.

4.5 Data Analysis

Data received from participants of this study were all completed without any errors and omissions. In this study, the process of data analysis was based on data reduction and interpretation. [19] asserts that data analysis in qualitative research involves data preparation, coding and interpreting data. The study analysis followed four steps as suggested by [19] where triangulation was adopted.

Step 1: Designed qualitative and quantitative data collection instruments. Quantitative data was collected using questionnaire and qualitative data using interviews and document analysis.

Step 2: This step organised and bring meaning to the collected data on step 1. The step organise data to create understanding in answering the research questions. Statistical Package for the Social Sciences (SPSS) was used to interpret quantitative data and DOI for qualitative data.

Step 3: This step merged two sets of results and synthesize the results. The step further ensures reliability and accuracy of the study results.

Step 4: This step provides discussion of the results from merged data and a more comprehensive understanding. This step further enables the researcher to suggest a framework for Cloud Computing adoption for South African government.

In quantitative research, data was analysed using computer software packages such as Statistical Package for the Social Sciences (SPSS) to analyse pre-coded numeric data. While in qualitative research, data can be analysed using Diffusion of Innovation (DOI) which is relevant for this study to provide a guiding technique for the study.

SPSS had integrated services of computer programmes to employ reading of data from questionnaires. It enable manipulation and data management in different methods and produce statistical reports [20]. Data was analysed using SPSS as a computer program for analysing quantitative data.

5. Findings and Results

This section presents findings and interpretation of data obtained through the multi-data collection instruments, questionnaires and interviews. In the questionnaire, participants were asked to identify OSS challenges at DSD and Cloud Computing benefits. In the interviews, participants where asked how can Cloud Computing be an alternative solution to OSS. Document review was used to assess Cloud Computing cost reduction approach.

5.1 Open Source Software implementation challenges at DSD

Open Source Software have proved to have implementation challenges over the years and these failure could not enabled cost reduction of IT services as initially aimed by its objective. Figure 4 indicate Open Source Software implementation

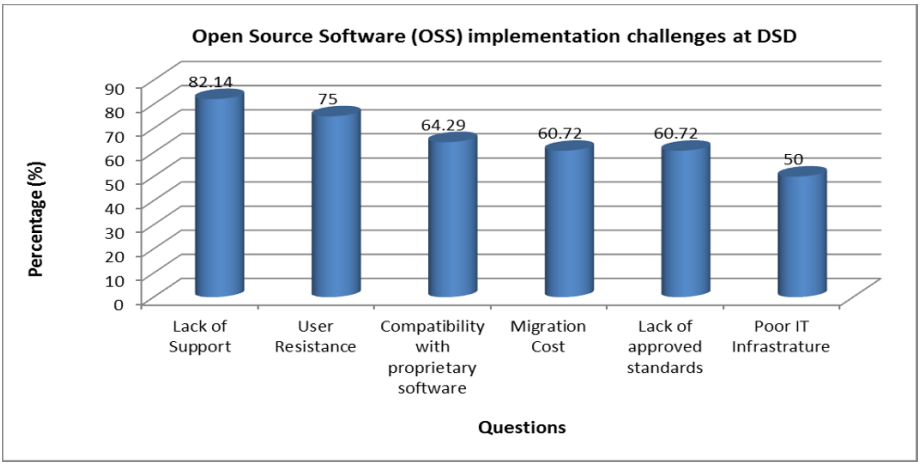


Fig. 2: Open Source software Implementation challenges at DSD

Lack of support is the most OSS implementation challenge on top of the list with 82.14% of respondents that DSD is experiencing. 75% of respondents indicated that user resistance is another contributing factor of OSS implementation failure. 64.29% of respondents perceive compatibility with proprietary software while migration cost and lack of approved standards are lower at 60.7% of respondents both. The least contributing factor towards OSS implementation failure at DSD is Poor IT infrastructure with 50% of respondents.

5.2 Benefits of Cloud Computing

There are various advantages of cloud for different enterprises over and above the most popular cost reduction advantage the graph represents the key benefits relevant to the context of SA government departments.

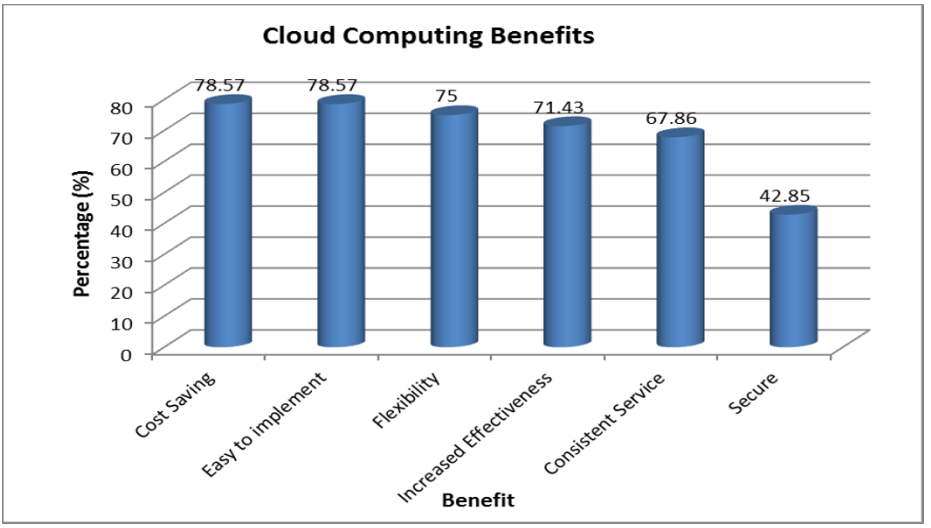


Fig. 3: Cloud Computing Benefits

According to DSD respondents, Cloud Computing can benefit DSD by cost saving and easy implementation which they rated 78.57% both. Other benefits include flexibility and increased effectiveness (75% and 71.43% respectively). Respondents perceive Cloud Computing to have a consistent service as they rated 67.86% though most respondents don't perceive Cloud Computing to be secure as they rated 42.85%.

5.3 Cloud Computing Challenges

As much as Cloud Computing can offer uncountable benefits, it has some challenges. According to [23] major challenges faced by Cloud Computing adoption in government are: the need for scalability, reliability, securing data in the cloud, open standards and interoperability, revise procurement practices, resolve potential legal

issues, regulate the cloud market, redefine the roles of the IT workforce, assess the Return on Investment (ROI) of Cloud Computing and government cloud coordination.

[6], [24] attest that cloud security is a serious concern that should be addressed before an organization decide to adopt Cloud Computing. Though cloud security is a risk, there are security measures that can be considered, Cloud Data Security (CloudDataSec) and Security Management as a Service (SMaaS).

5.4 Cloud Computing as an alternative solution

The study findings reveal that Cloud Computing promise to be cost reduction ICT alternative compared to OSS and any other traditional ICT solutions.

Participants acknowledged the cost-effectiveness of Cloud Computing for SA government, and strongly recommended the adoption of Cloud Computing as an alternative ICT solution. When asked about the benefits of Cloud Computing, they emphasised the cost-effectiveness of cloud computing as a key benefit, and the following comments were made:

Out of six interview respondents, this is what five respondents said regarding cost reduction. The Respondents were asked" What are perceived benefits of using Cloud Computing at DSD"

Respondent 1: "Allow to use as you go (pay per use model), Cost saving and maintenance."

Respondent 2: "Visualization in the cloud driver might be costly, can have a quick response which is cost and time saving."

Respondent 3: "Save cost – capital investment"

Respondent 4: "Save money because it use pay as you use model and maintenance of servers."
Respondent 5: "Cost saving – no worry about the space or maintaining the service"

The study also considered migration of E-Mail service to cloud. E-Mail service was mentioned to be the mostly used service in the department and promise to save over 44% of the current E-Mail service spending.

6. Discussions of findings

This results show that OSS had implementation challenges at DSD. Some of those challenges are lack of support and user resistance. This challenges correlate with challenges of ICT's at DSD. There should be proper support structure and conduct awareness activities.

According to [2] lack of support, compatibility with proprietary software and user resistance are the top three OSS implementation challenges followed by migration cost and lack of approved standards. DSD respondents attested that these are the challenges they experienced with regard to implementing OSS in the department.

The researcher was given access to E-mail service invoices. The researcher also sourced E-mail quotation service from the cloud provider to analyse possible cost reduction. From these documents, it was evident that DSD can save 44% of ICT service cost if adopts cloud E-mail service such as Unified email Management (UEM) over OSS.

Findings further revealed that Cloud Computing will provide relative advantage to the department [10] [11] [12] [22] [23]. The department should consider mitigating the security concern and ensure that that user's gain confidence with their information hosted on the cloud.

7. Recommendations

It is therefore recommended that SA government consider Cloud Computing as an alternative solution for SA government for effective cost reduction approach. Security measures need to be addressed before cloud implementation. To aid the adoption process, the study recommended a Cloud Computing framework for the SA government based on the study findings to aid Cloud Computing adoption process.

The framework proposes factors such as need analysis, solution assessment that should be considered by government departments to guide adoption of an appropriate cloud service cloud service. These factors are complimented by continuous improvement, change management, project management and leadership..

8. Conclusion

ICT solutions can play a strategic role towards service delivery improvement in the SA government. However government departments are reluctant to invest in ICT solutions due to lack of ICT skills, high cost of ICT solutions, performance issues, downtime and disaster recovery and so forth.

This study therefore suggested Cloud Computing as an alternative solution for ICT service cost reduction as was aimed by OSS. Cloud Computing promise to offer more advantages which are cost reduction, rapid implementation, flexibility, increased effectiveness and consistent service. The findings of the study revealed that indeed Cloud Computing can reduce ICT services cost, effective and efficient.

References

1. J.S. Mtshweni, “Open Source Software Implementation within South African government”, Tshwane University of Technology, South Africa (2008)
2. K. Behnia, “Cloud Computing”, BMC software, United States (2010)
3. B. Sosinsky, “Cloud Computing Bible”, Wiley Publishing Inc, Asia Pacific (2011)
4. J. Hurwitz, M. Kaufman, F. Halper, D. Kirsch, “Hybrid Cloud for Dummies” Wiley Publishing, Canada (2012)
5. A.K. Soman, “Cloud-based solution for HealthCare IT”, CRC Press Taylor & Francis Group, New York (2011)
6. J. Rosenberg, A. Mateos, “The Cloud at your service: The when, how and why of enterprise Cloud Computing”, Manning Publications, New York (2011)
7. J. Rhoton, “Cloud Computing explained”, Recursive limited, United States (2011)
8. P. Mell, T. Grance, “The NIST Definition of Cloud Computing, Department of Commerce: NIST”, United States (2011)
9. V. Kundra, “Federal Cloud Computing strategy”, The white house: United States (2011)
10. V. Kundra, “State of Public Sector Cloud Computing”, The white house: United States (2010)
11. K.J. Jackson, “Government Cloud Computing”, Dataline, Virginia (2009)
12. V. Kundra, “State of Public Sector Cloud Computing”, The white house: United States (2009)
13. M.B. Miles, A.M. Huberman, “Qualitative Data Analysis”, SAGE Publications, New York (1994)
14. M. David, C.D. Sutton, “Social Research: The basics”, SAGE Publications, New York (2004)
15. R.K. Yin, “Case study research design and methods”, SAGE Publications, Thousand Oaks (2003)
16. M.S. Olivier, “Information Technology Research: a practical guide for Computer Science and Informatics”, 3rd Edition, Van Schaik Publishers, Pretoria (2009)
17. D.R. Cooper, P.S. Schindler, “Business Research Methods”, McGraw Hill, New York (2003)
18. J.W. Creswell, “Qualitative Inquiry & Research Design: Choosing Among Five Approaches”, SAGE Publications, New York (2007)
19. K.N. Brek, I.S. Francis, “A review of the manuals for BMDP and SPSS”, Journal of the American Statistical Association, Taylor & Francis 73 (361) (2010)
20. F. Etro,”The economic impact of cloud computing on business creation, employment and output in Europe”, University of Milan, Europe (2009)
21. IBM, “The benefits of Cloud Computing: A new era of responsiveness, effectiveness and efficiency in IT services delivery”, IBM corporation (2009)
22. P.D. Leedy, J.E. Ormrod, “Practical Research: Planning and Desing”, Prentice Hall, Canada (2005)
23. J.D. Breul, J.W. Kock, “Moving to the cloud: An introduction to Cloud Computing in government”, IBM centre for the Business of Government (2009)
24. W. Kim, S.D. Kim, E. Lee, S. Lee, “Adoption issues for Cloud Computing”, Proceedings of MoMM2009, Dec 14 – 16. ACM (2009)

Architecture of Information Security Policies: A Content Analysis

Isabel Lopes[1] and Pedro Oliveira[2]

[1]Centro ALGORITMI, Universidade do Minho
[1 2]School of Technology and Management, Polytechnic Institute of Bragança, Portugal
{ isalopes, pedrooli }@ipb.pt

Abstract. The growing importance that Information Systems (IS) have in our companies naturally brings about a need to rely and trust in their use. There are a number of technologies which help ensure the security and trust in the IS use. However, technology alone does not solve all the problems, which is why there is a need for well-defined information systems security policies in order to ensure the data integrity and confidentiality. Nevertheless, there is a lack of information concerning the contents that such policies must have. This work aims to contribute to the filling of this gap. It presents a synthesis of the literature on information security policies content and it characterizes 15 Small and Medium Sized Enterprises (SMEs) information security policy documents as far as their features and components are concerned. The content analysis (CA) research technique was applied to characterize the information security policies. The profile of the policies is presented and discussed and propositions are made for possible future works.

Keywords: Features and Components of Information Security Policies, Information Security, Small and Medium Sized Enterprises.

1 Introduction

The massification of computer use as well as the vast internet use within organizations has brought about an increasing exposure of information. SMEs are also being affected by this problem but have fewer resources available to intervene in the management of information security.

According to [1], information is an asset which, like any other asset, is important and essential to an organization's business, and must therefore, be appropriately protected. Information is currently seen as one of the most important resources within an organization, giving a decisive contribution to its higher or lower competitiveness. In the view of [2] and [3], information security must be understood within the organization's context of culture, policies, organizational structures and operating environment used in order to ensure the integrity, availability and confidentiality of its information. Among information security controls, the literature gives a central role to information security policies.

Despite the significant number of studies on the topic of information systems security (ISS) policies, until mid-2000s the literature revealed a limited number of

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_46

empirical studies on this security measure. Indeed, some authors had pointed to limitations on the research performed, such as the inexistence of a coherent theory about information security policies [4] and the inexistence or low expression of empirical studies focusing on the adoption, content and implementation of information security policies [5,6]. Since the time when these observations were made, several studies of empirical nature on ISS policies have arisen, such as [7]. The majority of the works in this last set of studies promoted surveys that addressed the intentions and behaviors of employees, examining factors which facilitate or inhibit compliance with ISS policies. These works, however, did not consider the specific ISS policy documents held by organizations nor the connection between the wording in those documents and employees' behaviors or intentions to protect information systems assets.

The literature on this topic may have been enrichened, but its focus can be quite wide. As it is not viable or even conceivable to address all the aspects regarding ISS policies, we decided to focus this work on their content. Therefore, we studied 15 ISS policy documents formally adopted in SMEs and centered our analysis on their content.

The paper is structured as follows. After this introduction, we review the literature on the features and components of information security policies. Then, the research questions are presented and the research strategy is described. Afterwards, we present the main results of the study. The paper ends by drawing conclusions and suggesting future work.

2 Architecture of Information Security Policies

Information security protects information from several types of threat in order to ensure business continuity, minimize damage and maximize both return on investments and business opportunities [8].

In order to reach this level of protection, companies must stop worrying only about crackers' attacks or about the implementation of firewalls and/or anti-viruses. They must start focusing their attention on the creation of an actual information security culture. For [9], setting a firewall does not alone ensure the security of internet access. Therefore, according to this author, a set of other considerations must be established, such as policies, procedures, norms and other management instructions.

The ISS policy is a document which must describe the recommendations, rules, responsibilities and security practices to be adopted by the company so as to achieve a desirable standard of information systems protection. Since the security policy has to be formulated according to the company in which it is going to be implemented, its drafting is a complex task and complies with a series of features and components. These two points constitute the content of an ISS policy and are therefore defined below.

2.1 Features of Information Security Policies

One of the policies main features is the way they are structured, with different authors recognizing different forms of structuring. The author [10] acknowledges the existence of organizational policies, which establish general guidelines for the information security program, and of technical policies, which establish the security requirements that a product or a computer system should observe. In turn, [11] acknowledge the existence of three fundamental structures for policies:

- Individual policy – In this structure, the organization creates a separate and independent security policy for each technology and system used.
- Complete policy – In this structure, which is the most common according to the authors, the organization centrally defines, controls and manages one single document which includes all the technologies used and provides general guidelines to all the systems used by the organization.
- Modular complete policy – This policy is centrally controlled and managed as in the case of the complete policy, and it consists of general sections, with descriptions of the technologies used, and discussions about the systems responsible and appropriate use. For this author, this is the most effective structure for information security policies.

An additional important feature is related to the policies language. Security policies must be written in a simple and understandable language, free from technicalities and ambiguous terms which may prevent their clear understanding. Their precision must not be jeopardized, which is why a policy must be written in a clear way, thus not generating any doubt or question from its recipients.

The length of a policy depends on the amount and complexity of the systems and agents that it covers, as well as the level of abstraction applied in its writing, since a document with a high level of abstraction will not come into extensive detail. The author [12] recommends a length ranging between one and five pages.

The most common approach is a policy containing few words and that is widely directed. Therefore, its text must be direct, succinct and concise.

The way the policy will be disseminated among all the users of the information system must also be taken into account. The policy may be provided in paper or in digital format. This aspect must be analyzed according to the kind of company so as to ensure that the dissemination is as effective as possible.

Finally, but not less important, security policies must follow a periodic updating process subject to relevant organizational changes such as: staff increase, changes in the computerized infrastructure, high staff rotation, development of new services, regionalization of the company, change or diversification of the line of business, etc. The periodicity of the policy review ranges from six months to one year.

2.2 Components of Information Security Policies

Although it is accepted that an ISS policy may vary considerably from organization to organization, this possibility has not prevented some authors from bringing forward some guidance on the elements that policies should typically include.

By comparing several information security standards, Hone and Eloff isolated the following elements as generic components that ISS policy should include [12]:

- Need for and Scope of Information Security
- Objectives of Information Security
- Definition of Information Security
- Management Commitment to Information Security
- Approval of the Information Security Policy
- Purpose or Objective of the Information Security Policy
- Information Security Principles (risk management, compliance, access control, etc.)
- Roles and Responsibilities
- Information Security Policy Violations and Disciplinary Actions
- Monitoring and Review
- User Declaration and Acknowledgement
- Cross References (to other information security documents)
- General Elements (authors, date of policy and review date of policy)

Defining a security policy which:

- Includes the organization's information security general framework and goals
- Considers legal or contractual requirements regarding information security
- Is aligned with the risk management strategic context of the organization in which the ISS policy is being implemented and maintained
- Establishes the criteria for evaluating risk
- Is approved by the direction.

Most certainly, one of the main points to be defined in an ISS policy is the goal and target of its corresponding information system, its priorities regarding services, users, methodologies and technologies, among others. Thus, one of the most important aspects to be considered is the scope of action that the policy intends to establish.

The following policy structure can be used as a basis for creating information security common policies [13]:

- Policy Title: Name of the Policy Area
- Policy Purpose: Briefly illustrates the purpose of the Policy
- Policy Applicability: Defines various internal and external entities as well as the people to which a particular Policy statement will apply
- Executive Owner: Identifies the person who has the ultimate authority and responsibility for any changes and updates in the policy. Any changes or updates in the policy have to be approved by the Executive Owner
- Custodian: The person who is responsible for maintaining, communicating, and updating the policy based on directions from the Executive Owner
- Enforcement: Defines the consequences of any violation of the policy
- Policy Sub Area: Defines sub areas of a policy area, e.g. Logical Access Management – Access Control
- Policy Statement: This section describes the control statements' part of the specific policy
- Policy Effective Date: This section defines the date from which the policy is applicable and is to be followed

3 Research Strategy

Since the aim of this work is to analyze the documents which go under the name of ISS policies, we started with a literature review, always focusing on the features and components of a policy. Subsequently, we had to collect ISS policies. Given the intention of making a comparison between several policy documents, we decided to restrict the collection of documents to a single group of enterprises. With this option, we sought to minimize the possibility of documents belonging to different enterprises having different features and components, due to particular characteristics of each of those enterprises as well as specific information security needs.

The enterprises that we selected for the collection of the policies was that of SMEs. These enterprises was chosen for two main reasons. Firstly because in Portugal, SMEs represent 99.8% of business. Their representativeness is extremely high, which makes them deserve more attention in many respects. Secondly, because when focusing our attention on SMEs, a study carried out by [14] revealed that among the 307 SMEs surveyed, only 15 stated to have an ISS policy. One of the conclusions drawn from that study was that the implementation and consequent adoption of an ISS policy has not yet become a reality in SMEs.

The status of SME is defined in the Decree-Law n. 272/2007 of November 6, according to the companies' number of permanent workers, which must be under 250; the turnover, which must be under or equal to 50 million Euros; and an annual balance-sheet total which must be under or equal to 43 million Euros.

In Table 1, we present the number of workers and their representativeness within Portuguese business.

Table 1. Number of workers and percentage in 2012 in Portugal

Type of Enterprise	N. of Workers	Percentage
Micro	1-9	94.6
Small	10-49	4.7
Medium sized	50-249	0.7
SME= 1+2+3	1-249	99.8

3.1 Research Questions

The analysis of the documents enables us to globally list the features and components of the 15 ISS policies under study. Among the features and components, there are some specific issues which deserve our attention.

Thus, with respect to the policies' features, we will address the following issues:

1. What is the length of the policy documents?
2. How are the policies written?
3. What is the expected durability of the policy documents?
4. What is the structure of the policies?
5. How are the policies delivered?
6. What kind of documents are the policies?

With respect to the policies' components, we put forward the following specific questions:

1. What components do the policies contain?
2. Are there any components that make part of all the policy documents?
3. Are there any components that are not present in any of the policy documents?
4. What is the purpose of the policies?
5. What is the scope of the policies?
6. What kinds of responsibilities do the policies determine?

3.2 Research Method

The use of a research method is paramount since it represents the means to an end. A research methodology does not look for solutions but chooses the way to find them, integrating knowledge through the methods which are applicable to the various scientific or philosophical subjects. Although there are several ways to classify them, research approaches are normally distinguished between quantitative and qualitative [15]. It is acknowledged that the choice of the method must be made according to the nature of the problem being addressed. Therefore, we considered appropriate to follow a quantitative research method (traditional scientific research), based on the positivist rational thought, according to which through empirical observations, we build theories (expressed in a deductive way) that try to explain what is observed. Among the possible research methods to use, we applied the CA.

CA is a method which differs from the other research methods because instead of interviewing or observing people, the researcher deals with pre-existing records and interferes based on those records.

CA is a research technique for the objective, systematic, and quantitative description of manifest content of communications. So that this description can be objective, it requires a precise definition of the analysis categories, in order to enable different researchers to use them and get the same results. So that it is systematic, the whole relevant content must be analyzed in relation to all the meaningful categories. Finally, quantification allows the provision of more precise and objective information concerning the occurrence frequency of content features [16].

4 Results

The aim of the study is to characterize the content of ISS policy documents that have been adopted by SMEs. Such characterization will be made by answering the twelve research questions listed in point 3.1.

The length of the documents analyzed ranges from a maximum of 10 pages and a minimum of one page. The average length is 3.6 pages. With regard to the number of words, the documents analyzed ranged between a maximum of 3987 words and a minimum of 212 words, with a mean of 1266 words.

Most ISS policies are easy to read and understand, appropriately structured and written in a clear and intelligible way. Some documents use a number of technical

terms from the information security domain, but there is a concern to define them either immediately after their use or grouped in a list containing the respective definitions.

None refers to the durability of the document or to the periodicity in which the policy must be revised.

Another finding from the analysis of the 15 documents is that none of them constitutes a purely technical ISS policy. The analyzed documents can be classified as organizational policies.

With respect to the way the policy is delivered to the users of the SME Information System so that they become acquainted with it, we found that in 9 of the cases (60%), the policy is handed in person by the head of the IT department. In the remaining cases, the policy is delivered in digital format.

Among the 15 policies, 14 (93%) have a clearly identifiable title. Nevertheless, the title of the documents varies considerably, though they may be grouped into the following categories: regulation (six cases), norm (five cases), manual of rules and procedures (one case), job instructions (one case), rule (one case) and policy (one case). Despite this variety, most of the titles include a reference to IS or IT, such as information, IT equipment, email, internet, computers, and applications.

In Table 2, we present the components of a policy as well as the frequency of their presence in the 15 documents.

Table 2. Components Contained in the Information Security Policies

	Policies																
Components	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Nº**	**%**
Objective of the information security		X			X				X	X						4	27
Purpose of the policy		X	X	X	X		X	X	X		X	X		X	X	11	73
Scope of the policy		X	X				X	X		X	X	X	X	X	X	10	67
Definitions				X	X				X							3	20
Guidelines		X														1	7
Requirements	X	X	X	X	X	X		X	X	X	X	X			X	12	80
Directives		X	X	X	X	X	X	X	X	X	X	X	X	X	X	13	87
Responsibility	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	15	100
Responsibility of the owner		X									X					2	13
Communication of incidents										X					X	2	13
Allocation of resources		X						X	X							7	47
Punishments			X	X	X		X	X	X		X	X		X	X	10	67
Communication procedure			X												X	2	13
Policy communication targets		X	X	X										X		4	27
Statement of notification	X	X		X	X			X						X		6	40
Location of the policy							X	X						X	X	4	27
Author of the policy	X	X	X						X			X	X			6	40
Date of approval		X		X		X	X		X	X		X		X		8	53
Date of entry into force										X	X					2	13
Approval of the policy		X		X		X	X	X		X	X	X		X		9	60
Contacts	X		X	X	X		X	X	X	X	X	X	X		X	12	80

The components which are present in more than 50% of the documents are listed here in a decreasing order of frequency: Responsibility, Directives, Requirements, Contacts, Purpose of the policy, Scope of the policy, Punishments, Approval of the policy and Date of approval. Among these components, only one is universal to the 15 documents, namely responsibilities.

With regard to the components which are not present in any of the documents, we can highlight the following: Executive summary, Relation between security and business objectives, Coordination among organizational entities, Ethics concerning information security, Threats, Review date of policy and Approval of reviews.

In some documents, the purpose of the policy was stated as the reason for the formulation of the policy and in other documents to specify what the SME wants to achieve with the policy. The incidences of the purpose are the IT resources (nine cases), internet and email (one case), information (one case).

As far as responsibilities are concerned, the major types of responsibilities allocated to users or organizational units, i.e., those that appear in more than half of the documents, are listed in Table 3.

Table 3. Types of Responsibilities

	Policies																
Responsibilities	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**Nº**	**%**
Information security policy	X	X	X		X			X	X			X			X	8	53
Internal organization of information security			X						X						X	3	20
Responsibility for assets		X	X		X	X	X	X	X	X	X	X	X	X	X	13	
Secure areas								X	X						X	3	20
Operational system access control			X		X	X	X	X	X		X	X		X	X	10	67
Protection against malicious code	X	X			X			X	X		X	X		X	X	9	60
Backup			X		X	X	X	X	X		X	X		X	X	10	67
Security management network		X	X	X	X			X	X	X		X	X			9	60
Media Handling		X					X							X	X	4	27
Exchange of information	X	X										X		X		4	27
Monitoring							X						X	X	X	4	27
Requirements for access control			X					X							X	3	20
User access management								X							X	2	13
User responsibilities		X	X		X			X	X			X			X	7	47
Network access control		X			X		X	X	X		X			X		7	47
Operating system access control					X		X	X	X		X			X	X	7	47
Application and information access			X					X	X						X	4	27
Of the IS safety requirements							X								X	2	13
Security of system files					X	X	X	X	X			X	X	X	X	9	60
Security in development and support processes		X			X		X		X		X		X	X	X	8	53
Compliance with legal requirements								X	X					X	X	4	27
Compliance with the security norms							X	X	X						X	4	27
Other information security object					X		X				X					3	20

The responsibilities which appear in over 50% of the documents are listed here in a decreasing order of frequency: Responsibility for assets, Operational systems access control, Backup, Security management network, Protection against malicious code, Security of systems files, Security in development and support processes, Information security policy.

With respect to the responsibilities which are not contained in any of the analyzed documents, we can highlight the following: Information Classification, Security Equipment, Cryptographic Controls, Job Changing, Before Employment.

5 Conclusions

This study involved the analysis of 15 ISS policies adopted by SMEs and focused on the features and components of the policies. This work contributes to the literature by analyzing information security empirical materials and bringing more practical and practitioner oriented perspectives to information security research. By focusing on the substance and form of actual ISS policies, it elucidates an area of information security research that has been largely ignored, in spite of its practical relevance for the improvement of information security by organizations and it supplements the literature whose traditional focus has been on individual intentions towards ISS policies.

Within this context, we consider that, in order to achieve organizations' wellness, it is important to implement security measures which take into account the confidentiality, integrity and availability of the information contained in information systems [17,18] so as to prevent, detect and respond to the threats which such systems are exposed to and therefore, protect information.

The research method used in the analysis of the documents was the content analysis. Since it consists of a technique aiming at an objective, systematic and quantitative description of the symbolic behavior and since its object is the content of communication, the content analysis revealed to be the appropriate method for this kind of research.

This research work has some limitations, namely as far as the number of documents collected and the delimitation of the study to SMEs are concerned. We must point out that a more significant number of documents would lead to a more sustained analysis. However, it is important to acknowledge that the adoption of ISS policies is not institutionalized in SMEs, and also that these policies are usually documents strictly reserved for the company, which makes it difficult to access this type of security control.

In the light of all this, among future works which can be conducted, we highlight the creation of a model of an information systems security policy which may be adopted and adapted by various companies according to their organizational culture. Another possible work may consist of relating the content of the policies which were analyzed to the recommendations found in literature.

Acknowledgment

This work has been supported by FCT - Fundação para a Ciência e Tecnologia within the Project Scope UID/CEC/00319/2013

References

1. ISO/IEC 27002: Information technology — Security techniques — Information security management systems — Requirements (2005)
2. Beatson, J. G.: Information Security: The Impact of End User Computing. In G. G. Gable e W. J. Caelli (Eds.), IT Security: The Need for International Cooperation — Proceedings of the IFIP TC11 Eighth International Conference on Information Security, Amsterdam, pp. 35–45. Elsevier (1992)
3. Beal, A.: Segurança da Informação: princípios e melhores práticas para a proteção dos ativos de informação nas organizações, São Paulo: Atlas (2005)
4. Hong, K.S., Chi, Y.P., Chao L.R., Tang J.H.: An integrated system theory of information security management. Information Management & Computer Security, 11 (5), 243-248 (2003)
5. Fulford, H., Doherty, N.F.: The application of information security policies in large UK-based organizations: an exploratory investigation. Information Management & Computer Security, 11 (3), 106-114 (2003)
6. Knapp, K., Marshall, R., Rainer, K, Ford, N.: Information Security: Management's Effect on Culture and Policy. Information Management & Computer Security, 11 (1), 24-36 (2006)
7. Karyda, M., Kiountouzis, E., Kokolakis, S.: Information systems security policies: a contextual perspective. Computers & Security, 24 (3), 246-260 (2005)
8. ISO/IEC 17799 International Standard ISO/IEC 17799:2000 Code of Practice for Information Security Management, International Organization for Standardization/International Electrotechnical Commission (2005)
9. Wood, C. C.: Writing InfoSec Policies, Computers & Security, 14 (8), 667-674 (1995)
10. Lindup, K.R.: A New Model for Information Security Policies. Computers & Security, 14 (8), 691-695 (1995)
11. Whitman, M.E., Townsend, A.M., Aalberts, R.J.: Information Systems Security and the Need for Policy, In Information Security Management: Global Challenges in the New Millennium (Dhillon, G. Ed.), Idea Group Publishing (2001)
12. Höne, K., Eloff, J.: Information security policy – what do internationalinformation security standards say? Computers & Security, 21 (5), 402-409 (2002)
13. Communications and Information Tecnology Commission, Information Security Policies and Procesures Development Framework for Government Agencies http://www.citc.gov.sa/English/RulesandSystems/RegulatoryDocuments/OtherRegulatoryDocuments/Documents/CITC_Information_Security_Policies_and_Procedures_Guide_En.pdf
14. Lopes, I., Oliveira, P.: Understanding Information Security Culture: A Survey in Small and Medium Sized Enterprises. Álvaro Rocha et al (eds.). New Perspectives in Information Systems and Technologies, Volume 1. ed. Cham: Springer International Publishing, v. 275, p. 277-286 (2014)
15. Myers, M. D.: Qualitative Research in Information Systems ACM Computing Surveys (CSUR), MISQ Discovery (1997)
16. Berelson, B.: Content Analysis in Communications Research. Free Press, New York (1952)
17. Kim, D., Solomon, M. G.: Fundamentals of Information Systems Security, Jones and Bartlett Publishers (2010)
18. Tipton, H., Krause, M.: Information Security Mangement Handbook. Auerbach Publications (2009)

The Information Value: perception of the problem

Maria Aparecida Lopes da Cruz[1], Henrique Manuel Dinis dos Santos[2],

[1] PhD student of Doctoral program in Information Systems and Technology – University of Minho
[2] Centre ALGORITMI, University of Minho
cidazen@gmail.com
hsantos@dsi.uminho.pt

Abstract. It is almost a commonplace to note that we now live in the information age. This fact gives information a central role, being a natural consequence the need to look more objectively to the information value. In an attempt to contribute to this response, at least from a specific application area, this article focuses on the use of scientific information by researchers and their process of valuation. The main objective of the research is to analyze models and propose amendments, or even a new model with a view to a better perception of the value of information.

Keywords: Information; Bibliometric study; Citation analysis; Information systems.

1 Introduction

In the present era of the Information Economy, based on the aggregation and exploitation of a huge amount of data (Cyberspace), the information can be linked virtually to everything, subject to changes and processes that strive for increasing its value, seeking to satisfy numerous needs of consumers [1]. In this perspective, knowing the value of information (quantitatively or qualitatively) can be of great importance, especially when linked to critical processes, such as the decision taken in the financial field, clinical data in healthcare, or even risk analysis in Information Systems Security. To answer this need, several models have been investigated, mainly based on the analysis of the sources, the perception of the impact and likelihood of occurrence of any anomaly [2]. Using as a case study the development of scientific information, this work aims to contribute to a better understanding of information valuation models and to propose a more efficient one, in the perspective of information systems and scientific research, based on bibliometric parameters already known and used in the rea. This paper also describes an ongoing survey whose main objective is to study how researchers handle, objectively or subjectively, the value of the information they use or retrieve. The added value to existing methods is the exploration of qualitative factors within the existing quantitative bibliometric parameters.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_47

1.1 The concept of value

By doing an extensive bibliographic review on the economic value of information, in the work "The value of information - approaches in economics, accounting, and management science", published in the Journal of the American Society for Information Science, Repo [3] states that theories as the theory of Shannon information, dealing with probabilities, not with meanings, provides a fragmented view of the concept of "value", making it unable to produce a working definition for the value of information. In our case, looking for a working definition of information to infer its value, we face the same difficulty. Value and meaning is quite subjective when it comes to individuals, difficult to measure and we did not find practical measurements in the constructs, within Information Science. Bibliometric is the field of study that comes closest to this ideal. However, these metrics measure the quality and quantity of scientific production, not necessarily the value of the information itself. Its measurements can be good indicators, but do not determine the value of the information, nor clarify the evaluation process carried out by a particular user. The alternative would be to use the sociology knowledge, which comes up as interesting fundamentals in Information Science, but it was not in our interest to build an object of study from the sociological bias, eventually missing the vision of the information system. So, a more practical and robust view, oriented to the study of psychological constructs with a tradition of analysis and established value, was required. In our particular case, the vision of economic value in itself would not be so decisive, but the constructs developed to make it viable are much more promising. Evolving a market concept over the scientific research development process may seem an inadequate adaptation of concepts for very diverse areas. On the other hand, the business context of globalization and intense competition, as well as a continuous technological development, has become the issue of information security risk, also a rising issue in the Information Systems Management perspective. Besides, we should take into account that every executive is an information user, and to understand their decision process it will require inevitably to understand their use of information sources, which is implicit to the value question. In this context, the study of the interaction and mutual influence among the various information sources [4] is crucial for understanding the decision-making dynamics. Finally and as we may expect, in this study area there are some usage models of information well established, but not so well formalized.

More objectively, why it is so important to determine the value of information? There are many practical and academic reasons for this, as denoted above. But we list the ones we consider most important based on several studies [3], [5] and [6]:

1. Determine the value assigned to the user information is of fundamental importance in the discovery of the consumption patterns by knowledge workers and a central element in the issue of Information Literacy in Information Science;
2. The vision of information as a commodity and the use of rational methods to infer its value can provide the empirical foundation necessary to build more realistic models of how is performed the collaborative process (with regard to exchange of information) in scientific research groups;
3. A combination of economic, social and behavioral approaches can provide a method of practical assessment of resources to be made available by universities and

research institutes by signing databases and scientific resources to faculty and researchers;
4. This same view can also contribute to the systems theory, to lay the foundation of how the information should be treated in the implementation of information systems, especially those who are facing the management information area;
5. Finally, it is a vision that can complement the various existing information metrics, essential in any process concerning Management of Information Systems (MIS).

We are not referring to the use of research sources or as share information with colleagues, but how the individual selects and values the information he/she needs diary. What are the search and selection criteria they use? What makes them using certain information and not another? Also we do not mean here the pure subjective aspects, but to a cost/benefit relation that is established and that leads him/her to use a particular source and not another. There seems to be a lack of knowledge on this reality because studies tend to focus more on processes of evaluation the work produced than in the reality of the information management by people who do information related work. In this way, interesting questions cease to be addressed, like: How scientists as individuals perceive their interactions with the academic ecosystem, and how they use the information resources available to fill their information needs?

1.2 Research models in Information Science

Wilson [7] presents various search models of information and makes a study of several different types of scientific researchers, such as social, medical and chemical scientists, and determines the eight basic features in any such process: initiation, chain, demand (browsing), differentiation, monitoring, extraction, verification and completion. Initiation concerns the initial search process by the most appropriate available sources to the subject or theme, as required. Chaining is the next step, when the first evidences are taken to make sense and to form a conceptual framework. Normally there is a chain of references that connect to each other.In searching or browsing there is a semi search targeted to specific local sources about the objects defined by previous searches. The differentiation is about a finer awareness of the quality of consultation and of the material sources. In source monitoring the level of quality of the documents used in researching is maintained and renewed. The extraction ultimately makes up the download of material previously selected throughout the process. Verification comprises an assessment of the information, and its accuracy on the subject researched. Finally, the completion phase triggers the seeking of complementary information in order to complete a task or project. Wilson believed that the pursuit of information is dependent on the quality of information, and that it would depend on the search pattern and the ease of access to it. Studding the overall search process the author works with two quite subtle concepts: information seeking behavior and information searching behavior [7]. Information seeking behavior is intentional quest for information to fulfill a certain goal, and this process requires using several types of information systems (manual or automatic). Information searching behavior is the researcher's behavior when using these various types of systems, and involves cognitive activities to judge the relevance of

information [7]. The former refers more to an initial search behavior analysis to found references. The second is an analysis of behavior, judgmental attitude, towards what was found, and can be considered as the moment when content assessment takes place - it is an attitude of valuation. From the perspective of information systems the basic concern is the process by which users are informed by an information system. The information is often evaluated as a psychological process, and therefore capable of being evaluated by measuring psychological constructs. The user attitudes are seen in this perspective as reflecting the value of an information system, and derived from the usage users make of the system it is possible to infer what value the system has for him/her. The reason for choosing this approach is its proximity to the perspective developed in Information Science, in particular studies on the acquisition of information and its dissemination in organizations. The MIS definition of attitude concept will be important in this work, especially in the final proposal of a model: a predisposition learned to respond in a consistently favorable or not, with respect to a particular object [8] (see Fig. 1).

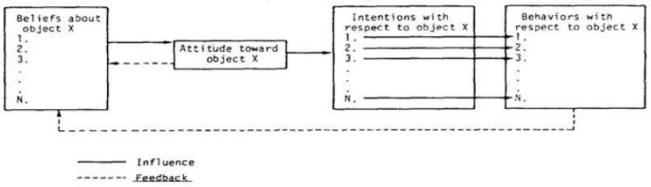


Fig.1. Schematic representation relating attitudes, beliefs, intentions and behavior toward particular object information according to the MIS approach. (Source: Swanson, E. B.: Measuring user attitudes in MIS research: A review. Omega, 10,2, 157-165 (1982))

Attitudes can be distinguished as beliefs, behavioral intentions and actual behavior [9]. Beliefs give a security dimension to a particular attribute identified with that object. The intention locates the information sought in a dimension of possibilities and associates a certain action to it. The behavior itself is the action end opposite the object.

2 Similar models in MIS

In the economic field the information behavior is linked mainly to the corporate decision process. Everything begins with a stimulus / opportunity that force the search for more information, leading in the end to a decision process. Choo [10] considers four classical models of decision making in organizations: the rational model, the process model, the political model and the anarchic model. The rational model was initially developed by March and Simon [11] and refined by Cyert and March [12] and then by March [13] alone. It is basically a cognitive model, supporting the decision-making process at achieving goals and always collecting information about a problem. It is guided by norms and simplified routines. The procedural model is presented in the Mintzberg, Raisinghani and Theoret work [14]. Unlike the previous, this is a more "unstructured" model, being guided not so much by the cognitive and logical aspects, but the context that presents itself. The model the resulting model

these various adaptations comprises several phases. The identification phase is the need to make a decision and develop an understanding of the issues involved in the decision, and involves recognition and diagnostic routines. At this stage the need for a decision is defined as information need. The diagnosis tries to understand the stimuli that trigger the decision and the relevant causal relationships by seeking information, consulting the existing channels, in addition to opening new channels [15]. In the following phase of development, is the search for solutions to the problem, consisting of search routines (research) and creating routines (development / projects). In the alternative selection phase are evaluated and is the choice of a practice solution. In the stage routines are probing and evaluation [15].The political model was developed by Allison [15] and it approaches the decision-making process as a game, where different "players" occupy different positions and exert varying degrees of influence, according to the rules and their respective bargaining power. Here prevails the political aspect, each of which exerts its power according to their position in the game. In the anarchic model, organizations are "organized anarchy" with problematic situations decision, without much definition and inconsistent with technological processes that are not well understood and where the dedication of time people are not well defined. The procedural models is considered the one that best represents the decision-making process and have chosen primarily based on the model of Mafra Pereira and Barbosa [16] in a study of models of strategic decision-making in small businesses, with a sequence of steps in decision-making process: the pre-decision, the decision itself and the post-decision. The time to pre-decision consists of four steps: identifying the need for decision, type of information required, choice of information sources and content analysis obtained at the end of the search process. The decision itself includes the factors that influenced more effectively. The moment of post-decision consists of three steps, which correspond to the implementation of the chosen decision, evaluating the results obtained and the registration of the decision as explicit knowledge for future similar decisions, including around a learning factor in the process.

3 Proposal of a model

Based on the previously described models and taking into account the case study, an adapted model was designed (see Figure 2), which will be validated by applying a proper questionnaire in two groups of researchers.

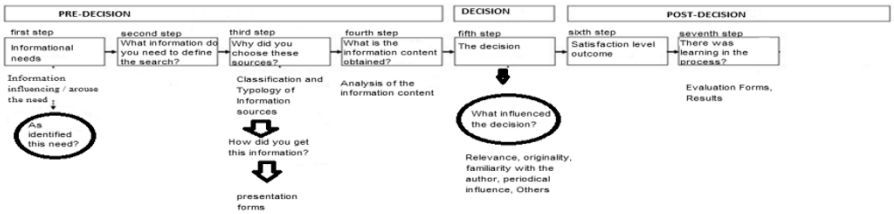


Fig. 2. Model proposed to identify the process of evaluation of information by the researcher based on the original model of Mafra Pereira& Barbosa: Strategic Decision Making Model General(X Enancib, 5, 2009).

In our adaptation of the original model, we use only 7 steps, because our goal is much more specific than the original model - to analyze the search and the use of scientific information reaching some sort of equation valuation at the end. As in the original model we divide the process in three stages. The pre-decision evolves in 4 steps, where the researcher starts his decision-making process on the information needed. The first step reflects the time the researcher identifies a necessity. In this process we can already begin to identify how the researcher appreciates the information when searching for primary sources of information that will likely be even informal. In the second step a further refinement happens, the definition of the content will really look at the universe originally intended, probably with the definition of key-words. In the third step the researcher identifies the reason for the choice of certain bases, and even at this stage there is an influence of non-formal channels of information. Here again we try to identify if there are other sources besides the databases. Finally, the fourth step, where the researcher tries to identify the obtained information content (texts) ending this phase of pre-decision.At the stage of decision comes the fifth step, aiming to identify the critical occurrence that leads to the final choice (relevance, originality, familiarity with the author, prestigious publication and others). At the stage of post-decision the researcher identify the level of satisfaction and learning. And here we have also identified the way this evaluation is measured.In the proposed model we do not considered fundamental issues such as initial informational identification and document type. However, it is necessary to form the above description of the process of the investigator decision. We hope to make a significant contribution through the questionnaire, where we can validate this model and also provide insight into the field of metrics to enable infer values for factors such as evaluation forms of Informational Content, Satisfaction and Learning level in the decision-making process the researcher. We believe that the result of this measurement may give us the indication of the value of information, not just in general but also individual, group or field of knowledge form.

4 Conclusions

The discussion about the value of information was addressed over time in many works in the field of Information Science and Information Systems. However, it was never seen as an end in itself. The quantitative bibliometric that emerged satisfied some contexts, such as databases valorization and citation analysis. The publication of indexes also cater well to the practical issues of valuation information. The investigation of the use of information has always been more linked to Information Science area, mainly through the analysis of information behavior. This can be easily deduced through the references of our work and the base model we used. The classic models, in both areas of Information Science and Information Systems, indicate their ability, in which we also believe, but they lack their applicability behind the specific environments they were made to. So our main issue is to look for a more general model, even if we only take as case study the information valuation process assumed by researchers. What we are attempting is not to create something entirely new, but rising a discussion that we consider important for the two areas - Information Systems

and Information Science - using a theoretical framework and tools that have been developed over time, from a new perspective. Through a survey we try to capture the user experience regarding the use of information (assuming this really helps to form the basis of their attitude towards it), and to find the factors that can contribute to that goal. We believe that the overall model explained in this paper can give us the answer.

References

1. Lewis, T.:The new economics of information. In: Internet Computing, IEEE, 2, 5, pp.93-94, Sep/Oct (1998)
2. Lawrence, David B.: The economic value of information. Springer Science & Business Media (2012)
3. Repo, A.J.: The value of information – approaches in economics, accounting, and management science. Journal of the American Society for Information Science. 40, 2, 68-85(1989)
4. Choo, Chun Wei.: Information management for the intelligent organization: the art of scanning the environment. Second Edition. ASIS Monograph Series, Medford, New Jersey (1998)
5. Ahituv, N.: Assessing the value of information: problems and approaches. In: Proceedings of the 10th International Conference on Information Systems, Boston, MA. (1989)
6. Ellis, David.: A behavioural approach to information retrieval design. Journal of Documentation. 45, 3,171-212 (1989)
7. Wilson, T.D.: Models in Information Behavior Research. Journal of Documentation. 55,3,249-270 (1999)
8. Fishbein M., Ajzen I.: Belief Attitude, Intention and Behavior. Addison-Wesley, Reading, Massachusetts USA (1975)
9. Zmud, R. W.: An empirical investigation of the dimensionality of the concept of information. Decision Sciences,9,2, 187-195 (1978)
10. Choo, Chun Wei.: A Organização do Conhecimento: como as organizações usam a informação para criar significado, construir conhecimento e tomar decisões. SENAC, São Paulo (2003)
11. March, J. G., Simon, H. A.: Limites cognitivos da racionalidade. In: Teoria das organizações. Fundação Getúlio Vargas, Rio de Janeiro, cap. 6, pp. 192-220 (1975)
12. Cyert, R. M., March, J. G.: A Behavioral Theory of the Firm. 2a. ed. Oxford, Blackwell (1992)
13. March, J. G.: A Primer on Decision Making: how Decisions Happen. Free Press, New York (1994)
14. Mintzberg, H., Raisinghani, D., Théorêt, A.: The Structure of "Unstructured" Decision Processes. Administrative Science Quarterly, 21, 2, pp. 246-275(1976)
15. Mafra Pereira, Frederico Cesar, Barbosa, Ricardo Rodrigues.: A decisão estratégica por executivos de micro e pequenas empresas e a cadeia alimentar informacional como modelo integrativo de fontes de informação. In: X Enancib, (2009), http://enancib.ibict.br/index.php/enancib/xenancib/paper/viewFile/3232/2358
16. _____: Modelos de tomada de decisão em empresas de pequeno porte: estudo de caso em uma escola de atendimento especializado de Belo Horizonte. DataGramaZero. 9,4, ago.(2008)

Project Management in 2016 Olympic Games

Maria José Sousa[123] / Fabiano Lima[3] / Jair Martins[4]
[1]CIEO – Universidade do Algarve
[2]Universidade Europeia
[3]Instituto Universitário de Lisboa
[4]Universidade do Sul de Santa Catarina
Estrada da Correia, 53 – 1500 – 210 Lisboa
PORTUGAL
maria-jose.sousa@europeia.pt

Abstract. The main goal of this paper is to analyses "Which project management model best fit a mega event like the 2016 Olympic Games?" The organizations which participate in the Olympic Games project management in Rio are under the pressure of external scenarios of uncertainty and also several constraints to manage all the Olympic resources and need to deal with limitations of costs and time – the model adopted can help to achieve a major success of the event. According to studies made on the past, Olympics Project Managers face various challenges and the models adopted can help to achieve the ambitious goals of the event. The main finding of this research is that project management maturity models benefits management approaches and reinforce the definition and the use of strategic plans enhancing the control techniques of project management and also that a sustainability dimension is necessary to orchestrate the successful completion of a project with the amplitude of Olympic Games.

Keywords: Project Management, Project Management Models, Sustainability, Maturity

1 Introduction

The 2016 Olympic Games will take place in Rio, Brazil. It will be the major event of sports industry of 2016 and it will be necessary to manage several sports structures and to integrate diverse kinds of resources with efficiency. In order to accomplish that goal the companies that are conceiving and developing the games structures adopted several project management models. In order to analyze the project management models this research will try to answer the research question "Which project management model best fit a mega event like the 2016 Olympic Games?" The limitations of resources,

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_48

costs and time are variables that influence the project management model adoption.

According to studies made on the past Olympics Project Managers face various challenges and the models adopted can made an integration of various and disperse project management tools. The efficient management of the Games is also important for the sustainability of the project using monitoring and reporting tools on the economic, environmental, and social performance of the Olympic Games. According to the structure of this paper it will presents a literature review that covers project management models. It will discuss the importance that project management can deliver as a useful integrative tool for managers in the 2016 Olympic Games and will also present a model proposal of project management sustainability of this mega-event.

2 Literature Review

2.1 Project Management

Project management is an important tool for organizational development and for running mega sports events. It helps to achieve the objectives of a project and the focus of any project management plan is on its successful results [1]. Project managers are responsible for the effective and efficient delivery of the project and in achieving its goals assuming a leadership style to accomplish their role. All projects begins with the breakdown structure of the work into several tasks, along with the respective timelines for the tasks, the financial resources, the human resources allocation and the responsible matrix, where the leader of each working package is identified [2]. Resources are normally a constraint for a project managers: time, human resources and the budget available for the project. These are constraints for the project managers that will try to plan the tasks and the resources allocated to achieve the project goals [3]. For mega events such as the Olympic Games, timeline is very important since the Games need to take place during the scheduled time due to the large number of individuals and organizations associated with the event and the complicated logistics involved [4].

Project management definition, planning and review techniques are the most critical dimensions of project management, namely, the work breakdown structure definition, the budgeting, the review and cost control preventing deviations from the project planning. These techniques help to control the project and to enable the organization to achieve its goals. The review of the project it's crucial because it helps to identify the tasks that may not be able to accomplish the goals in terms of schedule and costs. It requires control measures to be adopted to prevent a negative impact on the overall project.

Although it is widely accepted that mega-events such as the Olympic Games have a large impact on and leave an important legacy to the host city,

the Olympic Games have not been part of the sustainability debate. The high concentration implied by the Games in time, in space and in investment need to be analyzed in light of the sustainable development impacts in environment, in society and in economic ecosystem. Games organizers and the IOC need to ensure host cities as well as their citizens, are left with a positive long term legacy in terms of life quality and also economic and financial structure in order to maintain the sustainability of the host countries.

2.2 Maturity Project Management Models

Project management can beneficiate from models as the maturity models which provides an approach for continuous improvement and for developing prospective scenarios. First, in an increasingly competitive environment, it is necessary to ensure that the successful results of one project can be extended to future projects, not only supported on the procedures standards, but also on the leadership role and on the responsibilities of the project manager [5]. Practices and techniques of project management are recognized by many organizations in various industries as being essential skills, which benefit businesses [6]. These skills are measured through the use of benchmarking and comparative models. Hillson [7] clarifies that the benchmarking process aims to diagnose strengths and weaknesses, to measure the current capacity and to identify areas for improvement. According to Kwak & Ibbs [8], most companies consider using practices and support tools which are applicable for project management processes, as they permit them to adapt to changing business environments, yet they need a reference model for the efficient implementation of such tools.

Maturity in project management consists of developing repeatable processes and systems which lead to project success [9]. Project management maturity models emerge which provides companies with the necessary mechanisms to allow them to identify the key areas for opportunity and improvement in project management tasks. Additionally, these models serve to develop comparative indicators for the application of project management practices and techniques across organizations which operate in the same business environment or sector. Maturity has been expressed by organizations as a potential key factor for increasing performance, for achieving goals and for being successful. Organizational project management maturity and competency seem to be promising variables which are both related to project success [10], [11]. Dinsmore [12] believes that maturity shows how an organization has progressed in relation to the incorporation of project management as a way of working, thus reflecting its effectiveness in completing projects.

Basically, the purpose of the maturity model is to provide a framework for improving an organization's business result by assessing the organization's project management strengths and weaknesses, by enabling comparisons with similar organizations, and by measuring the correlation between an

organization's project management level and its project performance [13], [14],[15].

Hastak and Shaked [16] provided a three layer risk management model developed for the construction industry, but that can also be applied to other sectors as sports industry. This model suggests that a project faces three levels of risks that are interrelated to each other, project level risks, market level risks and finally the macro level risks. While the project level risks are associated with the technology, financials, resources and design of the project, the market risks are associated with the market in general but considering the same factors. The macro level risks are associated with the operations of the project in a given macro environment and thus include the economic, political and other financial risks.

2.3 Project Management of Mega Sports Events

Emery [17] carried out a research across 11 countries involving 178 organizers of major sports events and found that the most important factors in determining the success of such an event are the sponsors, sporting authorities and the media. In case of Athens Olympics for instance the sports facilities were planned to be ready at least 10 months before the scheduled games to enable the actual testing of all the facilities before the mega event [18]. This is indicative of the high levels of facility management techniques being used by the organizers to minimize the risks of failure during the event.

To prevent the failure project management, business models are important mainly when aspects like the budgeting management is not effective and the planning does not reflect the reality, refers Jennings [19] in his research on the cost overruns in case of major events like the Olympic Games. Flyvbjerg and Stewart [20] found that the Olympic Games from 1960-2012 faced cost overruns, with an average overrun of 179 per cent in real terms. The researchers also compared other major sporting events with Olympics and found that the incidence and cost overrun in case of Olympic Games was significantly higher than any other sporting event creating awareness for the financial and social sustainability of the host city.

In terms of the sustainability of the event and also the host city it should be important to define a plan venues for other uses than the Olympic Games, and also the possibility to use temporary infrastructures, because evidence from the past shows that many competition venues built for the Games have received poor post-Games usage and the financial support of this structures contributes for the increase of the economic crises of the host countries [21].

One solution is found in the design of multi-purpose venues. It is indeed preferable to conceive spaces which can be modified according to the circumstances. The Games last for only 16 days and reusing Olympic facilities is one of the greatest challenges to the host city authorities in terms of both city activity and financial profitability.

3 Conceptual Model

Project Management is the application of knowledge, skills, tools, and techniques to project activities in order to meet their demands, being carried out by means of the integration of the processes of initiation, planning, execution, monitoring and control, and closure, as it offers the Project Management Institute[1) (PMI, 2013).

The application of knowledge, skills, tools and techniques to achieve the goal of the project is carried out by a person responsible: the project manager. The main responsibilities of project manager are: Identify the needs of the project; Establish clear objectives and tangible; Meet the expectations of all stakeholders; Promote the due establishment between quality, scope, time and cost. This latest award is the need to balance three conflicting factors (time, cost and scope or quality) factor being the remainder, the consequence of balance. Therefore, if there is time, cost and scope, the consequence will be the quality of the project. Another turn, if there is time, cost and quality, the consequence will be the scope of the project.

This way, the project management includes the balancing of conflicting restrictions the project that include, among others: scope, quality, schedule, budget, resources and risk.

The relationship between these factors is that if any of them change, at least one of the other will probably be amended, in what is called Theory of triple restriction [22].

Successful Projects are those that deliver the product or service specified within the scope, time, and budget and with qualities and this is precisely what is expected of the committees' organizers of the 2016 Olympics.

The professional project management is essential for doing the right thing (effectiveness) in the right way (efficiency) seeking the effectiveness by means of a strategic planning, i.e. by a process of mobilization to achieve success through a proactive behavior [23], considering the current environment and future aiming to: Produce all deliveries planned; Complete within the timeframe planned; Run within the approved budget; Deliver according to all functional specifications, performance and quality; Meet all of the goals, objectives and goals; Achieve all stakeholder expectations.

In this context of project management of mega-events and for its success, it is therefore essential to define a model of project efficiency and sustainability for the success of the event, including also awareness for the future of the country [24]. Those proactive behaviors must be integrated into the earliest stages of the Games' conceptualization and planning, being part of a strong governance based on principles of sustainable development.

4 Methodology

The methodological approach of the research was quantitative and also qualitative. The qualitative techniques to collect and analyze data was content analysis from the literature review of papers on project management and also Olympic Games. The search of articles was based on the keywords "project management", “Olympics Sustainability” and "Olympic Games” and the period being considered was between 1996 and 2015. And also an interview with a project Manager of the 2016 Olympic Games Committee in order to understand the models of project management used and the process of planning and execution of this sportive mega event.
For the quantitative analysis it was conceived a questionnaire based on the theoretical framework with 36 questions. All questions, or statements, are assumed to have the same weight. A scale of six choices, ranging from ‘‘disagree completely’’ (1) to ‘‘agree completely’’ (6), was adopted to measure the responses. The informants represent both small and large companies, based in different locations, and from a wide range of industries working for the sports mega event Olympic Games 2016.

5 Results and discussions

With the constant search for techniques of project management, the 2016 Olympic Games organization has matured the use of the procedures indicated by PMBOK© Guide (A Guide to the Project Management Body of Knowledge). The large investments in infrastructure, technology and energy, leads the construction companies and the service providers to invest heavily to put in practice the Framework of PMI (Project Management Institute) that helps to conceive and to manage the Olympic Games mega projects [25].

Since the conception of the idea of the Olympic Games project to its execution, there is usually a time frame of several years during which the planning needs to be undertaken and thus planning becomes even more important due to the potential risks associated with the external and macro factors.

The objectives of project management are to enable the project to be able to achieve its desired objectives and cost [26]. Project management in case of mega events such as the Olympic Games also needs to ensure that the project is also able to create a long-standing reputation for the host nation to be able to organize events of such scale to enable the country to pitch for such events in future as well [27]. To ensure that all stages of the project are successful it began with several phases and procedures. The following table (1) shows the phases, the respective activities, the sponsor and the schedule of each phase:

Table 1. Olympic Games Phases.

Phases	Activity	Sponsor	Time
Initiation	The countries interested in hosting the Olympics applies for.	IOC	9 years before the games.
	Announcement of the winner	IOC	Seven years before the Olympic Games
Planning	Develop venues project plan	OCOG	From winner announcement to implementation starts
Implementation	Implement venues project plan	OCOG	Vary by venue (legacy or temporary), at least 6 months
Games Time	Starts games operation	OCOG	From Olympic Athletes Village opening
Monitoring and Controlling	Track venues projects	OCOG Central Planning and IOC	From planning to Closing
Closing	Decommission venues	OCOG	One week after games time operation finishes. Four weeks of duration, in general

For the Olympic Games to become an example of sustainability, they must be integrated early into long-term urban and regional policies based on principles of sustainable development [28]; [29]. This dimension need to be considered when defining a project management model for this kind of mega-events.

5.1 Project Management Model Proposal

The project management maturity model, as the framework and tool to evaluate the level of organizational project management capability [30]. The maturity stages of the model proposal of this research includes three dimensions. The first stage or level, is Technical Project Management. At this level project managers concentrates on the resources and tasks [31] and all the techniques they can use to plan, implement and monitorize the project work packages.

The next stage is the Project Governance Model consisting in managing the internal team efforts in order to achieve predefined project goals with predetermined constraints to time and resources of all kind [32], namely, financial, equipment´s, technology and others.

At the third stage is the Project Sustainability Model consisting in the integration of a set of projects considering a long-term strategy. Sustainable development principles must be integrated into all phases of the projects

conceptualization, feasibility, bidding, strategic and operational planning, operations and dissolution [33]. At this level the managerial approach must be wider, and include a balanced view on how to distribute scarce resources between competing desires.

The research hypothesizes that an organisation in general is less capable on its first stage than in the final stage of the model. An organisation should be more capable on Project Governance than Technical Project Management. Further it should be more capable on Project Sustainability than in Project Governance.

Table 2 Maturity Stages of a Project for Sports Mega Events

Project maturity stages					
	Mean	S.D.	Minimum	Maximum	Cronbach Alpha
Technical Project Management	4.31	0.78	2.35	5.76	0.8763
Project Governance Model	3.64	0.93	1.59	5.87	0.8871
Project Sustainability Model	3.85	0.91	1.45	5.55	0.8388

As showed in table 2, the three concepts of maturity levels have high internal consistency as shown by the help of Cronbach alpha. There is a very high correlation between the three concepts: all correlation coefficients are significant at the 0.01 level. However the number of observations is too low to conduct a factor analysis to identify the variables that explain the pattern of correlation.

Table 3 Dimensions of the Project Maturity Model for Sports Mega Events

Dimensions					
	Mean	S.D.	Minimum	Maximum	Cronbach alpha
Technical Project Management					
Project Management Techniques	4.17	0.91	1.76	5.68	0.6955
Risk analysis	3.75	0.96	1.00	5.69	0.6523
Responsibility	3.88	0.98	2.00	6.00	0.6432
Project Governance					
Decision Taking	4.16	1.09	1.36	6.00	0.5312
Knowledge Sharing	3.65	1.04	2.00	6.00	0.7736
Co-operation	4.11	0.77	2.00	6.00	0.5627
Project Sustainability					

Strategy	3.99	0.89	1.55	5.66	0.5566
Integrated approach	4.14	0.95	2.00	6.00	0.6278
Partnerships for sustainability	4.19	1.23	1.00	6.00	0.4955
Mitigation measures	3.80	0.95	1.50	5.68	0.7043
Sustainability monitoring and reporting tools	3.85	1.10	1.55	5.69	0.4823
Education	3.50	1.22	1.55	5.66	0.7289

Table 3 studies the different dimensions of maturity, broken down into Technical Project Management, Project Governance and Project Sustainability. We observe large differences between organisations as they are expressed through large values for standard deviations and considerable differences between minimum and maximum values. In this sense the questionnaire is able to distinguish between the situations of the different companies and might be used by an organisation to measure its own performance. Some of the concepts have a low Cronbach alpha and need to be studied using a larger sample.

7 Conclusions

This paper proposes a Project Management Model for a sports mega event like the Olympic Games 2016. It considers dimensions like the project management techniques and also strong governance and the ability to play an active part in promoting measures favoring sustainable development of the host city. This will imply changes in the nature of Olympic Games planning and efficiency using the main techniques of project management, but also incorporating sustainability principles. Applicant and bidding cities must understand the opportunities and the risks of hosting a mega event such as the Olympic Games. Hence the need to work towards maximizing the Games' benefits and minimizing their potential negative effects. The return on investment is in the long term and is certainly worth the efforts.

References

1. Ibbs, C. W., Kwak, Y. H.: Assessing project management maturity. Project Management Journal, 31, 1, 32-43 (2000).
2. Baccarini, D.: The logical framework method for defining project success. Project Management Journal, 30, 4, 25-32 (1999).
3. Yu, A.G., Fleett, P.D., Bowers, J.A.: Developing a value-centered proposal for assessing project success. International Journal of Project Management, 23, 428-436 (2005).

4. Griethuysen, P. (Van) and Hug, P.-A.: *Projet Oggi Olympic Games Global Impact. Fiches Techniques*, Lausanne: Aists, September 2001
5. Turner, J.R. & Müller, R.: The Project Manager´s Leadership Style as a Success Factor on Projects: Literature Review. Project Management journal, 36, 1, 46-61 (2005).
6. Belassi, W., Tukel, O.: A new framework for determining critical success/failure factors in project. International Journal of Project Management, 14, 3, 141-151(1996).
7. Hillson, D.: Effective Opportunity Management for Projects. New York: Marcel Decker (2003).
8. Kwak, Y. H., Ibbs, C. W.: Project management process maturity model. Journal of Management in Engineering, 18, 3, 150-155 (2002).
9. Judgev, K., Müller, R.: A Retrospective Look at our Evolving Understanding of Project Success. Project Management Journal, 36, 4, 19-31 (2005).
10. Cooke-Davies, T.: The "real" success factors on projects. International Journal of Project Management, 20, 185-190 (2002).
11. Lim, C. S., Mohamed, M. Z.: Criteria of project success: An explanatory re-examination. International Journal of Project Management, 17, 4, 243-248 (1999).
12. Dinsmore, P.C.: Winning in Business with Enterprise Project Management. New York: Amacom (1999).
13. Wateridge, J.: IT projects: A basis for success. International Journal of Project Management, 13, 3, 169-172 (1995).
14. Freeman, M., Beale, P.: Measuring Project Success. Project Management Journal, 23, 1, 817 (1992).
15. Shenhar, A. J., Levy, O., Dvir, D.: Mapping the dimensions of project success. Project Management Journal, 28, 2, 5-13 (1997).
16. Hastak M, Shaked A.: ICRAM-1: Model for international construction risk assessment. *Journal of Management Engineering* 16(1): 59-69 (2000).
17. Emery, P.: Past, present, future major sport event management practice: The practitioner perspective. *Sport management review*, 13(2), pp.158-70 (2010).
18. Roper, T., *The Sydney Olympics And Their Impact On Development*, Cities' Experiences: The Impact Of Major Events On The Development Of Large Cities, World Association Of Major Metropolises, Metropolis: 95-98 (2002).
19. Jennings, W.: *Mega-Events and Risk Colonisation Risk Management and the Olympics* (2012).
20. Flyvbjerg, B. & Stewart, A.: Olympic Proportions: Cost and Cost Overrun at the Olympics 1960-2012. (2012) [Online] Available at:

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=2238053 [Accessed 11 November 2015]
21. Holden, M., MacKenzie, J. & Van Wynsberghe, R.: Vancouver's promise of the world's first sustainable Olympic Games. Environment and planning. *Corporate Government & policy*, 26(5), p.882 (2008).
22. Cuellar, M.: *Assessing Project Success: Moving Beyond the Triple Constraint*. International Research Workshop on IT Project Management 2010. Paper 13 (2010).
23. Jennings, W.: Why costs overrun: risk, optimism and uncertainty in budgeting for the London 2012 Olympic Games. *Construction Management and Economics*, 30(6), pp.455-62 (2012).
24. Hadjichristodoulou, C. et al.: Mass gathering preparedness: the experience of the Athens 2004 Olympic and Para-Olympic Games. *Journal of environmental health*, 67(9), pp.52-57 (2005).
25. Leopkey, B. & Parent, M.: Risk management issues in large-scale sporting events: A stakeholder perspective. *European Sport Management Quarterly*, 9(2), pp.187-208 (2009).
26. Pitsis, T.S., Clegg, S.R., Marosszeky, M. & Rura-Polley, T.: Constructing the Olympic dream: a future perfect strategy of project management. *Organization Science*, 14(5), pp.574-90 (2003).
27. Liu, Y.W., Zhao, G.F. & Wang, S.Q.: Many hands, much politics, multiple risks–the case of the 2008 Beijing Olympics Stadium. *Australian Journal of Public Administration*, 69(s1), pp.S85-98 (2010).
28. Kissoudi, P.: The Athens Olympics: optimistic legacies–post-Olympic assets and the struggle for their realization. *The International Journal of the History of Sport*, 25(14): 1972-90 (2008).
29. Stamatakis, H., Gargalianos, D., Afthinos, Y. & Nassis, P.: Venue contingency planning for the Sydney 2000 Olympic Games. *Facilities*, 21(5/6), pp.115-25 (2003).
30. Turner, R.: *Handbook of Project-Based Management*. London: McGraw Hill (2009).
31. Anderson, E. S., Jessen, S. A.: Project maturity in organisations. International Journal of Project Management, 21, 457-461 (2003).
32. Kerzner, H.R. *Project management: a systems approach to planning, scheduling, and controlling*. London: John Wiley & Sons (2013).
33. Koskela, L. & Ballard, G. Should project management be based on theories of economics or production? *Building Research & Information*, 34(2), pp.154-63 (2006).

Acceptance Factors of ERP Systems

Bayona Sussy[1], Ventura Saul[1], Morales Vicente[2]

[1] Unidad de Posgrado de la Facultad de Ingenieria de Sistemas e Informática, Universidad Nacional Mayor de San Marcos,
Ciudad Universitaria - Av. Germán Amézaga s/n, Lima, Perú
[2] Facultad de Ingeniería en Sistemas, Electrónica e Industrial, Universidad Técnica de Ambato
sbayonao@hotmail.com, saul.ventura@gmail.com, jvmorales99@uta.edu.ec

Abstract. Nowadays, the ERP systems (Enterprise Resource Planning) have an important presence in most industries due to the benefits they offer, in this way, it is critical their acceptance and use by the end users. The main goal of this study is to determine the factors that influence the intention to use ERP systems, employing the model UTAUT (Unified Theory of Acceptance and Use of Technology) as a theoretical base. Also the Confirmatory Factor Analysis (CFA) with a sample of 121 end users was used to validate the proposed extended model. The results show that the intended use of ERP systems was significantly influenced by training in problem solving and adaptation to local government regulation, in that order of importance.

Keywords: ERP, adoption models, TAM, UTAUAT

1 Introduction

The phenomenon of globalization has intensified competition in the business world, so then companies must increase the quality of their processes by process integration and optimized information flow. The solutions offered to support this purpose have a common denominator: ERP Systems. These systems emerged as business solutions since the early nineties, and they offer several benefits, including efficiency, quality, productivity and profitability [1]. Thus, from the 90's, thousands of companies have been implementing ERP systems. A multi-module system that helps organizations to become more agile their business processes [2].

According to Soto-Acosta [3], ERP systems play an important role in information processing in organizations, giving more flexibility and shorter response cycles in their operations, in this way, the success of this type of projects is crucial for the company competitiveness. However, ensuring the success of projects of ERP systems

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_49

to take advantage of its benefits, requires efforts which are accompanied by technological and organizational changes, since it is expected that the business processes will be done in new ways, including how to how people do their specific work [4]. This article seeks to answer the following question: What factors can predict the levels of acceptance of ERP systems in large Peruvian companies?

This article is divided into 5 sections. Section 1 contains the introduction. Section 2 contains the literature review about ERP systems, the models of acceptance and the factors composing them. In Section 3, the research methodology is presented. Section 4 contains the analysis of the results. Finally in Section 5 the conclusions of this study are presented.

2. Literature Review

2.1 ERP Systems

In the most basic definition, according to Addo-Tenkorang et al. [5], an ERP is a business information system which integrates and controls all business processes throughout the organization. The enterprise resource planning (ERP) is a business information system that has been designed to integrate and optimize business processes and transactions in a corporation.

In the opinion of Suganthalakshmi et al. [6], an ERP is an integrated software package consisting of a standard set of functional modules (production, sales, human resources, finance, etc.) developed or integrated by the provider but able to be adapted to the specific needs of each client. The current generation of ERP systems also offers reference models or templates of processes that aim to transfer the current best practices to the business processes of the organization.

2.2 Technological Acceptance Model

Various theories and models of technology acceptance have been developed in the last 30 years by different authors. Among the most important models are: Innovation Diffusion Theory (IDT), Theory of Reasoned Action (TRA), Social Cognitive Theory (SCT), Theory of Planned Behavior (TPB), Technology Acceptance Model (TAM) , Motivational Model (MM), Technology Acceptance Model 2 (TAM2), Unified Theory of Acceptance and Use of Technology (UTAUT). The term "acceptance" in the literature does not have a single definition. Davis [7] describes the acceptance as user decision about how and when they will use a certain technology.

The acceptance of technology by users has been the subject of several previous researches. There are many models that have been used for this purpose, as the Technology Acceptance Model (TAM), versions 1, 2 and 3. TAM is up to date the reference model in the research on the acceptance or rejection of a technology by users and moreover has been the basis for creating new models that seek to explain the factors that influence acceptance levels in particular contexts. Another popular model,

the Unified Theory of Acceptance and Use of Technology (UTAUT) [8], is also one of the most used because its authors determined that offers a higher percentage of explanation of the intention and use of technologies. Even since the 2012, this model has a special version called UTAUT-2, which target is the consumer technology contexts, that is where the user must pay to use the technology. In Table 1, the list and description of acceptance models are presented.

Table 1. Models and theories of acceptance.

Model	Year	Models and Theories Description
TRA	1975	Fishbein and Ajzen [9] proposed a derivative psychology database model, which seeks to measure the behavioral intention and performance.
TAM	1989	Davis [7] proposed two factors to determine the attitude of individuals with regard to any technology, this attitude is the basis of the intention of use.
MPCU	1991	Thompson [10] proposed this model to predict the intention of use of the PC.
MM	1992	Davis [11] proposed this model derived from psychology to explain behavior, adoption and usage of the technology
TPB	1995	Taylor and Todd [12] extended TRA to include another additional variable to determine the intention and behavior.
C-TAM-TPB	1995	Taylor and Todd [13] integrated social and normative factors and for behavioral control.
IDT	1995	Rogers [14] provided a sociological approach that attempts to explain how individuals or groups adopt an innovation.
SCT	1995	Compeau [15] proposed this model applied to information systems to determine their use.
TAM2	2000	It was excluded the attitudes from the original model, incorporating other factors classified into two groups: those related to the processes of social influence and also the factors related cognitive processes.
UTAUT	2003	Venkatesh et al. [16] integrated eight models to measure the user's intention and use of technology (TRA, TPB, TAM, MM, C-TAM-TPB, MPCU, IDT, SCT).
TAM3	2008	It incorporated elements based on perceived ease of use with the aim of producing practical guidance and suggestions for the professionals.
UTAUT2	2012	UTAUT extension model to study the acceptance and use of technology in the context of consumption.

Each model consists of a set of influence factors which are responsible for the predictive power of the model. Some of these factors are repeated in more than one model and many others have been derived and / or refined to meet the different contexts of each investigation. Table 2 presents the factors related to each of the more important acceptance models.

Table 2. Factors associated with the models and theories of acceptance.

Model	Factors
TRA	Attitude, subjective norm
TAM	Perceived usefulness, perceived ease of use
TPB	Attitude, subjective norm, perceived behavioral control
IDT	Complexity, relative advantage, compatibility, visibility, testing capability
TAM2	Perceived usefulness, perceived ease of use. Subjective norm, Experience, voluntariness, Image, demonstrability of results, Relevance of work, quality of the result
UTAUT	Expectation of performance, effort expectancy, social influence, facilitating conditions
TAM3	Perceived usefulness, perceived ease of use, subjective norm, experience, voluntariness, image, demonstrability of results, relevance of work, quality of the result,
UTAUT2	Expectation of performance, effort expectancy, social influence, facilitating conditions, hedonic motivation, price, habits

2.3 Application of the Technology Acceptance Models

Next, it describes some applications for each of the more important acceptance models which are reviewed in this study.

- **Theory of Reasoned Action (TRA)**: The theory of reasoned action seeks to predict consumer intentions and behavior, thus also provides a relatively simple basis for identifying where and how to direct attempts to change consumer behavior.
- **Technology Acceptance Model (TAM)**: The TAM model has been applied in numerous studies of information technology, such as word processing, spreadsheet applications, email, web browsers, web sites, etc.
- **Theory of Planned Behavior (TPB)**: Recently, several studies found that TPB help to better predict behavioral intention related to the health than TRA model, Given That the TPB has improved the predictability of intent in various fields related to health, Such as condom use, leisure, exercise and diet.
- **Innovation Diffusion Theory (IDT)**: A literature review conducted by Nor [17] indicates that the applications for IDT model have been mixed. For example, IDT was used in the development of tool, used as part of research and comparative studies with other theories, such as TAM.
- **Technology Acceptance Model 2 (TAM2)**: Like its predecessor, TAM2 is useful to measure the levels of intent and use of new information technologies, in any context either individually or in groups, personal or corporate.
- **The Unified Theory of Acceptance and Use of Technology (UTAUT)**: Several researchers use UTAUT theory to study the process of acceptance of innovation by the users. Its power predictive about the use of technology is up to 70%, a much higher rate than other technology acceptance models [8].
- **Technology Acceptance Model 3 (TAM3)**: TAM3 is useful in explaining the differences between relationships and behaviors of the factors in the pre and post implementation stages of some technologies.

- **The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2)**: The UTAUT 2 model is useful in the context of use of consumer technologies such as e-learning, telephony, internet, etc.

3 Research Methodology

This research applies a model variant of the Unified Theory of Acceptance and Use of Technology (UTAUT) to explore the factors that determine the use of ERP systems. Using an online survey, 121 ERP system users were respondents. The purpose of the study is to verify if the results of the study clearly show that the factors: government regulation, data quality and problem solving training, play a key role in the intended use of ERP systems. The chosen model is the Unified Theory of Acceptance of Technology (UTAUT), based on the following:

- Due to be the technology acceptance model that offers greater explanation in an organizational context.
- Another argument for supporting our choice of model UTAUT, is due to the results of the investigation of Williams [18], who found that a significant number of studies in recent years, 450 studies, refer to the theoretical model, but only 10% of them, have used in the practical field, this fact representing an opportunity to explore their empirical use.

Finally, the UTAUT model contains factors which are the result of reviewing multiple theories and previous models that were developed in research of different areas of knowledge. Since its publication, the 2003, it has been the baseline model for studies of various technologies with positive results [16].

Basically there are two types of users who were part of the survey process, these are:

- Experts (specialists): This group includes employees who have leadership roles, functional leaders and were also key project implementation members for the ERP system.
- End users: participants in the projects of organizations that have implemented or are implementing ERP systems.

Table 3 presents a general description that provides a demographic overview of the respondents who participated in this study in terms of gender, age, education and experience.

The survey was developed through a website format, with a questionnaire consisting of 20 questions of the following types: single answers, multiple answers, rating scale (Likert scale) and demographic questions. It was sent in groups and individually to a number of people on the basis of the given sample in the quantitative study.

Table 3. Demographic information.

Variable		Frequency	Percentage
Gender	Male	74	61%
	Female	47	39%
Age	Less than 30	38	31%
	31-40	70	58%
	41-50	11	9%
	51-60	2	2%
	More than 60	0	0%
Education	Technical	22	18%
	Graduate	28	23%
	Master	71	59%
Experience	Less than 1 year	16	13%
	1 to 2 years	29	24%
	3 to 5 years	47	39%
	More than 5 years	29	24%

The goal is validate the assumptions based on the gotten results. The Likert scale which was used is: 5 Strongly Agree, 4 Agree 3 Neither agree nor disagree, 2 Disagree, 1 Strongly Disagree. In addition to the standard baseline model variables, new variables were used in order to extend the model: government regulation, quality of data and training in problem solving.

The indicators for each factor are a set of questions that capture the respondents' opinion on the influence of each factor on the dependent variable: Usage Intention.

The questions related to Government Regulation were:

- RG1: The system has the necessary local adaptation.
- RG2: I have the necessary knowledge of aspects of legislation and safety regulations for using the system.
- RG3: The adaptation of the system in regulatory terms is supported by a group of people against difficulties.
- RG4: The adaptation of the system in regulatory terms is not compatible with other systems that I use.

The questions related to Quality of Data were:

- CD1: The current data is the expected in order to use the system correctly.
- CD2: I have the necessary knowledge of the situation of the initial data.
- CD3: The quality of the initial data is supported by a group of people against difficulties.
- CD4: The quality of the initial data is not compatible with other systems that I use.

The questions related to Training in Problem Solving were:

- ER1: My training helps me to use the system.
- ER2, I have the necessary knowledge to solve the problems of the system.
- ER3: The features of the ERP system help me to solve their problems easily.
- ER4: The procedure for solving problems is supported by a group of people against difficulties.

- ER5: The procedure for solving problems is not compatible with other systems that I use.

The questions related to the dependent variable: Usage Intention, were:

- IU1: I intend to continue using the ERP system in the future.
- IU2: I plan to continue the frequent use of the ERP system.
- IU3: I intend to increase my use of the ERP system in the future.
- IU4: I would recommend to my colleagues to use the ERP system.

The population is made up of large companies in Peru within their different productive sectors or economic activities. The universe of these productive sectors on which companies will be chosen is based on the fourth revision of the International Standard Industrial Classification (ISIC), adopted in Peru under Resolution No. 024-2010-INEI 29 January 2010.

4. Analysis and Results

In this study the focus of structural equations (SEM) of data through the SPSS and SPSS Amos tools for data processing is used. The results of the Confirmatory Factor Analysis (CFA) in its third iteration, Table 4, shows that all the loads of the indicators for each factor exceeds the value of 0.6 and the mean variance of each factor is equal to or greater than 0.5, minimum criteria to use this type of approach in order to validate a model.

As part of the final model, they remained two of the three factors proposed as part of the baseline model; these are Government Regulation and the Training in Problem Solving.

Table 4. Confirmatory Factor Analysis 3.

Factors	Observed Variables	CFA 3		
		Factor Loading *	Loading Squared	AVE
Government Regulation (RG)	RG4	0.79	0.63	0.6
	RG3	0.72	0.52	-
	RG2	-	-	-
	RG1	-	-	-
Quality of Data (CD)	-	-	-	-
Training in Solving Problem (RP)	RP5	-	-	0.5
Usage Intention (BI)	BI4	0.81	0.65	0.6
	BI3	0.72	0.51	-
	BI2	0.67	0.45	-
	BI1	0.82	0.67	-

4.1 Government Regulation

To over 80% of respondents, it is important to have a specialized support to facilitate the adaptation of the system and the corresponding adoption by users (see Fig. 1). 74% of the respondents also consider that the adaptation of the system to local regulation should be aligned to other systems to facilitate the integration thereof (see Fig. 2)

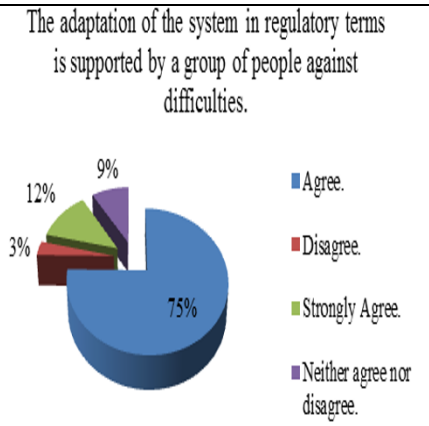


Fig. 1. Specialized Support

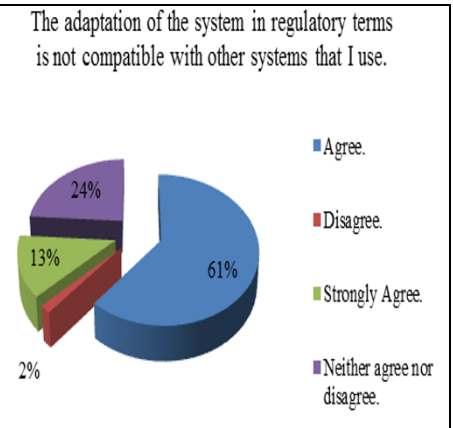


Fig. 2. Compatibility with other systems of the organization

4.2 Quality of Data

This factor was part of the model until its second iteration, where the main indicator was the importance of the audit to the Data Quality for users of ERP systems, agreeing 77% (see Fig. 3)

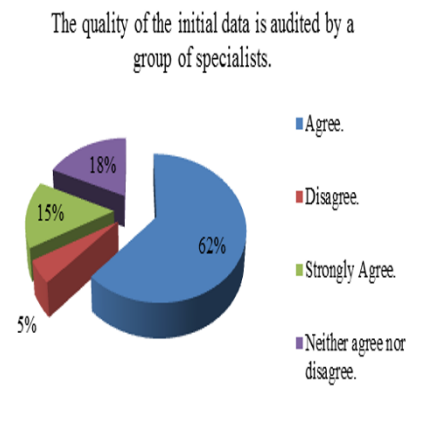


Fig. 3. Audit of the quality of data

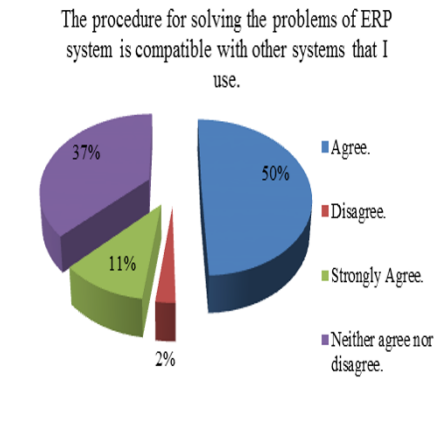


Fig. 4. Training helps you use the system

4.3 Training in Solving Problem

This factor also proved to have a direct and positive influence on the intention to use ERP systems. One of the questions was about the procedure to follow to resolve the problems, agreeing 61% of respondents that there must be compatibility with existing systems procedures (See Fig. 4).

4.4 Usage Intention

When he asked if he intended to continue using the ERP system, 73% of the people answered agree, 24% strongly agree, while 2% were neutral and only 1% disagreed (See Fig. 5).

When the users were asked if they had plans to continue the frequent use of the ERP system, 75% answer agree, 22% strongly agree, while 2% were neutral and only 1% disagreed (See Fig. 6).

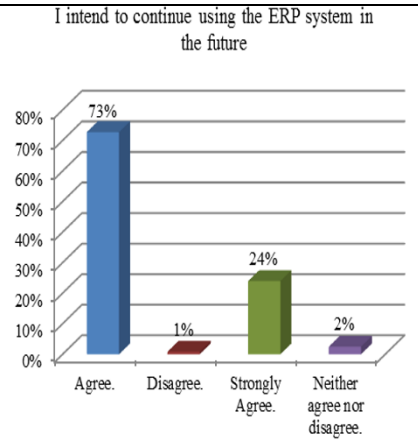


Fig. 5. Continue the use of the ERP system

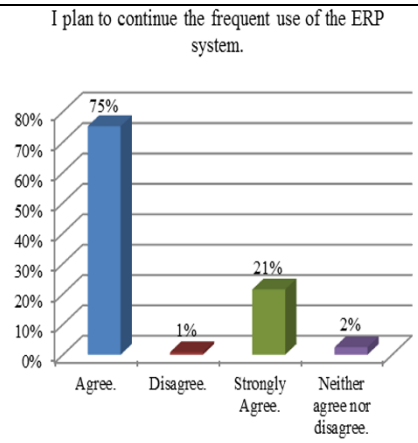


Fig. 6. Plans to continue frequent use of the ERP system

When the users were asked if they would recommend using the system to their colleagues, 79% answered agree, 14% strongly agree, while 5% were neutral and only 1% disagreed (see Fig.7).

When the users were asked if they intended to increase the use of the ERP system in the future, 69% answered agree, 26% strongly agree, while 3% were neutral and only 1% disagreed (see Fig. 8).

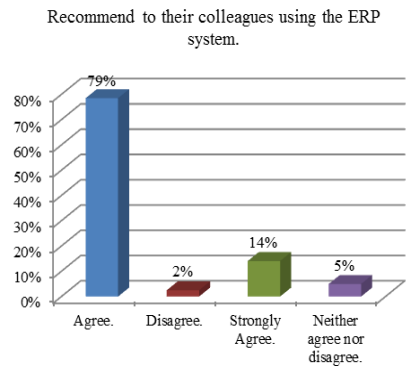


Fig. 7. Recommend to their colleagues using the ERP system

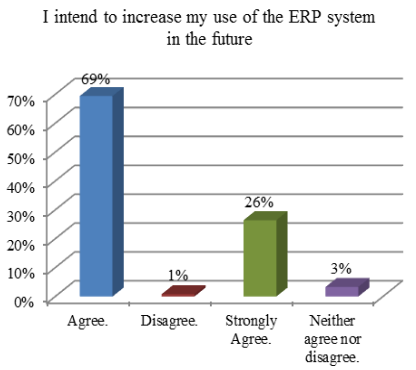


Fig. 8. Increase the use in the future

5. Conclusions

Evaluation studies of user acceptance towards new technologies facilitate the understanding of the factors that influence the intention to use these technologies in business. In this way this understanding becomes a key element to ensure the successful of the implementation projects. Large amounts of money are invested to deploy these technologies in businesses and their returns of investment, largely, are defined by the levels of acceptance of end users, so it is important to plan and implement actions to influence the attitude of the Users in order to promote effective use of these technologies.

The results of the study clearly showed that the factors: government regulation and training in problem solving play a key role in the usage intention of ERP systems. For that reason, government regulation must be regarded as a critical factor in implementation projects of ERP systems in large Peruvian companies, especially due to the ERP systems which are selected for those companies came from the overseas. Additionally, these kind of large companies in their capacity as major contributors are rigorously more audited in terms of taxation, internal control and security, according to the local regulations. Training in problem solving, is a special type of training which should be most widespread in implementation projects of ERP systems, in order to achieve autonomy and improve the performance of end users with this technology since the beginning of his operation. This is important because it increases the user's trust towards the benefits of the system and consequently reduces their resistance to change.

References

1. Gore, A.: Exploring the competitive advantage through ERP systems: From implementation to applications in agile networks, Oulu, Finland: University of Oulu. (2008)

2. Yulung, L.: ERP adoption in Chinese small enterprise: an exploratory case study, Journal of Manufacturing Technology Management 22(4), pp. 489 --505 (2011)
3. Soto-Acosta, P., Ramayah, T., Popa, S.: Explaining intention to use an enterprise resource planning system: A replication and extension, Technical Gazette, 20(3), pp. 397--405 (2013)
4. Rittik, G.: A Comprehensive Study on ERP Failures Stressing on Reluctance to Change as a Cause of Failure, Journal of Marketing and Management, 3(1), pp. 123--134 (2012)
5. Addo-Tenkorang, R., Helo, P.: Enterprise Resource Planning (ERP): A Review Literature Report, World Congress on Engineering and Computer Science, 2, pp. 1--9 (2011)
6. Suganthalakshmi, T., Muthuvelautham, C.: Grouping of Critical Success Factors for ERP Implementations, International Journal of Management, 2, pp.125—133 (2011)
7. Davis, F. D., Bagozzi, R. P., Warshaw, P. R.: User Acceptance of Computer Technology: A Comparison of Two Theoretical Models. Management Science, 35(8), pp. 982--1003 (1989)
8. Venkatesh, V., Morris, M. G., Davis, F. D., y Davis, G. B.: User Acceptance of Information Technology: Toward a Unified View. MIS Quarterly, 27, pp. 425--478 (2003)
9. Fishbein, M., Ajzen, I.: Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research, MA, USA: Addison-Wesley (1975)
10. Thompson, R. L., Higgins, C. A., Howell, J. M.: Personal Computing: Toward ad Conceptual Model of Utilization. MIS Quarterly, 15(1) pp. 125--143 (1991)
11. Davis, F. D., Bagozzi, R. P. Warshaw, P. R.: Extrinsic and Intrinsic Motivation to Use Computers in the Workplace. Journal of Applied Social Psychology, 22(14), pp. 1111--1132 (1992)
12. Taylor, S., Todd, P. A.: Understanding information technology usage: a test of competing models. Information Systems Research, 6(2) pp. 144--76 (1995)
13. Taylor, S., Todd, P. A.: Assessing IT usage: the role of prior experience. The role of prior experience. MIS Quarterly, 19(4) pp. 561--570 (1995)
14. Rogers, E.M.: The diffusion of innovations, New York: New York Free Press (1995).
15. Compeau, D. R., Higgins, C. A.: Computer self-efficacy: Development of a measure and initial test. MIS Quarterly, 19(2) pp.189--211 (1995)
16. Venkatesh, V., Thong, J. Y. L., Xu, X.: Consumer acceptance and Use of information technology: extending the unified theory of acceptance and Use of technology. MIS Quarterly, 36(1) pp. 157--178 (2012)
17. Nor, K., Pearson, J., Ahmad, A.: Adoption of internet banking: theory of the diffusion of innovation. International Journal of Management Studies, 17(1) pp. 69--85 (2010)
18. Williams, M., Rana, N., Dwivedi, Y., Lal, B.: Is UTAUT Really Used or Just Cited for the Sake of It? A Systematic Review of Citations of Utaut's Originating Article, European Conference of Information Systems, pp. 1--13 (2011)

IT as a Driver for New Business

Maria José Sousa
Universidade Europeia
Plataforma para o Crescimento Sustentável
Instituto Universitário de Lisboa
Estrada da Correia, 53 – 1500 – 210 Lisboa
PORTUGAL
maria-jose.sousa@europeia.pt

Abstract. This research focuses on the role of Information Technologies (IT) as a driver for creating new business. The research question is "What are the key businesses that are emerging due to IT?" The research was supported on a qualitative methodology through documental analysis and semi-structured interviews to IT Managers of organizations which represents the main economic sectors. The technologies under analysis were Internet of Things, Cloud Technology, Big Data, Mobile Technologies, and Artificial Intelligence and Robotics. A main result of this research was the new disruptive business that are emerging from the impact of this technologies on the markets.

Keywords: IT, New Business, IOT, Cloud, Big Data, Mobile Technologies, Artificial Intelligence, Robotics

1 Introduction

Creating a theoretical framework that helped preparing and understanding the work in the field about the role of Information Technologies (IT) as a driver for creating new business was the first goal of this research.

The Internet, mobile technologies, artificial intelligence, big data, robotics, nanotechnology, and other disruptive technological phenomena are potentially causing profound changes in organizations and society [1].

The Internet has changed the music industry, tourism, trade and services and the digital assumed a huge importance in all economic activities. Emerged new services such as e-tourism, e-health, e-marketing, and digital learning, among others.

The artificial intelligence is changing the industry, especially in areas that require close collaboration between people and computers. The Big Data is changing the way we organize, access, select, visualize and use information. Robotics has introduced major changes, mainly in the automotive industry,

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_50

aeronautics and also health. Nanotechnology is changing the computer industry, the energy industry and the health industry.

These advanced technologies are assumed to be drives of change and have a great impact on the economy through the creation of new business [2] [3].

The article briefly explores the new information technologies, followed by the presentation of the methodology and the research findings. The article concludes with emergent business which are being developed through the massive use of IT.

2 Emerging IT in the Era of Digital

The introduction of digital products, services, channels, and interfaces emerges from the knowledge sharing processes in organizations and digital technology are transforming all kind of industries [4].

The definition of *digital* differs in terms of types of digital technologies: *Internal technologies* include analytics, search engine optimization, competitive intelligence, and social media monitoring; and *External technologies* consist of the platforms used to reach customers and deliver content—website, ads, landing pages, e-mail campaigns, and apps of all kinds [5], [6], [7].

In resume, companies are adding digital offerings such as analytics, mobility, social media, and smart-embedded devices into their core businesses [7].

Digital technology, and particularly its manifestation as big data analytics, will become a fifth strategic dimension needing to be accounted for in many companies. More and more firms will need to find a way to integrate this capability into their existing business models. Digital technologies can be used to create user and consumer communities, provide brand building and e-commerce channels [8].

On the other hand, organizations need to define its digital vision and leaders must translate that vision into a set of targets that drive to success. Even if the digital function is not measured as a business, it should have clear performance indicators that create accountability and serve as guideposts of progress.

Thus, the main technologies analyzed in this research are the following:

1. Internet of Things (IoT)
   During the past few years, the Internet revolution has redefined the business-to-consumer (B2C) industries, such as the communications industry, trade and financial services [9], [10]. Focusing on the Internet of Things it's possible to state that is a network of systems, equipment and

devices capable of acquiring and processing information that can be shared using the internet communication protocol [10]. In the coming years, the Internet of Things will change the manufacturing, energy, agriculture, transport and other industrial sectors [11]. These technological implications will lead to new business opportunities [12], [13], [14], [15], [16] along with new risks, for companies and for society, as it combines the global reach of the Internet with the ability to control the physical world, including machines and plants [9]. It will also radically transform work processes due to new interactions between people and machines [3].

2. Cloud Technology:
   Is a model of technology and Internet-based services in real time or on-demand. According to the National Institute of Standards and Technology (USA) cloud computing is a model that allows access to the ubiquitous network upon request from a shared pool of configurable resources (eg, networks, servers, storage, applications and services) that can be rapidly provisioned and released with minimal management effort or interaction with the service provider [17]. The concept involves use, anywhere and platform independent applications through the Internet without being installed on personal computers or organizations. Application providers develop, store, perform maintenance, update, backup and scaling, which allows a reduction of costs through new business models [18]. The concept of cloud computing includes among others the concept of Software as a Service (SaaS), there is no need to purchase software license usage, being paid a value for the resources used and / or by the use of time. The Cloud services further include Platform as a Service (PaaS), for example, an application framework and Infrastructure as a Service (IaaS) provides technical infrastructure components such as storage, CPU, memory, and network [17].

3. Big Data:
   This is a new phenomenon associated with increased volume of data [19] as a result of the Internet, social networks and mobile devices. The potential value of this data has led to the development of new management techniques and analysis of large data sets such as images, text or speech. Skills such as data analysis, data selection, data security is of great relevance to all employees of an organization [20]. This technology allows you to capture and interpret data, in order to enable companies to have access to details of their operations, in order to make strategic decisions, including intelligence on solutions based on analysis of large volumes of data with the following characteristics: volume of

data to be analyzed; variety of data which result in different information for the same operation [21]. Speed, veracity and value of the data.

4. Mobile Technologies:
   Include mobile communications devices and applications that are integrated and that allow multiple uses and collaboration. Mobile technologies bring new business models for companies and offer opportunities for growth and new working methods [22]. There are innumerable possibilities of using mobile devices as they allow access to information in real time [23]. Examples of these technologies include: laptops or notebooks, palmtops or PDAs, smartphones, GPS devices (global positioning system). These mobile devices allow you to perform a set of activity, increasingly important for businesses and for the individual as they allow to send high-definition photos, videos, PowerPoint presentations and messages, allow also make information updates, make payments, consult balances and statements, manage the contact list and calendar. Access and send e-mails quickly and practice and allow access to information anywhere, anytime. Allow also to be trained from mobile devices (m-learning).

5. Artificial Intelligence:
   Is the development of computer systems able to perform tasks that normally require human intelligence? This technology has numerous applications in industry [22]. Human tasks can be defined in a tight and computers form may mimic this, the AI currently being applied in different situations, such as games, software, security systems, robotics, to writing recognition devices and voice, medical diagnosis and telecommunications programs [24]. There is also the application of Artificial Intelligence to Business Intelligence processes, through the processing of dynamically calculated indicators.

6. Robotics:
   Integrates technologies that automate systems and have very small, high-performance sensors. The new generation of robots work alongside the people and flexibly perform many tasks in unpredictable environments [22]. Examples include unmanned aerial vehicles, vacuum cleaners, as well as consumer products such as toys and equipment for the home. Robots are still limited to the factory assembly lines and other controlled tasks, but a new era of robotics is emerging and will allow its use through GPS technology, like smartphones, in other precision activities [22].

The analysis of this technology helped to identify potential new business [4], [5], [6], [7], [8] which were explored with the people interviewed during the empirical research process.

3 Research Methodology

The methodological approach of the research was qualitative and the main technique to collect and analyze data was content analysis from the literature review of papers on emergent technologies and also new business. The search of articles about the new technologies emerging to the markets was based on the keywords "emergent technologies" and the period being considered was between 2010 and 2015.

It was found 19,128 papers on ScienceDirect database and the search was restricted to the domain of information science resulting in 69 papers about emergent technologies analyzed individually and only 2% of the papers analyzes more than one of the technologies on discussion in this paper. The Wordstat software for content analysis to extract and analyse the article's title, abstract and keywords was used to extract expressions. As a result, up to 162 expressions were identified. Meaningless expressions were excluded while the rest were retained and grouped thematically. It was possible to identify more than 70 expressions considered valuable as presented in table 1:

Table 1 - Emergent Technologies

descriptor	Content
Internet of Things	Internet; network of systems; internet communication protocol; industrial sectors; new business; physical world; interactions between people and machines.
Cloud Technology	On-demand; cloud computing; ubiquitous network; service provider; platform independent applications; Internet; Application providers; Software as a Service; Platform as a Service; Infrastructure as a Service.
Big Data	Volume of data; Internet; social networks; mobile devices; analysis of large data sets; data analysis; data selection; data security; intelligence; variety of data; speed; value of the data.
Mobile Technologies	Mobile communications devices; Mobile applications; Mobile technologies; new business models; new working methods; mobile devices; information in real

descriptor	Content
	time; smartphones; GPS; access to information anywhere, anytime; m-learning.
Artificial Intelligence	Computer systems; Human intelligence; applications in industry; cybernetics; games; security systems; robotics; writing recognition devices; voice recognition devices; medical diagnosis; telecommunications programs; Business Intelligence; dynamically calculated indicators.
Robotics	Automate systems; high-performance sensors; robots; unpredictable environments; unmanned aerial vehicles; vacuum cleaners; consumer products; factory assembly lines; controlled tasks; robotics; GPS technology; smartphones; precision activities.

This expressions associated to the six emergent technologies helped to create the semi-structured interview. The interviews were realized with IT Managers from seven organizations in order to understand the new technologies that were emerging and the new business arising from the technological innovation market.

The sample of this study relied on available subjects, who were easily accessible [25]. The main criteria for selecting the subjects were that they must be IT Managers. All the participants took part in this research on a voluntary basis.

The procedures of content analysis dealt with single interview transcripts by the following (adapted to the context) steps [26]:

(1) Review the interview transcripts thoroughly and find the key themes and patterns.
(2) Produce labels for these key themes.
(3) Revise the labels to be the systematic categories, which match the literature.
(4) Sort the interview transcripts into the systematic categories.
(5) Find the links among the categories for the individual interviews.
(6) Examine the differences and similarities of the data for each category.
(7) Integrate the links of the categories among the seven subjects.

This process helped to identify disruptive opportunities for new business that emerged from new technologies arising to the markets.

4 Findings from the research

In the analysis of the interviews it was identified and explored the disruptive opportunities for new business according to the technologies identified in the literature.

1. Internet of Things

Create new products and services: IoT will help to create and distribute new products and services at an unprecedented rate and scale. Create and destroy industries: IoT brings new opportunities for generating new economic opportunities and industries. IoT allows to define and create new digital processes, new infrastructure to manage the huge amount of data that needs to be treated. It will transform the way work is done: the IoT will lead to the redefinition of new types of jobs to be created and will reshape the nature of the work.

2. Cloud Technology

Potential to change the way of provisioning IT services within large companies. Use of hardware features and software delivered computers over a network or the Internet, as a service. The concept of Cloud Computing offers the flexibility and speed of execution to allow companies increase agility and respond faster to changes in the market. Resources are massively scalable over the Internet. Cloud is an infrastructure that can enhance the markets and makes them more competitive.

3. Big Data

The IT industry will have several disruptive opportunities because of Big Data for most of the software and hardware in order to store and manage large amounts of data. Short-term opportunity lies in operational efficiency and productivity. In the long run, there will be new business models around pay-per-use services. Vertical industry segments will emerge through shared relationships with customers and partners.

4. Mobile Technologies

It can be applied to various organizations and also to the market itself, in terms of purchasing, logistics, distribution, service, sales and maintenance. Business models based on App Stores allows easy access to personalized information on mobile devices anytime and anywhere. 3D screens for smartphones and tablets will drive large-scale use of 3D products. This trend is starting through portable game applications because of the increasing amounts of data. It can be applied to data simulations with 3D application for military purposes, medicine, fashion, architecture, and entertainment, among others.

7. Artificial Intelligence and Robotics

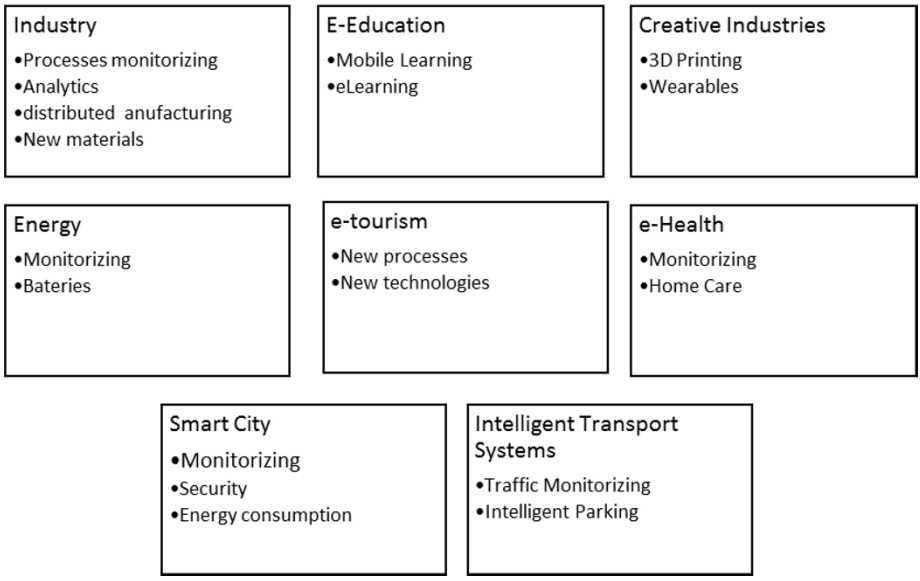
The latest generation of robotics by applying AI systems achieves significant advances in productivity and improving performance. For example, the automation of the cars, which allows them to be self-directed, could lead to reducing the number of accidents, avoid human error and lapses in concentration, among others. Robots have faster access to information and store large amounts of data.

In medicine can be used to perform high-precision operations, as they are able to respond without emotions, and can also aid in the diagnosis of diseases, as they can analyze an enormous amount of data in real time.

These technologies are changing the way markets and organizations work. The possibility of workers bring their own technological device to work (BYOD), leads to structural changes in work organization.

Accordingly, new business are emerging associated to new clusters like e-education, energy, e-tourism, e-health, creative industries, smart cities and intelligent transport systems, as showed in Figure 1.

Figure 1. New Business



The focus of the clusters should be in coordination between the various existing economic activities, establishing symbiotic relationships of growth.

Innovation favors a growth oriented to the market and more sustainable by creating opportunities to expand these activities in new ways, with new joints and greater economic and financial sustainability.

The different clusters have activities which may have a multiplier effect on other clusters, acting as a "broad-spectrum technologies" which encourages innovation and differentiation increasingly important in the construction of competitive advantages.

5 Conclusions

This paper identifies the main technologies that are emerging in the market and their impact on the creation of new businesses. Emergent technologies create opportunities for innovation, leading to many changes. For example, the Cloud computing has generated a disruption through innovation in business models. Furthermore, they originate new ways of doing business, such as Internet solutions of Things which will provide integrated business process solutions.

Organizations tend to develop new skills, strengthening its competitive position by adopting technologies such as, Internet of Things, Cloud Computing, Mobile Technologies, Big Data Artificial Intelligence and Robotics.

Technology drives new business models, but it is important to develop the human capital of the organizations and prepare them for the new market challenges.

References

1. Brem, A. and Voigt, K.-I.: *Integration of market-pull and technology-push in the corporate front end and innovation management — insights from the German software industry*. Technovation, 29: 351–367 (2009).
2. Dedrick, J.; Kraemer, K.L. and Seever, P.: *Global market potential for information technology products and services*. Globalization of I.T (2007).
3. Porter, M. and Heppelman, J.: How Smart, Connected Products are Transforming Competition, *Harvard Business Review* (2014)
4. Routley, M.; Phaal, R. and Prober, D. Exploring industry dynamics and interactions. *Technol. Forecast. Soc. Chang*., 80: 1147–1161 (2013).

5. Timmers, P.: Business Models for Electronic Markets. *Electronic Markets*, 8, 3-8 (1998).
6. R. Phaal, C.J.P. Farrukh, D.R. Probert. Technology roadmapping — a planning framework for evolution and revolution *Technol. Forecast. Soc. Chang*., 71: 5–26 (2004).
7. Routley, M., Phaal, R., Probert, D.: Exploring industry dynamics and interactions. *Technol. Forecast. Soc. Chang*. 80, 1147–1161 (2013).
8. Haegeman, K., Marinelli, E., Scapolo, F., Ricci, A., Sokolov, A.: Quantitative and qualitative approaches in future-oriented technology analysis (FTA): from combination to integration? *Technol. Forecast. Soc. Chang*. 80, 386–397 (2013).
9. Maló, P., et al.: *Deliverable D3.1b Roadmaps for IoT Deployments*, FP7-288315 PROBE-IT. Pursuing Roadmaps and Benchmarks for the Internet of Things (2013).
10. Guinard, D., Trifa, V., Mattern, F. and Wilde, E. From the Internet of Things to the Web of Things: Resource-Oriented Architecture and Best Practices. *Architecting the Internet of Things*, 97-129. (2011)
11. Gluhak, A., Krco, S., Nati, M., Pfisterer, D., Mitton, N. and Razafindralambo, T.: A Survey on Facilities for Experimental Internet of Things Research. *IEEE Communications Magazine*, 49: 58-67 (2011).
12. Chui, M.; Löffler, M., and Roberts, R.: *The Internet of Things*, McKinsey Quarterly (2010).
13. Bucherer, E., & Uckelmann, D.: *Business models for the Internet of Things. In Architecting the Internet of Things*. Berlin-Heidelberg, Germany: Springer (2011).
14. Fan, P. F., & Zhou, G. Z.: *Analysis of the business model innovation of the technology of internet of things in postal logistics*. In Proceedings of industrial engineering and engineering management. 532-536: IEEE Press (2011).
15. Hui, G.: How the internet of things changes business models. *Harvard Business Review* (2014).
16. Sun, Y., Yan, H., Lu, C., Bie, R., & Thomas, P.: A holistic approach to visualizing business models for the internet of things. *Communications in Mobile Computing*, 1(1), 1–7 (2012).
17. Chard, K.; Caton, S.; Rana, O. and Bubendorfer, K.: *Social cloud: cloud computing in social networks*, in: Proceedings of the 3rd International Conference on Cloud Computing IEEE Cloud, (2010).

18. Osunmakinde, I.; Ramharuk, V.: Development of a Survivable Cloud Multi-robot Framework for Heterogeneous Environments. *International Journal Advanced Robotic Systems*, vol. 11: 164 (2014).

19. McAfee, A., & Brynjolfsson, E.: Big data: The management revolution. *Harvard Business Review*, 60, 60–66 (2012).

20. Chen, H., Chiang, R., and Storey, V.: Business Intelligence and Analytics: From Big Data to Big Impact, *MIS Quarterly* (36:4), pp. 1165-1188 (2012).

21. Taylor, B.: *Data science in human capital research and analytics*. Symposium presented at the 30th Annual Conference of the Society for Industrial and Organizational Psychology, Philadelphia, PA (2015).

22. Brynjolfsson, E. and McAfee, A. *The Second Machine Age: Work Progress, and Prosperity in a Time of Brilliant Technologies*. W.W. Norton & Company, New York, (2014).

23. Bhalla, M. and Bhalla A.: Generations of Mobile Wireless Technology: A Survey. *International Journal of Computer Applications*, Volume 5-No.4, (2010)

24. Bostrum, N. *Superintelligence: Paths, Dangers, Strategies*. Oxford University Press, (2014).

25. Zikmund, W. G.: *Business Research Methods* (6th edition). USA: Harcourt, (2000).

26. Berg, Bruce L.: *Qualitative research methods for the social sciences* (5th ed). Pearson, Boston, MA, (2004).

Improving the success of IS/IT projects in Healthcare: Benefits and Project Management approaches

Jorge Gomes, Mário Romão

ISEG, Rua Miguel Lupi, 20
1200-781 Lisboa, Portugal
{jorge.gomes@phd.iseg.ulisboa.pt; mario.romao@iseg.ulisboa.pt}

Abstract. Rapid changes in the business environment are increasing the pressure on organisations to ensure the delivery of successful projects to fulfil their strategic goals. The use of emerging information systems and technology (IS/IT) has rapidly grown in several contexts, including healthcare. There have been two major drivers for the investments in Health IS/IT: the ever-increasing burden from chronic disease with costs growing significantly faster, and; the recognition of the need for greatly improved quality and safety in the delivery of healthcare. Both of these key drivers have led to very heavy investments in IS/IT in order to enable timely information-sharing for clinical decisions. The authors argue that by combining the Project Management (PM) approach with the Benefits Management (BM) approach, one can improve the current low success rate of implementations and enhance the reliability of the delivery of benefits from investments in IS/IT.

Keywords: Project Management, Benefits Management, Project Success, IS/IT Health investments.

1 Introduction

The investments on IS/IT for healthcare are financially relevant and still growing worldwide. Therefore it seems wise that the organisations should give more attention to adopting formal project evaluations and benefits management methodologies in order to ensure that the expected benefits from investments are eventually realised [1], [2], [3]. Since the late 1960s we have been witnessing an increased boom in IS/IT healthcare investments and this phenomenon has expanded dramatically over last 10 years. IS/IT for healthcare refers to any tool or framework that enhances the communication, processing or transmission of information by electronic means for the purpose of improving human health [4]. IS/IT is recognised as a key instrument in healthcare delivery and in public healthcare [5]. The globally accepted assumption is that technology can, and does have a positive effect on healthcare, although the evidence supporting its practical use is low [6]. In fact, many decisions on the implementation of the IS/IT in healthcare are made with little or no information about the impact and consequences of its use [7]. Project Management is a set of initiatives

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_51

and management activities that is required to ensure that projects are delivered according to plan [8], and that they achieve the expected objectives and benefits [9].The practice of project management has evolved over the last thirty years and project success assessment has become more linked to the needs of business, or to its customers, rather than just technical issues [10]. However the assessment may differ, depending on the perception of the different stakeholders involved. Nowadays the "iron triangle" (time, cost and quality constraints) is inadequate to measures the success of projects, as success is not related exclusively to the completion of a project´s scope, but also to the achievement of business objectives [11]. Success is perceived differently by the different stakeholders involved in the projects [12]. Usually stakeholders have different perspectives about the purpose of the project and different expectations about what outcomes should be achieved by the project [13], [14]. According to Walsham [15], the involvement of different stakeholders during the earlier phases of the project design is essential for a project's success. Shenhar and Dvir [16] defined the four dimensions of project success as being: 1) efficiency-meeting schedule, cost and scope; 2) impact on the customer - meeting the requirements, customer satisfaction and benefits for the customer; 3) business Success – sales, profits, cash flow, service quality and market share; 4) preparing for the future - new technology, new market, new product line, new core competency and new organisational capability.

2 Health IS/IT

Worldwide surveys show that around 70-80% of all information systems and information technology fail (e.g. CHAOS report) [17]. Despite best practices and the definition of the procedures and methodologies applied, we continue to see flaws in the implementation of information systems based projects [18]. The CHAOS report [17] study ranks the most common risk factors and is a recipe for successful projects. When IS/IT is successfully developed and implemented, there is wide consensus that it offers tremendous opportunities to help healthcare professionals in their daily operations and with the efficiency and effectiveness of care [19], [20]. A reliable patient information system is crucial for the quality of care and is one of the key factors of a patient-centred approach. The computer-based patient information system has the potential to store and retrieve large amounts of information and it is a reality that its use improves the effectiveness and efficiency of patient care. Since the 1990s, the computerisation of healthcare organisations has rapidly increased [21], [22], [23], [24] and the systems failures' reports that have accompanied these decades of implementation [25], [26], [27], [28] evidence enormous loss of money and loss of confidence in IS/IT from the side of users and managers. The use of IS/IT in healthcare is recognised as being a major factor for the promotion of improvement in patient care [29] and it is usually widespread in any modern hospital [30]. IS/IT in health provides an important impact on administrative operations, namely, a decrease in paperwork and the workload of the professionals, and it also increases efficiency and expands access to affordable care. Furthermore, it has also been shown that it is effective in preventing medical errors and in reducing health care costs.

The introduction of IS/IT systems offers tremendous opportunities for healthcare professionals and they radically affect health organizations, namely, by accessing a large amount of information regarding patients, support for the clinical decisions and direct access to vast resource and knowledge data bases [31]. IS/IT in healthcare should deliver relevant medical information about patients and support decisions based on the latest scientific research [23]. There is a broad consensus that organisational factors are more crucial to the successful implementation of IS/IT than just purely operational matters [32]. Obtaining successful change is much easier with the commitment of all stakeholders, and the earlier this involvement is achieved, the easier is the path to a successful project [33]. The implementation of IS/IT in healthcare is distinct from other projects in other sectors. The key differences are mainly related to the environment, the diversity of systems and devices and the challenge of integration and interoperability, all of which are requirements for meeting the expectations of different stakeholder [34]. The effective integration of IS/IT practices for health professional applications tends to be influenced by several factors, which are related to individuals, professional groups, organisational and contextual characteristics, as well as to the nature of their own intervention [35] [36]. One of the most critical factors that are recognised by the academic literature is resistance to change by healthcare professionals, particularly amongst doctors [37] [38]. The complexity of systems, organisational diversity and the amount of investment needed, and also the difficulties on the successful IS/IT adoption, are all largely justified by the way that IS/IT is implemented, and by the need to identify best practices and to act on a number of critical factors in order to reduce the chance of failure [39] [40]. According to Reyes-Alcázar et al., [35] the critical success factors that need to be considered for the health sector are the following: 1) a patient-centred approach - needs and expectations of end-users [36]; 2) leadership - the importance on improving the quality of healthcare [37]; 3) team work – a multidisciplinary process focussed on a healthcare team that shares common goals [38]; 4) autonomy and responsibility – the need for a greater degree of autonomy amongst health professionals [39]; 5) an integrated view of healthcare - the quality of patient care as perceived by end-users is a key element [40]; 6) professional skills – promoting skills encourages professional development [35]; 7) results focussed – the measurement and evaluation of clinical performance, hospital management and end-user satisfaction [41]; 8) internal and external audits – the concept of continuous quality improvement [42], [43], [44].

3 Benefits and Project Management approaches

Benefits and Project Management methodologies are crucial for the success of IS/IT investments, mainly in the areas that experience complex system integration, such as IS/IT Healthcare projects. Many factors can lead to failures in IS/IT projects in healthcare, such as: incomplete or unclear scope, planning, failure to identify and involve stakeholders and communication and risk management problems [45], [46]. The management of the project stakeholders' needs is an essential part of project management and is crucial for ensuring project success [47]. Any intervention

concerning the public service perspective should be based on their expectations and their needs [35]. Over the last decades, a significant amount of literature has referred and advocated a patient-centred approach for healthcare [36]. The benefits management process approach focusses especially on the benefits of IS/IT investments [3], [48]. The potential benefits are identified, a realization plan is defined and then the results are reviewed and evaluated. Benefits management comprises a set of management activities which are designed to ensure that an organisation realises the benefits from an investment. In recent years there has been a significant interest in benefits management. Although it has been recognised for more than one decade, there are still many projects and programmes that fail to realise their expected benefits. Recent surveys highlight that only a minority of responding organisations had adopted a comprehensive approach to managing benefits [49]. There are a set of principles to follow for realizing benefits through IS/IT investments, namely [50]: 1) just having the technology does not necessarily give any benefit, or generate value; 2) benefits occur when IS/IT allows people to carry out their work differently; 3) benefits result from changes and innovations in ways of working; 4) all IS/IT projects have outcomes, but not all outcomes are benefits; 5) benefits must be actively managed if they are to be realised. Benefits are typically delivered through extensive changes to business practices and decision making. There is a consensus that organisational factors are far more critical to successful implementation than technical considerations [51]. Problems are often the result of either a lack of common understanding of the purposes of changes, or from different perspectives as how to achieve them successfully [52]. In this study, we follow the Benefits Management model developed by Cranfield University of UK [3]. This model is widely cited, and is one of the most well-known in the literature [53]. The Benefits Dependency Network (BDN) is the key central tool of the model (Fig.1). It is a framework designed "to enable the investment objectives and their resulting benefits to be linked in a structural way to the business, organisation and IS/IT changes required to realise those benefits" [54].

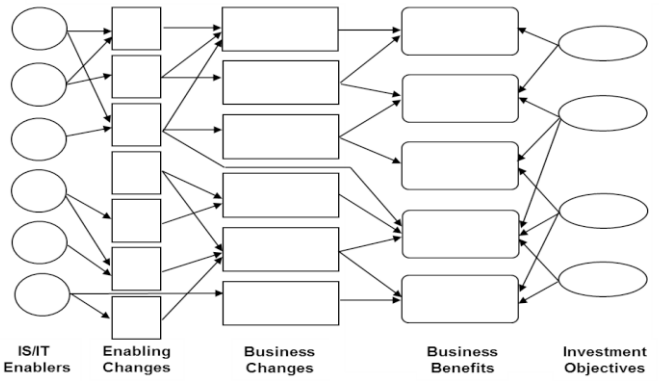


Fig. 1. Benefits' dependency network [3]

Developing a BDN is an interactive process, as it requires changes which are identified and a network of interrelating changes and benefits evolves and the feasibility of achieving some of the benefits originally identified will be questioned [33], [55], [56]. Building the BDN (Fig.1) highlights that the objectives and the related benefits were achieved by the combination of the business changes powered by the enabling changes and IS/IT enablers. A BDN depicts the business changes that can enable organisational change [57]. The majority of business value from investments in IS/IT comes from the changes that the organisation is able to make [54], [55], namely: 1) in a new build, or by reformulating old processes; 2) new functions and responsibilities; 3) new teams, groups or operational divisions; 4) new governance; 5) new measurements and metrics; 6) Redefinition of the appraisal and reward schemes; 7) new procedures for managing and sharing information. The IS/IT investment enables and performs organisational change, not only in managing the technology issues needed to improve business processes and organisational performance. The realization of benefits obviously depends on the correct implementation of the technology. Studies suggest that success and failure in projects depends on organisations ability to accommodate and exploit the capabilities of such technology. Changes in business represent how the organisation wants to work in the short time, but other investments and changes will need to be made in the future. Benefits' management considers a five-stage cycle [54]: 1) identifying and structuring benefits; 2) planning the realization of benefits; 3) executing the realization of benefits plan; 4) evaluating and reviewing results; 5) the potential for further benefits. The initiation process is a crucial stage of the benefits' management approach. In this phase, all the desired benefits should be identified and documented. Best practices recommend the involvement of the key stakeholders in order to maximise the likelihood of their commitment to the benefits achieved. The realisation of benefits plan should include the key assumptions and a risk analysis of those benefits that are expected to contribute to outcomes, and this should be seen as a crucial component of the decision-making processes. Ward et al., [3] highlight that, without a plan, it is difficult to predict how an organisation might effectively realise business benefits. Business cases represent the interface between business and investments [58], and thus it is extremely important to ensure that this interface is well defined [59]. Benefits' monitoring compares results with benefits the realisation plan during the project, and assesses whether any internal or external changes have occurred that will affect the delivery of planned benefits [56]. The benefits' management process includes a stage of post-implementation review, which is a crucial project phase. This review stage should not focus just on technology usage. Instead, the review should explore which of the expected benefits have been achieved, whether any unplanned benefits arose, and which planned benefits are still expected, but may well need additional attendance in order to ensure that they are fully completed. Benefits' review is the process by which benefit delivery is addressed and evaluated and it is when new opportunities for further benefits are identified. Reiss et al. [57] highlight that the relationship between projects, programmes and benefits is frequently quite complex, especially regarding the following aspects: 1) Projects do not deliver benefits, but create simple deliverables; 2) Programmes rarely deliver benefits directly, but create capabilities that will enable the desired benefits to be achieved; 3)

Benefits management processes ensure that the capabilities created are used to deliver anticipated business benefits.

4 Framework

In our framework (PM&BM) (Fig.2) we combine the PMBOK 5th version (PMI, 2013) project management approach [60], with the Cranfield Model [3] benefits' management approach.

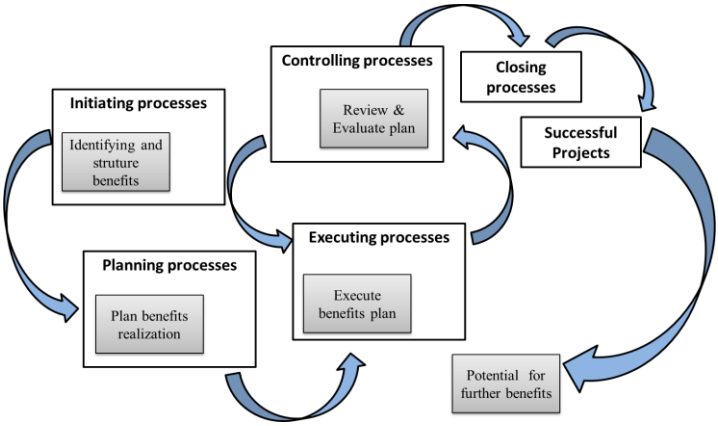


Fig. 2. PM&BM framework

In Table 1, we show the combined phases from these two approaches. There are five process groups required for PM&BM projects. PM&BM processes are linked by the outputs which are produced. The output of one particular phase becomes the input for the subsequent phase. For example, planning processes provide a project management plan and a realization of benefits plan for the executing group. This processes groups that have clear dependencies and which are typically performed in each project. The PM&BM processes group are often identified prior to completing the project, and can have interactions within a processes group, and among processes groups.

Table 1. PM&BM life cycle processes groups

Initiating	Commit the organization to a project and set the overall solution Define project objectives alignment with strategic objectives Approvals, resources and assignment of the project manager Establish the connections between drivers, objectives and benefits Identify benefits and business changes Identify stakeholders and change and benefits' ownership Build the business case

Planning	Scope statement and scope management plan Work breakdown structure Project schedule and schedule management plan Resource requirements, cost management plan, and project plan Measurements scales for benefits and required changes. Stakeholders agreement for the benefits and the required changes Business case approval that supports the realizations of benefits plan
Executing	Managing work results and requests for change Using tools and techniques in the implementation of the project plan Business changes management Follow up of the realization of benefits
Controlling	Performance reports, change requests, updates and corrective actions Updates to the risk management plan Evaluation of benefits' achievement and lessons learned
Closing	Formal acceptance and closure
Successful projects	Project management success (time, budget, requirements/quality) Strategic alignment, changes and stakeholders' expectations
Further benefits	Identify new opportunities and identifying new benefits

It is also understood that alongside planned benefits unplanned benefits often emerge which are the consequence of an implemented change or another gained benefit. The achievement of benefits obviously depends, partially, on an effective implementation of technology assets. However, evidence from project successes and failures shows that it is organizations' inability to accommodate and exploit the capabilities of the technology that causes the poor return from many investments in IS/IT [61]. The realization of benefits plan and the benefits' dependency network are means of ensuring that these links are made explicit. Besides, these are the basis for the business case, as this is the tool that includes not only those benefits that are intended to be identified and specified, but also how each one can be achieved [54], [61].

5 Conclusion

Projects are powerful assets which are designed to bring about change and deliver some form of benefit. Projects are affected by internal and external factors and their success is largely dependent on the satisfaction of stakeholders' expectations. The evaluation and the realization of benefits are both processes which assist organisations to spend money wisely and then account for the amounts spent. Changes and benefits achieved are expected to continue after the end of a project. IS/IT assets support a greater capacity for the planning, monitoring and evaluation of activities in healthcare and they maximize health gains through the efficient allocation of resources. IS/IT also provides greater support for healthcare operations, assisting the integration of information and facilitates for the efficient flow of processes and clinical acts. This study highlights that a combination of benefits and project management outcomes could contribute to enhancing the chances of success through the systematic application of best practices, namely: 1) The involvement of different stakeholders in defining objectives, expectations and benefits; 2) Creating a greater awareness of how project results lead to achieving objectives and to the corresponding benefits; 3)

Establishing a formal method for planning and evaluating objectives, expectations and benefits, in line with initial requirements; 4) Creating an environment of learning and improvement. The authors argue that this combined approach provides a more efficient and useful framework for supporting decision-making which helps organisations improve the success of their projects.

References

1. Dibb, S.: Customer Relationship Management and Barriers to the One Segment. Journal of Financial Services Marketing, 6(1), 10-23 (2001).
2. Schultz, J. R.: Measuring Service Industry Performance; Some Basic Concepts. Performance Improvement, 45 (4), 13-19 (2006).
3. Ward, J., Taylor, P., Bond, P.: Evaluation and Realization of IS/IT Benefits: An empirical study of current practice. European Journal of Information Systems, 4, 214-255 (1996).
4. Bukachi F., Pakenham-Walsh, N.: Information technology for health in developing countries. Chest Journal, 132(5), 1624-1630 (2007).
5. Drury, C.: Management Accounting for Business 3th edition. Bedford Row, London: Thomson Learning (2005).
6. Wootton R.: The future use of telehealth in the developing world. In, Chapter 28, R. Wootton, N. Patil, R. Scott, and K. Ho (eds.), Telehealth in the Developing World. London, United Kingdom: Royal Society of Medicine Press (2009).
7. Kazanjian, A., Green, C.: Beyond effectiveness: the evaluation of information systems using a comprehensive health technology assessment framework. Computers in Biology and Medicine, 32, 165-177 (2002).
8. Brynjolfsson, E., Hitt, E.: Paradox Lost? Firm-level Evidence on the Returns to Information Systems Spending. Management Science, 42(4), 541-558 (1996).
9. Devaraj, S., Kohli, R.: Performance Impacts of Information Technology: Is Actual Usage the Missing Link? Management Science, 49(3), 273-289 (2003).
10. Kerzner, H.: Applied Project Management: Best Practices on Implementation. John Wiley & Sons, Inc., New York (2000).
11. Turner, R., Zolin, R.: Forecasting Success on Large Projects: Developing Reliable Scales to Predict Multiple Perspectives by Multiple Time Frames. Project Management Journal (2012).
12. Freeman, M., Beale, P.: Measuring Project Success. Project Management Journal, 23(1), 8-17 (1992).
13. Lim, C. S., Mohamed, M. Z.: Criteria of project success. International Journal of Project Management, 17(4), 243-248 (1999).
14. Lyytinen, K., Hirschheim, R.: Information systems failures: A Survey and Classification of the Empirical Literature, Oxford Surveys in Information Technology, 4, 257-309 (1987).
15. G. Walsham, Interpreting Information Systems in Organizations, John Wiley & Sons, Chichester, UK (1993).
16. Shenhar, A. J., Dvir, D., Levy, O., Maltz, A, C.: Project Success: A Multidimensional Strategic Concept. Long Range Planning, 34, 699-725 (2001).
17. Standish Group.: CHAOS report 2000. Standish Group International, Boston (2000).
18. Gheorghiu, F.: Why companies fail on the way to implementing project management methodology. Project Management Today, 8(10), 1-7 (2006).
19. NCVHS: Information for Health: a strategy for building the National Health information Infrastructure. National Committee on Vital and Health Statistics, Washington, DC (2001).

20. WHO: Innovative care for chronic conditions: Building blocks for action. World Health organization, France, WHO/NMC/CCH/02.01 (2002).
21. Brailer, D. J., Terasawa, E.L.: Use and Adoption of Computer-Based Patient Records. California HealthCare Foundation, Oakland, CA (2003).
22. Dick, R.S., Steen, E.B., Detmer, D.E., editors: The Computer-Based Patient Record. National Academy Press, Washington, DC (1997).
23. Yasnoff, W.A., Humpheys, B.L., Overhage, J.M., Detmer, D.E., Brennan, P, F., Morris, R. W., Middleton, B., Bates, D. W., Fanning, J, P.: A consensus action agenda for achieving the national health information infrastructure. Journal of the American Medical Informatics Association, 11, 332-338 (2004).
24. Barrett, M. J., Holmes, B. J., McAulay, S. E.: Electronic Medical Records: A Buyer's Guide for Small Physician Pratices. California HealthCare Foundation, Oakland, CA (2003).
25. Southon, F., Sauer, C., Dampney, C.: Information technology in complex health services: Organizational impediments for successful technology transfer and diffusion. Journal of the American Medical Informatics Association, 4, 112-124 (1997).
26. Southon, F., Sauer, C., Dampney, C.: Lessons from a failed information systems initiative: Issues for complex organizations. International Journal of Medical Informatics, 55, 33-46 (1999).
27. Goddard, B.L.: Termination of a contract to implement an enterprise electronic medical record system. Journal of the American Informatics Association, 7, 564-568 (2000).
28. Poon, E. G., Blumenthal, T., Jaggi, M., Honour, M. N., Bates, D. W., Kaushal, R.: Overcoming barriers to adopting and implementing computerized physician order entry in US hospitals. Health Affairs, 23(4), 184-190 (2004).
29. Li, J., Jiang, Y., Fan, R.: Adoption of ICT at Hospital: A case study of UMMC. In proceedings of the 2010 International Conference on Electronic Computer Technology, ICECT, 157-167 (2010).
30. Lymberis, A., Dittmar, A.: Advanced Wearable Health Systems and Applications: Research and Development efforts in the European Union. Engineering in Medicine and Biology Magazine, IEEE, 26(3), 29-33 (2007).
31. Kohn, L., Corrigan, M., Donaldson (Eds): To Err is Human: Building a Safer Health System. National Academy Press, Washington DC (2000).
32. Markus, M. L., Axline, S., Petrie, D., Tanis, C.: Learning from adopters experiences with ERP: Problems encountered and success achieved. Journal of Information Technology, 14(4), 245–265 (2000).
33. Bradley, G.: Benefit Realization Management: A Practical Guide for Achieving Benefits through Change, Gower, Aldershot, Hants, England (2006).
34. Abouzhara, M.: Causes of failure in Healthcare IT projects. In Proceedings of 3rd International Conference on Advance Management Science, 19, IACSIT Press. Singapore, (2011).
35. Reyes-Alcázar, V., Torres-Olivera, A.: Núñes-García, D., Almuedo-Paz, A.: Critical Success Factors for Quality Assurance in Healthcare Organisations, in Quality Assurance Management, Prof. Mehmet Savsar (ed.) 2012.
36. Mead, N., Bower, P.: Patient-centredness: A conceptual framework and review of empirical literature, Social Science and Medicine, 51(7), 1087-1110 (2000).
37. West, B. Lyon, M. H., McBain, M., Gass, J.: Evaluation of a clinical leadership initiative. Nursing Standard, 19(5) 33-41 (2004).
38. Mickan, S. M.: Evaluating the effectiveness of health care teams. Australian Health Review, 29(2) 211-217 (2005).
39. Harrison, S. R., Dowswell, G.: Autonomy and bureaucratic accountability in primary care: what English practitioners say. Sociology of Health and Illness, 208-226 (2002).

40. Torres Olivera, A.: La gestión por procesos asistenciales integrales: una estrategia necesaria. Atención Primária, 31(9) (2003).
41. Patton, M. Q.: Utilization-Focused Evaluation, Thousand Oaks, Sage Publications, California, USA (1997).
42. Chovil, N.: One small step at a time: implementing continuous quality improvement in child and youth health services. Child and Youth Services, 31(1) 21-34 (2010).
43. Hyrkäs, K., Lehti, K.: Continuous quality improvement through team supervision supported by continuous self-monitoring of work and systematic patient feedback. Journal of Nursing Management, 11(2), 208-226 (2003).
44. Le Brasseur, R., Whissell, R., Ojha, A.: Organizational learning, transformational leadership, and implementation of continuous quality improvement in Canadian Hospitals. Australian Journal of Management, 27(2), 141-162 (2002).
45. Andrew, T.: IT projects: sink or swim. Computer Bulletin, 42, 24-26 (2000).
46. Pinto, J. K., Mantel, S. J.: The Causes of Project Failure. IEEE Transactions on Engineering Management, 34, 67-72 (1990).
47. Landin, O.S.: Evaluation of stakeholder influence in the implementation of construction projects. International Journal of Project Management 23, 321-328 (2005).
48. Gomes, J., Romão, M., Caldeira, M.: Linking Benefits to Balanced Scorecard Strategy Map. In New Perspectives in Information Systems and Technologies: Advances in Intelligent Systems and Computing, 206, 357-369, edited by Rocha, Á., Correia, A.M., Wilson, T., Stroetmann, K. A, Springer Berlin Heidelberg (2013).
49. Ward, J., Hertogh, S. D., Viaene, S.: Managing Benefits from IS/IT Investments: an Empirical Investigation into Current Practice. In proceedings of 40th Hawaii International Conference on Information Systems (2007).
50. Peppard, P., Ward, J., Daniel, E.: Managing the Realization of Business Benefits from IT Investments, MIS Quarterly Executive, March (2007).
51. Markus, M.L., Axline, S., Petrie, D., Tanis, C.: Learning from adopters experiences with ERP: Problems encountered and success achieved. Journal of Information Technology, 14, 4, 245-265 (2000).
52. Ramiller, N. C., Swanson, E. B.: Organizing Visions for Information Technology and the Information Systems Executive Response. Journal of Management Information System, 20, 1, 13-50 (2003).
53. Braun, J., Ahlemann, F., Riempp, G.: Benefits Management: A literature review and elements of a research agenda. In Wirtschafinformatik Proceedings, 54 (2009).
54. Ward, J., Daniel, E.: Benefits Management, Delivering Value from IS and IT Investments. Chichester, UK: John Wiley & Sons (2006).
55. Ward, J., Elvin, R.: A New Framework for Managing IT-enabled Business Change, Information Systems Journal, 9, 3, 197-222 (1999).
56. Payne, M.: Benefits Management – Releasing project value into the business, Hampshire, UK, Project Manager Today (2007).
57. Reiss, G., Anthony, M., Chapman, J., Leigh, G., Pyne, A., Rayner, P.: Gower Handbook of Programm Management, Gower Publishing (2006).
58. Morris, P., Jamieson, A.: Translating Corporate Strategy into Project Strategy. Newton Square, Pennsylvania: Project Management Institute, Inc. (2004).
59. Nogeste, K., Walker, D.H.T.: Project outcomes and outputs: making the intangible tangible. Measuring Business Excellence, 9, 55-68 (2005).
60. PMI: A Guide to the Project Management Body of Knowledge (PMBOK® Guide), Fifth Edition. Newtown Square, Pennsylvania, USA: Project Management Institute Inc. (2013).
61. Gomes, J., Romão, M.: How Benefits Management helps Balanced Scorecard to deal with business dynamic environments. In proceedings TMS2012 - Management Studies International Conference, Algarve, November (2012).

Simulation of BPMN Process Models: Current BPM Tools Capabilities

José Luís Pereira[1] and António Paulo Freitas[1],

[1]Universidade do Minho, Departamento de Sistemas de Informação,
Campus de Azurém, Guimarães, Portugal
jlmp@dsi.uminho.pt, a59742@alunos.uminho.pt

Abstract. Nowadays, more and more organizations are using Business Process Management (BPM) to prepare themselves to deal, in an effective way, with the increasingly difficult conditions of modern markets. Essential to BPM is the collection of tools which support the operationalization of the business process concept – BPM tools. These tools deal with business process models, which have to be described with a suitable language. In the present, BPMN is considered the standard modeling language to describe business processes. Once a business process is modeled, a process simulation approach might be used in order to find its optimized version. Therefore, the simulation of business process models, such as those defined in BPMN, appears as an obvious way of improving processes. This paper advances work previously published by the authors regarding BPM tools capabilities in terms of the simulation of BPMN process models. In this context a platform to support the characterization of BPM tools regarding process simulation capabilities has been developed. This platform might be helpful to users who want to select the most adequate BPM tool regarding their simulation needs.

Keywords: BPM tools, BPMN, process modeling, process simulation.

1 Introduction

Nowadays, more and more organizations are using Business Process Management (BPM) to prepare themselves to deal, in an effective way, with the increasingly difficult conditions of modern markets. Indeed, it is widely recognized that a business processes oriented management provides organizations with increased levels of performance and flexibility, as they can respond to the needs and changes of the markets in a most efficient and effective way [1].

Essential to BPM is the collection of tools which support the operationalization of the business process concept – the BPM tools. Due to the increasing relevance of the worldwide BPM market, BPM tools producers are improving their tools in order to gain higher market acceptance [2].

Core to BPM tools is the concept of business process model, which has to be described with a suitable language. Regarding the modeling of business processes there are several languages in use today, such as BPMN (*Business Process Model and*

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_52

Notation) [3], EPC (*Event-driven Process Chain*) [4], or UML-AD (*Unified Modeling Language – Activity Diagrams*) [5], to name just a few.

Since its conception, the BPMN has gained worldwide acceptance, and is now recognized as the standard process modeling language to use in the development of BPM projects. The use of this language has simplified the way organizations represent and communicate their business processes, as BPMN allows business process modelers to represent complex business processes easily and effectively [3].

The modeling of business processes, using the BPMN language, allows organizations to obtain graphical representations of their processes. Using the produced diagrams (*Business Process Diagrams*), organizations can assess whether their processes present anomalies, inconsistencies, inefficiencies and, therefore, improvement opportunities. The inability to quantify the processes weaknesses can be eliminated by organizations through the use of simulation. This approach allows organizations to anticipate process behaviors, based on estimations and mathematical calculations performed with the aid of a computer, thus letting them identify and quantify its shortcomings and anomalies.

This paper advances work previously published by the authors regarding BPM tools capabilities in terms of the simulation of BPMN process models. In a previous paper [6], we have analyzed the business process modeling and simulation areas, to identify the elements that must be present in the BPMN language in order to allow processes described in BPMN to be simulated. We concluded that, although there are several BPM tools with simulation capabilities which support BPMN, they still present several limitations regarding the simulation of process models. In this context, a platform to support the characterization of BPM tools regarding process simulation capabilities has been developed. This platform, which is completely extensible in terms of the characterized BPM tools and simulation properties to be supported, might be helpful to users who want to select the most adequate BPM tool regarding their simulation needs.

Concerning the structure of this paper, first we very briefly mention the BPMN language. Next, we identify the elements that the BPMN language and BPM tools have to incorporate in order to enable the simulation of business processes – simulation properties. In the following, we present the results of the analysis we made to some well-known BPM tools, regarding their support of those simulation properties. These results constitute the initial base of the platform we have developed to characterize BPM tools simulation capabilities, which is prepared to incorporate other evaluations, of the same or other BPM tools, using the same or other simulation properties. The core functionalities of this platform are also presented.

2 The BPMN Language

Before a business process can be analyzed, optimized, implemented and managed, it has to be modeled. Models of business processes are developed using specific languages, of which BPMN is one of the most widely used. BPMN stands for *Business Process Model and Notation* and is a language that has appeared in 2004, developed and sponsored by the *Business Process Management Initiative* (BPMI),

and later adopted as standard by the *Object Management Group* (OMG). The first version of BPMN was developed in order to standardize the graphical representation of business processes, providing a set of "graphic symbols" for the various elements of the process, with a coherent meaning and ability to represent their possible combinations [7].

White [8] argues that the main objective of BPMN is to provide a notation that is understandable to all the stakeholders around organizational processes, from business analysts, who document or define the models of business processes, to technical developers, who are responsible for developing the IT solutions that will support the those processes, and finally, to all users who will control and manage the processes developed.

The notation for the graphical representation of the language elements was designed so that different elements are distinguishable from each other and noticeable for modelers. For instance, it is normal to associate rectangles to business process activities, while decisions are represented by diamonds [9].

To organize the graphic elements of the language, BPMN distinguishes among five specific categories (*flow objects*, *data*, *connection objects*, *swimlanes* and *artifacts*). The flow objects, which are the major graphic elements to represent the behavior of a business process, are divided into three groups (*events*, *activities* and *gateways*). The data category provides the information necessary for the activities, and is divided into four groups (*data object*, *collections of data*, *input data* and *output data*). The connection objects define the way objects are linked and the order in which activities are performed during the process. Currently there are three groups of connection objects (*sequence flows*, *message flows* and *associations*). Swimlanes are divided in two categories (*pool* and *lane*). Pools allow the identification of the actors involved in the process. In order to increase the detail, pools may be sub-divided in lanes. Artifacts are used in order to provide additional information about the process that is represented. Currently, there are two types of artifacts (*group* and *notes*), and the process modeler can add more than one artifact to the process model.

3 BPM Tools and Process Simulation with BPMN

It is widely acknowledged today that simulation experiments are a reliable and credible source of insights with regard to the support of decision-making in organizations. Indeed, the ability to anticipate, in a tangible and understandable way, the probable results of a decision before making it in the real world, allows managers to better ground their decisions. Simply put, simulation assists managers in their decision-making duties, since it allows them to develop and analyze various scenarios of possible interest. The use of simulation to analyze “what if” scenarios eliminates the costs and risks that are inherent to testing them in a real environment.

As Sakurada & Miyake [10] put it, simulation is a technique that may be applied to understand the behavior of a system, with the purpose of assessing the consequences arising from changes made to their processes and/or physical settings (e.g. the capacity of the resources to execute tasks and the final aspect of the facility), without any disturbances to current operations.

With the growing importance of BPM in organizations, the use of BPMN to model their business processes is gaining more and more followers. If the elements needed for the simulation of processes were incorporated into the BPMN language, then one would be able, not only to model the processes, but also to simulate them. That is, by using the BPMN language enriched with the proper elements needed to support simulation, users not only have the ability to model business processes, but also the ability to simulate the processes modeled, with all the advantages of testing and analyzing different scenarios without any risks to the real system [11].

BPMN has been designed to standardize the graphical representation of business processes, without any concerns about simulation. Therefore, there is a need to define a set of "extensions" to the BPMN language, in order to allow process models developed in BPMN to be simulated. These are properties that the proponents of the BPMN language did not anticipate, but that are essential, so process models can be simulated.

In [6] we have identified a set of simulation properties grouped into six classes: *Context Definition*, *Time Consumption*, *Control*, *Resources*, *Costs* and *Priorities* (see Table 1). Some of these properties might be reflected in the BPMN models, others relate to the simulation engines themselves.

Table 1. Simulation Properties.

Properties	Description
Context Definition	
Starting Time	Setting a start time to run the simulation
Duration	Setting the duration of the simulation
Time Unit	Defining the time unit of the simulation
Cost Unit	Defining the cost unit of the simulation
Replications	Number of replications of the simulation
Time Consumption	
Transfer Time	Time spent in transit from one activity to the next
Waiting Time	Time spent waiting to be executed (queue time)
Processing Time	Time spent in the execution of an activity (probability distribution)
Control	
Arrival Rate	Definition of the process triggering pattern (probability distribution)
Branch Probabilities	Definition of probabilities for each branch out of a gateway
Resources	
Capacity	Setting the number of resources available to execute each activity
Allocation Plan	Definition of a sharing plan for the execution of activities
Unavailability	Definition of unavailability periods for resources
Schedule	Definition of work schedules for resources
Costs	
Activity	Definition of the processing cost of an activity
Resource	Definition of the hourly cost of each resource
Priorities	
Interruptions	Definition of activities that cannot be interrupted while running
Execution Priority	Definition of activities that have priority in execution

Concerning probability distributions, there are several distributions, which are normally available in every simulation tool (such as Normal, Triangular, Uniform, Beta, Exponential, Gamma, Erlang, Binomial, and Poisson), that should also be present in a BPM tool with simulation capabilities.

4 BPM Tools Analysis Regarding Process Simulation

Until recently, to simulate a business process modeled in, for instance BPMN, an analyst had to re-model the process model according to the specific language of the selected simulation tool. Such a situation is unjustified and awkward as it involves a duplication of work. Fortunately, this situation has begun to change, as more and more tools emerge in the market, which allow the simulation of business processes modeled in BPMN.

However, one can find a common pattern among those tools – all of them originated from BPM tools vendors, not from simulation tools vendors. So, these are essentially BPM tools which have been extended with simulation capabilities, not simulation tools which have incorporated BPMN as a modeling language. Therefore, it is not clear right now if those tools can, effectively, simulate BPMN business processes with the desired level of realism and accuracy. In order to clarify this situation we have made an analysis of the following tools, which have made relevant incursions in the simulation area, taking into consideration the simulation properties identified in Table 1:

- Bizagi (Modeler version 2.9);
- BIMP (online version);
- BonitaSoft (version 6.5.3);
- Visual Paradigm (version 12.1);
- BPSim (Trisotech BPMN 2.0 Modeler for Visio version 4.2.0).

To facilitate the analysis of these tools a simple scenario was developed which uses a common business process ("*Request of Order Delivery Date*"), dealing with the approval of the delivery date of an order. The main goal was to assess, for each BPM tool, which simulation properties are present or absent. The next table (Table 2) is a summarization of the simulation capabilities of each tool, taking into account the properties previously identified in Table 1. A mark (X) signals that a property is supported by the tool.

Table 2. Simulation Properties by Tool.

Properties	BIMP	Bizagi	BPSim	BonitaSoft	Visual Paradigm
Context Definition					
Starting Time	X	X	X	X	X
Duration	X	X	X	X	X
Time Unit	X	X	X	X	X
Cost Unit	X	X	X	X	X
Replications		X	X		

Time Consumption					
Transfer Time			X		
Waiting Time	X	X	X	X	X
Processing Time	X	X	X	X	X
Control					
Arrival Rate	X	X	X	X	
Branch Probabilities	X	X	X		X
Resources					
Capacity	X	X	X	X	X
Allocation Plan		X	X		
Unavailability					
Schedule	X	X	X	X	
Costs					
Activity	X	X	X	X	X
Resource	X	X	X	X	
Priorities					
Interruptions			X		
Execution Priority			X		
Probability Distribution					
Normal	X	X	X	X	X
Triangular	X	X	X		
Uniform	X	X	X		
Beta		X	X		
Erlang		X	X		
Poisson		X	X		

As we can see, there are substantial differences among tools regarding simulation capabilities. Considering that a simulation experiment is intended to faithfully represent the real system or, at least, represent it as accurately as possible, BPM tools that have limitations concerning the support of simulation properties won't be able to fulfill that requirement, leading to simulation results that might be far away from the real ones.

5 BPM Tools Simulation Capabilities Platform Development

Based on the identified groups of simulation properties that were identified (Table 1) we decided to develop a platform to support the characterization of BPM tools regarding their capabilities in terms of simulation support.

At this moment, a functional prototype of the platform, whose user interface, for now, is mainly in Portuguese, has already been developed. We decided to create two versions of the platform: a desktop version, with all the functionalities described below; and a web version, with a more limited set of functionalities (in particular, the extensibility functionalities), but with higher potential to reach more users, as soon as we translate the user interface to English. In the rest of this section, we choose to present only parts of the desktop version of the platform.

In Table 2, one can see the results obtained with our analysis of the five tools selected to this study. In that table we only show if a simulation property is, or is not, supported by a tool. Of course, a simple indication of presence/absence is not enough to properly characterize a given tool, as different tools may support the same simulation property with distinct levels of support. To solve that problem, if a tool supports a property, we propose to quantitatively characterize the level of support in a scale from 1 to 5 (1 - Insufficient;…; 5 - Excellent).

Besides a quantification of the support level to characterize how a given tool supports a given simulation property, there are other requirements that this platform must fulfill, in order to be useful.

One of the requirements we think is of utmost importance is that the platform should have the capacity to evolve. The platform should be extensible in the sense that the set of BPM tools could be expanded, and also the list of groups and simulation properties could be extended, if needed. In Fig. 1 we show some of the mockups used to maintain the set of BPM tools, groups of simulation properties, and simulation properties.

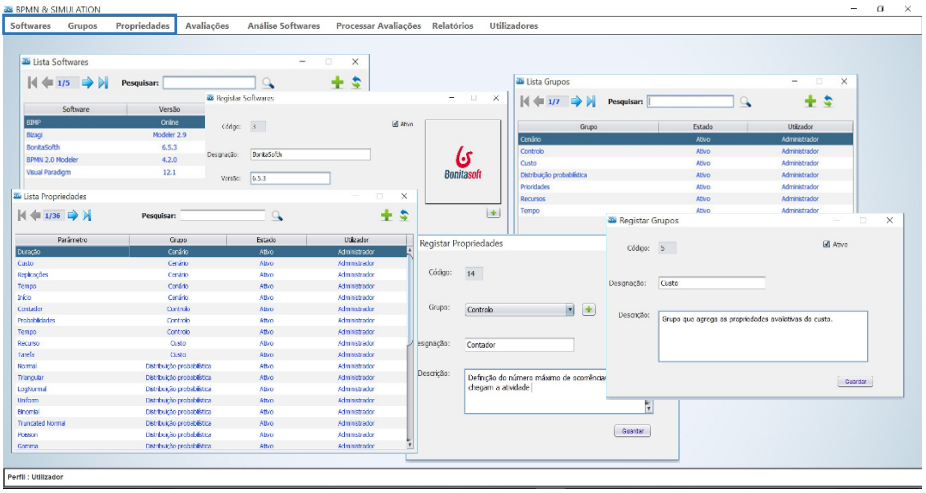


Fig. 1. Platform Maintenance – BPM Tools, Groups of Properties and Simulation Properties

The quantification of the support levels must be updated dynamically, taking into consideration the opinions of other BPM tool users. Indeed, it would be convenient that the contents of the platform could evolve by incorporating the evaluations of experienced users (contributors), thus improving its accuracy. In that sense, at each moment, the "knowledge" present in the platform would represent the weighted evaluations of the users that have contributed to its content until that moment.

If a contributor wants to make an evaluation, he/she has to select the BPM tool to characterize, the property groups to evaluate and, for each one of the selected groups, the properties to evaluate (Fig. 2). A contributor might also desire to change an evaluation that he/she has done in the past. Of course, this is also possible, as users change their opinions about BPM tools, and BPM tools also evolve thus leading to the need to change evaluations.

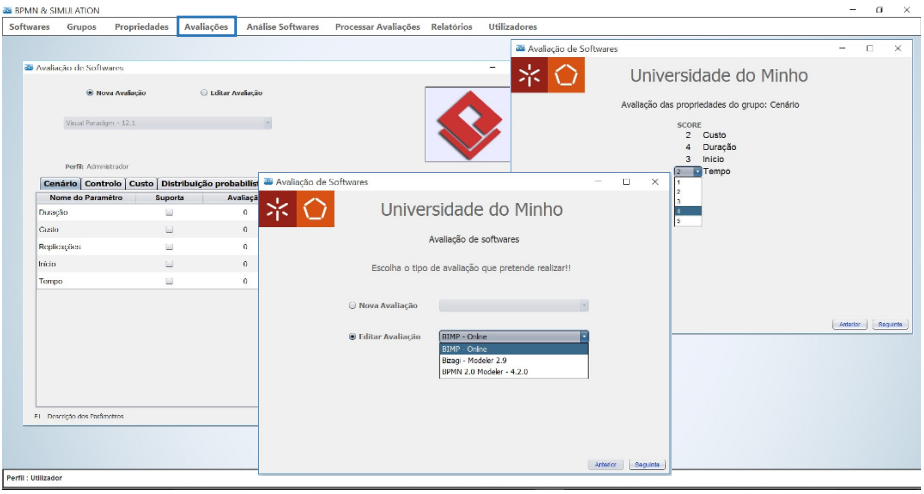


Fig. 2. Platform Maintenance – Evaluation of BPM Tools

Finally, the platform should assist users in the comparison of BPM tools, taking into account their specific needs in terms of simulation support. To do that, users should have the possibility to give weights to each of the simulation properties, in order to best characterize their needs in terms of simulation. So, users select the BPM tools and the groups of simulation properties, in which they are interested. For each group they select the desired simulation properties, assigning a value to each one of them (in a scale from 1 to 5), thus quantifying their interest in them (Fig. 3).

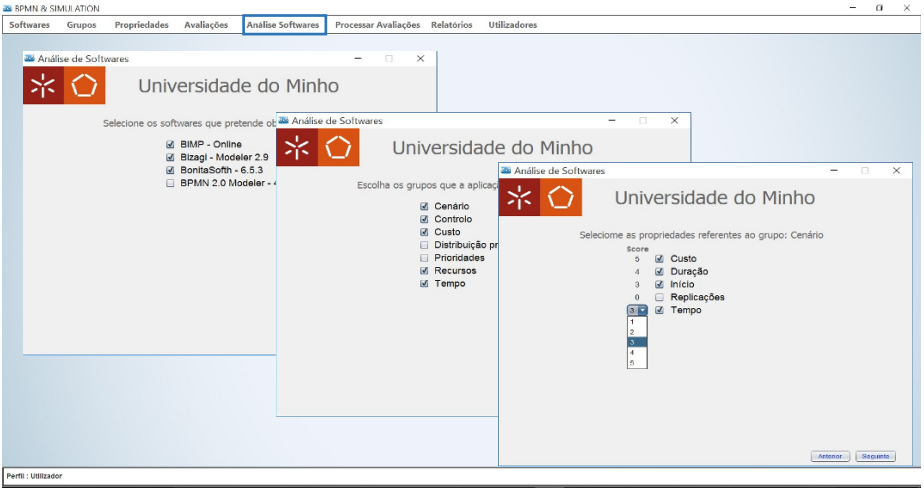


Fig. 3. Selection of BPM Tools, Groups of Properties and Simulation Properties to Analyze

Thus, obtaining the required information in the form of several different graphics and reports that he may choose (Fig. 4).

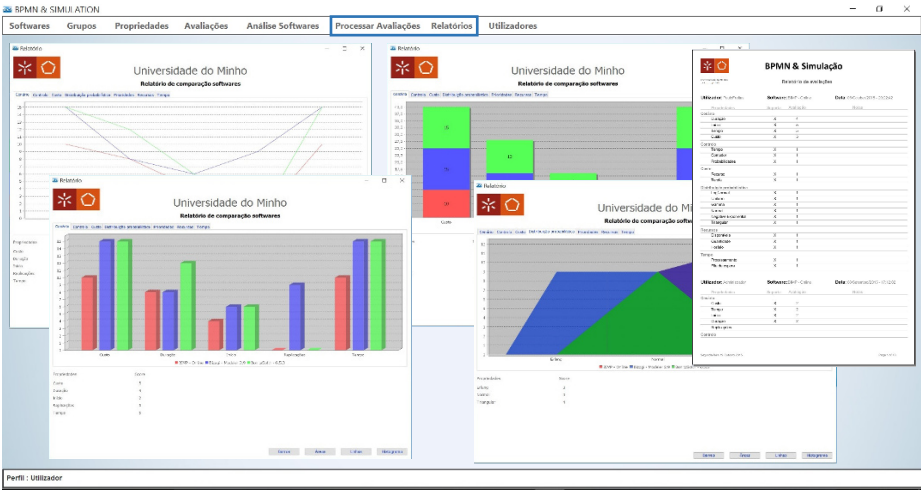


Fig. 4. Results of the BPM Tools Comparison

As was mentioned before, at this moment the user interface of the platform is entirely in the Portuguese language which, at least in the case of the web version, is an important limitation to its more ample usage. In the near future we intend to translate all the user interface to English, in order to make the platform available to more users.

6 Conclusions

With the worldwide acceptance of the BPM (Business Process Management) approach by organizations, a class of software tools has gained relevance – BPM tools. This is a large family of products intended to support the needs of organizations regarding the modeling, implementation, execution, monitoring and improvement of their business processes.

In this paper, we focus our attention, once again, in the modeling of business processes using the widely used business process modeling language BPMN. More specifically we want to clarify which is the level of support offered by modern BPM tools, regarding the simulation of business processes modeled in BPMN. Our interest in process simulation comes from the fact that the ability to simulate business processes, before their actual implementation in the field, might provide substantial gains to organizations and reduce the risks associated to changes. Indeed, by using simulation organizations may anticipate the effects of changes in their processes and evaluate different scenarios (what-if).

The analysis of some BPM tools underlying this work has revealed that, besides a minimum set of features needed to do simple simulation work, and which is common to all of them, there are very distinct simulation capabilities among tools. On the one hand, while there are already some BPM tools which may be used to do serious simulation work, on the other hand, there are others that still lack essential simulation capabilities. Anyway, it became clear that there is already an effort from BPM tools

developers, particularly those that support the BPMN standard, in enabling their products with simulation features. One can expect that, in a few years, simulation capabilities will be standard features of BPM tools.

This paper complements previous published work from the same authors with the presentation of a platform that was developed to support the characterization of BPM tools regarding their simulation capabilities. The prototype of the platform, which is available as a desktop application and as a web portal, is open to the community of BPM tools users, waiting to receive their contributions in order to improve its contents. The platform is prepared to continuously evolve and improve its content, giving support to users who need to choose a BPM tool, taking into account their specific simulation needs.

References

1. Brocke, J., & Rosemann, M. (2010). Handbook on Business Process Management 2. Decision Support Systems.
2. Buelow, H. (2010). Getting Started with Oracle BPM Suite 11gR1. Packt Publishing Ltd.
3. Freund, J. & Rücker, B. (2014). Real-Life BPMN: Using BPMN 2.0 to Analyze, Improve, and Automate Processes in Your Company (2nd Ed), CreateSpace Independent Publishing Platform.
4. Davis, R. (2008). ARIS Design Platform: Advanced Process Modelling and Administration, Springer.
5. Podeswa, H. (2009). UML for the IT Business Analyst (2nd Ed), Cengage Learning PTR.
6. Freitas, A.P., & Pereira. J.L. (2015). Process Simulation Support in BPM Tools: The Case of BPMN. Proceedings of the 5th International Conference on Business Sustainability. Póvoa de Varzim – Portugal.
7. OMG. (2011). Business Process Model and Notation (BPMN). Object Management Group, Inc.
8. White, S. a. (2004a). Business process modeling notation. Specification, BPMI. Org, (January), 1–296.
9. White, S. a. (2004b). Introduction to BPMN. BPTrends, 1–11.
10. Sakurada, N., & Miyake, D. (2009). Simulação baseada em agentes (SBA) para modelagem de sistema de operações. Simpoi, ANAIS (1980), 1–16.
11. Ribeiro, M., & Pereira. J. (2014). Multi-paradigm simulation projects: The need for practical guidelines. Proceedings of the 4th International Conference on Business Sustainability. BS 2014. Póvoa de Varzim – Portugal.
12. Oliveira, P., & Pereira, J. (2008). A Simulação Computorizada no Suporte à Optimização e Melhoria Contínua de Processos Organizacionais. Proceedings da 8ª Conferência da Associação Portuguesa de Sistemas de Informação. CAPSI 2008. Setúbal - Portugal.
13. Waller, A., Clark, M., & Enstone, L. (2006). L-SIM: Simulating BPMN Diagrams with a Purpose Built Engine, Proceedings of the Winter Simulation Conference. WSC 2006. 591–597. Monterey, CA.

Towards an Evaluation Model for the Quality of Local Government Online Services: Preliminary Results

Filipe Sá[1,4], Joaquim Gonçalves[2], Álvaro Rocha[3], Manuel Pérez Cota[4]

[1] Câmara Municipal de Penacova, Penacova, Portugal
[2] Instituto Politécnico do Cávado e Ave, Escola Superior de Tecnologia, Barcelos, Portugal
[3] Universidade de Coimbra, Departamento de Engenharia Informática, Coimbra, Portugal
[4] Universidad de Vigo, Escuela Superior de Ingeniería Informática, Vigo, Spain
filipe@cm-penacova.pt, jgoncalves@ipca.pt, amrocha@dei.uc.pt, mpcota@uvigo.es

Abstract. This paper sets forth the results obtained after applying a first round of the Delphi Method process towards the development of an evaluation model for the quality of local government online services. In this first round, we submitted a list of thirty quality dimensions divided amongst four domains to a group of fifty local e-government experts. The results obtained led us to exclude one dimension and assign a set of twenty two dimensions to their respective domains. Additionally, the results reveal a certain degree of hesitation as to the domain assigned to seven dimensions. Three new dimensions emerged.

Keywords: E-Government, E-Services, Service Quality, Public Services, Local Government

1 Introduction

With the emergence and the massive dissemination of the Internet, the provision of e-government services became the norm all over the Globe. The Web constitutes a great source of information for its interactive character, ease of use and low cost [1]. The first step involves the definition of an e-government. According to Rocha, Silva, Lamas, Castro and Silva [2] an e-government, following an encompassing perspective, involves the adequate and advantageous use of information and communication technologies by government agencies - central, regional or local - both in their internal and external relations, and particularly in their relationship with citizens. Santos, Melo and Dias [3] refer that the function of an Electronic Government is to restructure the organization of public services, adopting mechanisms that promote communication amongst different entities, thus simplifying processes. An e-government is more than a mere instrument providing cheaper and quicker services, it constitutes a mode of operation that ought to be implemented on central, regional and local levels in every country [4]. Official government websites

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_53

offering information and services first appeared on the internet in the mid-nineties, followed by the emergence of the term "eGovernment" in society [5].

Although we could conceptually perceive the degree of citizen satisfaction obtained from interactions with the Central and the Local Government as being similar, from our perspective, we are talking about two different realities, as the proximity between the citizen and the local administration sphere, as well as the jurisdiction deriving from local legislation, cause the citizen to assume a different posture in the relationship he establishes with the governmental service provider. That is, the level of demand towards a local government is higher owing to its specificity and proximity. Although local e-government services may be perceived as an extension of central government services, the former have a number of specificities that need to be stressed. In this sense, in the local public services context, the Government provides electronic services that are heavily influenced by their powers, typology, different territorial and local distribution, disparate levels of literacy and age amongst populations, different organizational structures, a strong proximity with citizens and local companies, different IT maturity levels, disparate channels for the provision of services and, last but not least, their strong influencing role over local and national legislation policies. The definition of e-Government, consisting of "using information technologies to support government operations, involve citizens and provide public services", remains valid for the Local Government context [6]. Local e-governments form a relevant topic and a solution for the implementation of democracy on a local level, providing e-services and rendering access to available information easier [7]. As they enjoy a certain pseudo autonomy, it is not uncommon to observe significant differences in the provision of the same services by neighbouring municipalities or between municipalities of similar sizes. Local governments must be closer to people and companies, providing high quality services, and displaying foresight and leadership to local communities. Local Public Services are thus facing the challenge of administrative modernization, trying to bring the residents closer to their services and, simultaneously, dematerializing their processes [8, 9].

Accordingly, concepts, models, *frameworks* and methodologies need to be evaluated in order to measure, in the specific context of local authorities, the quality of Electronic Government services, with a view to improve the level of satisfaction attached to these services.

Within the scope of the present study, the concept of local e-government concerns the provision of e-services through the internet, that is, online.

2 Methodology

This paper is part of an investigation process for the creation of an instrument to evaluate the quality of local government online services, and results from a first round of a Delphi Method process. In a previous stage we carried out a literature review, analysing a carefully selected sample of books, dissertations, theses and papers in this area, which allowed us to identify quality evaluation approaches for traditional, electronic and e-Government services, as well as an empirical study based on a series

of interviews to Local Government experts [10-12]. Based on the collected and analysed elements, we prepared a preliminary list comprised by thirty quality dimensions, divided into four domains, which formed the basis for the first round of the Delphi Method process.

The Delphi Method, originally developed by RAND Corporation, consists of a structured and interactive communication technique that adopts a series of questionnaires or rounds to collect and provide information, until a consensus is reached for a given theme [13-15,17]. In short, this method tries to identify and obtain expert views through a series of questionnaires, called rounds, until a maximum consensus is reached. Following the same line of thought, Santos [15] believes that this method is especially suited to reach consensus involving opinions, judgements or choices, namely to determine, predict and explore group attitudes, needs and priorities. This method stands out due to three fundamental characteristics: anonymity, interaction with a controlled *feedback* and the provision of statistics for group answers.

For this first round of the Delphi Method process we invited, by email, fifty experts and obtained forty four answers. The members of the panel were chosen from a group of experts including IT technicians from local governments, researchers/academy members, local government software developers and experienced users.

The questionnaire, including a list of domains and respective quality dimensions, was made available through the web, using a PHP and MySQL tool developed by the researchers, and asked the experts to score the relevance of each dimension in a five point Likert scale. The experts were also asked to attach a domain to each dimension. Additionally, the respondents could suggest new dimensions and domains. The criterion adopted to reject a dimension was based on the percentage agreement, coefficient of variation of the mean [1] and the percentile of the mean. This questionnaire was available from September 1 to September 30, 2015.

3 Previous Dimensions

In order to render the Delphi Method process easier, in this first round, and despite the fact that the experts were allowed to suggest new dimensions and domains, we adopted a predefined list of thirty dimension and four domains defined in the previous stages of this investigation [10-12].

This very list reflecting the perception of the authors, was developed in two stages. The first stage, as was previously mentioned, was based on a thorough literature review [11], in the course of which fourteen approaches were identified within the scope of Service Quality. From this group, nine are specifically connected to generic electronic services: SITEQUAL by Yoo and Donthu [18]; WebQual by Loiacono, Watson and Goodhue [19]; WebQual by Barnes and Vidgen [20]; eTailQ by Wolfinbarger and Gilly [21]; E-S-Qual by Parasuraman, Zeithaml and Malhotra [22]; e-TRANSQUAL by Bauer, Falk and Hammerschmidt [23]; the Review of the SERVQUAL scale by Li and Suomi [24]; the Framework of Sam and Tahir [25]; and e-SELFQUAL by Ding, Hu and Sheng [26]. The remaining five approaches concern the e-government context: E-GovQual by Papadomichelaki and Mentzas [27]; e-

GOSQ Framework by Agrawal *et al.* [16]; the Proposal by Alanezi, Kamil and Basri [28]; e-GSQA Framework by Zaidi and Qteishat [29]; and the Framework of Hien [30].

The second stage [10], which served as a complement to the literature review, involved the elaboration of twenty-five interviews, carried out in the form of a questionnaire administered to experts and/or users of online e-services involving the local public sphere, with a view to prospect and identify new dimensions and domains.

4 Application of the Delphi Method

The first step to set the Delphi Method process in motion involved the development of a tool to administer the questionnaires. To favour the design, and bearing in mind usability, we developed a questionnaire from scratch (Figure 1), programming in HTML, PHP, Javascript and MySQL.

A panel of experts was selected in order to initiate the process. Bearing in mind the intended profile and resorting to a convenience sample, we invited fifty prospective participants, including IT department responsible figures from local governments, software suppliers, university professors and regular e-service users. Despite the adoption of a convenience sample, we invited experts from different geographical areas.

The invitation was sent by email, which included the password and the link to access the questionnaire. First and foremost, the respondents were given access to the statements explaining the purpose of the study and the instructions to fill the questionnaire.

In this first round, we presented a list of thirty quality dimensions asking the participants to select those that should be included in an evaluation model for the quality of local government online services. For each chosen dimension the experts were also asked to choose a respective domain. The experts were also asked to score, in a five point Likert scale, the level of relevance attached to each dimension within a domain.

We obtained forty four answers, from twenty three IT responsible figures/technicians from local governments, nine service users, seven university professors, three politicians responsible for the modernization of local public services and two collaborators from software development companies.

The retention of dimensions for the next round was based on the compliance of at least two of the following requirements:

- Agreement above 50%
- Mean above the percentile 5
- Coefficient of variation below 33%

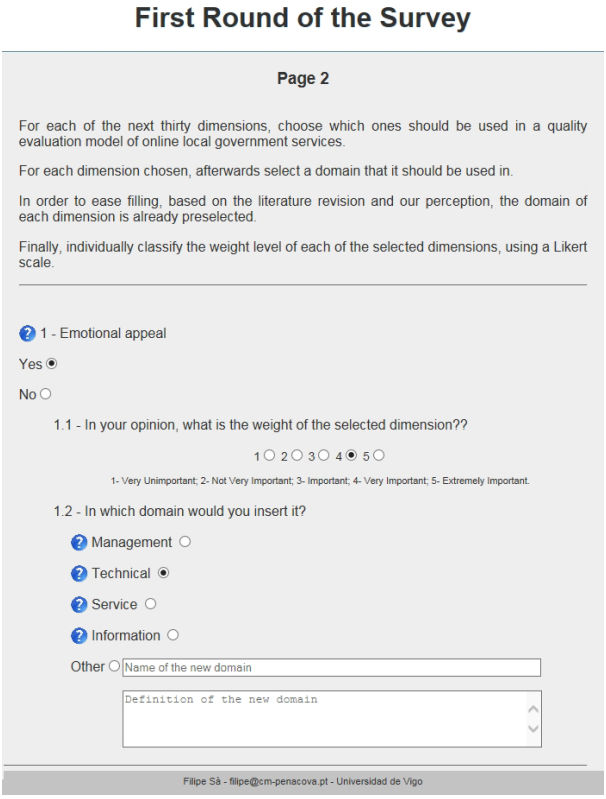


Fig. 1. Online questionnaire (http://www.cm-penacova.pt/egovernment)

5 Results from the First Round of the Delphi Method

The size of the sample (N=44>30) allowed us to treat the selected ordinal qualitative scale of scores assigned to each dimension as a quantitative scale, without losing accuracy and in order to estimate the adopted statistical indicators.

5.1 Relevance of the dimensions

We estimated the mean, the standard deviation and the coefficient of variation of the scores assigned to each dimension, based on the scores assigned by the experts who recognized their relevance. We also determined, for each dimension, the percentage of experts that recognized its relevance (Table 1).

Table 1. Mean and standard deviation of the assigned scores for each dimension

	Mean	Standard deviation	Coefficient of variation	Agreement
Safety	4,7	0,599	12,7%	97,7%
Transparency	4,56	0,666	14,6%	97,7%
Privacy	4,55	0,593	13,0%	95,5%
Deadline Compliance	4,55	0,663	14,6%	100,0%
Information Quality	4,45	0,663	14,9%	100,0%
Usability	4,43	0,63	14,2%	95,5%
Reliability	4,38	0,774	17,7%	90,9%
Service Availability	4,34	0,745	17,2%	100,0%
Complaints	4,3	0,773	18,0%	97,7%
Customer Support	4,3	0,674	15,7%	97,7%
Task Information	4,28	0,724	16,9%	88,6%
Online Services Advantage	4,26	0,724	17,0%	86,4%
Accessibility	4,25	0,781	18,4%	100,0%
Process Management	4,25	0,806	19,0%	81,8%
Compatibility	4,1	0,8	19,5%	93,2%
Interoperability	4,08	0,818	20,0%	86,4%
Empowerment	4,03	0,811	20,1%	88,6%
E-Participation	4	0,751	18,8%	90,9%
Technical Website Quality	3,95	0,749	19,0%	90,9%
Website Access Speed	3,91	0,895	22,9%	97,7%
Variety of Services Offered	3,89	0,831	21,4%	86,4%
Processing Speed	3,88	0,9	23,2%	93,2%
Online Integrity	3,81	1,023	26,9%	84,1%
Customization	3,8	1,08	28,4%	56,8%
Alternative Channels	3,78	1,031	27,3%	84,1%
E-Democracy	3,76	0,796	21,2%	84,1%
Politicians Role	3,68	0,945	25,7%	63,6%
Website Innovation	3,66	1,004	27,4%	72,7%
Website Design	3,34	1,056	31,6%	79,5%
Emotional Appeal	3,18	1,131	35,6%	38,6%

Only 38,6% of the experts recognized relevance in the “Emotional Appeal” dimension. Moreover, the obtained mean is below the percentile 5 (3,268) when

compared to all the other means, while revealing a coefficient of variation above 33%. Accordingly, this dimension does not comply with any of the requirements set forth for its retention, being thus removed from the second round of the process. The remaining dimensions comply with the predefined requirements, and they will be used in the next round.

5.2 Assignment of domains to the dimensions

We analysed the frequency of domain assignment to each dimension by the experts (Table 2).

Table 2. Frequency of domain assignment to each dimensions

	Management	Technical	Service	Information
Emotional Appeal	58,8%	11,8%	23,5%	5,9%
Customer Support	39,5%	9,3%	34,9%	16,3%
E-Democracy	73,0%	0,0%	18,9%	8,1%
E-Participation	65,0%	2,5%	25,0%	7,5%
Politicians Role	78,6%	0,0%	7,1%	14,3%
Complaints	39,5%	11,6%	39,5%	9,3%
Transparency	53,5%	0,0%	9,3%	37,2%
Alternative Channels	48,6%	16,2%	18,9%	16,2%
Empowerment	46,2%	25,6%	23,1%	5,1%
Process Management	75,0%	2,8%	16,7%	5,6%
Online Services Advantage	44,7%	13,2%	18,4%	23,7%
Information Quality	4,5%	0,0%	6,8%	88,6%
Task Information	5,1%	5,1%	0,0%	89,7%
Deadline Compliance	6,8%	2,3%	90,9%	0,0%
Service Availability	0,0%	11,4%	88,6%	0,0%
Online Integrity	2,7%	8,1%	83,8%	5,4%
Customization	4,0%	4,0%	92,0%	0,0%
Privacy	7,1%	7,1%	73,8%	11,9%
Safety	2,3%	20,9%	67,4%	9,3%
Processing Speed	2,4%	14,6%	80,5%	2,4%
Interoperability	7,9%	13,2%	78,9%	0,0%
Variety of Services Offered	5,3%	0,0%	86,8%	7,9%
Reliability	2,5%	5,0%	90,0%	2,5%
Website Innovation	0,0%	93,8%	0,0%	6,3%
Technical Website Quality	0,0%	92,5%	0,0%	7,5%
Usability	0,0%	95,2%	2,4%	2,4%

	Management	Technical	Service	Information
Website Access Speed	2,3%	90,7%	4,7%	2,3%
Website Design	0,0%	100,0%	0,0%	0,0%
Accessibility	0,0%	86,4%	11,4%	2,3%
Compatibility	0,0%	97,6%	2,4%	0,0%

The shading indicates the highest assignment frequency value for each dimension. The results reveal that the "Management" domain displays lower agreement values. The "Complaints" dimension divides the experts between the "Management" and the "Service" domains.

In order to determine the consistency of each assignment we estimated the percentile 75 for the frequency of each domain (Table 3).

Table 3. Consistency of each assignment of each domain

	Management	Technical	Services	Information
Percentile 75	46,8%	41,0%	79,3%	12,5%

The shadings in Table 2, namely in Customer Support, Complaints, Empowerment, Online Services Advantage, Privacy and Safety, indicate those whose frequency of assignment values fall out of the percentile 75, revealing lower consistency. It is important to note that four of the eleven dimensions of the Management domain and four out of eleven in the Services domain fall below percentile 75 (the dimension Complaints appears in both domains below percentile 75), while all the dimensions highlighted in the "Technical" and "Information" domains are above percentile 75. However, it must be noted that percentile 75 displays a significantly higher frequency value (79,3%) in the Services domain, indicating that the dimensions in this domain have greater consistency.

The scores obtained for each dimension considered the quartile of the average score for each dimension. Dimensions in the 4th quartile were assigned four points, while the ones in the 3rd quartile were assigned three points. The 2nd quartile received two points and, lastly, the 1st quartile was assigned only one point. As to the "Information" domain, only the median was considered, as only two domains existed. In this case, the most scored dimension was assigned two points and the other one point.

From the application of this method, the dimension "Emotional Appeal" was excluded, and a set of twenty two dimensions was obtained. Additionally, the results reveal a certain degree of hesitation as to the domain assigned to seven dimensions.

For each dimension we also defined a weight within the assigned domain. Table 4 shows these results.

The scores displayed for the dimensions without a defined domain reflect their weight when placed in either domain.

It is worthy of note that three experts allowed us to identify three new dimensions:

- "Utility" in the existing Service domain;
- "Settlement" in the existing Service domain;

- " Decision Democratization" in a new "Democratization" domain.

Table 4. Weight by dimension

Dimension	Domain	Weight
Transparency	Management	4
Process Management	Management	4
E-Participation	Management	3
E-Democracy	Management	2
Politicians Role	Management	1
Deadline Compliance	Service	4
Reliability	Service	4
Service Availability	Service	3
Interoperability	Service	3
Variety of Services Offered	Service	2
Processing Speed	Service	2
Online Integrity	Service	1
Customization	Service	1
Information Quality	Information	2
Task Information	Information	1
Usability	Technical	4
Accessibility	Technical	4
Compatibility	Technical	3
Technical Website Quality	Technical	3
Website Access Speed	Technical	2
Website Innovation	Technical	1
Website Design	Technical	1
Safety	Service|Information	4|4
Privacy	Service|Information	4|4
Complaints	Service|Management	3|4
Customer Support	Service|Management	3|4
Alternative Channels	Service|Management	1|2
Online Services Advantage	Management|Information	4|1
Capacitation	Management|Technical	3|2

In the second round of the method we will ascertain the domain to which these dimensions should be assigned and adjust all the weights.

6 Conclusion

This paper sets forth the results from the first round of the Delphi Method process applied to the evaluation of local government e-services approach under development. The Delphi Method process has, to the present moment, proved to be effective and allowed us in this first round, and with a significant level of consensus, to present a list of dimensions assigned to their respective domains, based on relevance ranking.

This round has also shown that the preliminary list, which served as a basis for this investigation process, is aligned with our initial purpose, to the extent that from all the identified dimensions only one, Emotional Appeal, was discarded. Doubts were raised as to the domain and the relevance assigned to Safety, Privacy, Complaints, Customer Support, Alternative Channels, Online Services Advantages and Empowerment. The remaining twenty three dimensions already reveal a high level of consensus, which, notwithstanding, must be validated in the next round of the Delphi Method process. It is worthy of note that three of the experts allowed us to identify three new dimensions.

As a result, we need to resume the Delphi Method process until a consensus is reached as to the relevance of the dimensions and their assignment to their respective domains, creating metrics and weights. Subsequently, we will define a method to evaluate the quality of local government online services.

Acknowledgments. We acknowledge the financial support of AISTI (Iberian Association for Information Systems and Technologies), which permitted the registration in the WorldCIST'16 (4th World Conference on Information Systems and Technologies), held at Recife, Brazil, 22 - 24 March 2016, and consequently this publication.

References

1. Leite, P., Gonçalves, J., Teixeira, P., & Rocha, Á. (2014). Towards a model for the measurement of data quality in websites. *New Review of Hypermedia and Multimedia*, *20*(4), 301-316.
2. Rocha, A., Silva, C., Lamas, M., Castro, R., & Silva, S. (2005). Governo Electrónico nas Juntas de Freguesia: Situação na Região do Minho. In *Actas da 6ª Conferência da Associação Portuguesa de Sistemas de Informação. Bragança, Portugal*.
3. Santos, P., Melo, A. I., & Paiva Dias, G. (2013, June). Administrative modernisation and e-government: The case of Águeda. In *Information Systems and Technologies (CISTI), 2013 8th Iberian Conference on* (pp. 1-6). IEEE.
4. Jukić, T., & Vintar, M. (2006). E-government: The state in Slovenian local self-government. *Organizacija*, *39*(3).
5. Jinmei, H. (2011, August). Quality evaluation of e-government public service. In *Management and Service Science (MASS), 2011 International Conference on* (pp. 1-4). IEEE.

6. Paiva Dias, G., & Gomes, H. (2014, June). Evolution of local e-government maturity in Portugal. In *Information Systems and Technologies (CISTI), 2014 9th Iberian Conference on* (pp. 1-5). IEEE.
7. Kunstelj, M., & Decman, M. (2005). Current state of e-government in Slovenian municipalities. *Electronic Journal of e-Government*, *3*(3), 117-128.
8. Rocha, Á., & Sá, F. (2013). Planning the information architecture in a local public administration organization. *Information Development*, 0266666913489841.
9. Sá, F., & Rocha, Á. (2012). Definição da arquitetura de informação em organismo da administração pública local. *RISTI-Revista Ibérica de Sistemas e Tecnologias de Informação*, (10), 51-64.
10. Sá, F., Rocha, Á., & Cota, M. P. (2016). Potential dimensions for a local e-Government services quality model. *Telematics and Informatics*, *33*(2), 270-276.
11. Sá, F., Rocha, Á., & Cota, M. P. (2015). From the quality of traditional services to the quality of local e-Government online services: A literature review.*Government Information Quarterly*.
12. Sa, F., Rocha, A., & Pérez Cota, M. (2015, June). Preliminary dimensions for a quality model of Electronic Local Government services. In *Information Systems and Technologies (CISTI), 2015 10th Iberian Conference on* (pp. 1-10). IEEE.
13. Keeney, S., Hasson, F., & McKenna, H. P. (2001). A critical review of the Delphi technique as a research methodology for nursing. *International journal of nursing studies*, *38*(2), 195-200.
14. Linstone, H. A., & Turoff, M. (Eds.). (1975). *The Delphi method: Techniques and applications* (Vol. 29). Reading, MA: Addison-Wesley.
15. Santos, L.D.d., *Factores Determinantes do Sucesso de Serviços de Informação Online* em Sistemas de Gestão de Ciência e Tecnologia, in Escola de Engenharia. 2004, Universidade do Minho. p. 259.
16. Agrawal, A., Shah, P., & Wadhwa, V. (2009). EGOSQ-Users' Assessment of e-governance Online-Services. *CSI India*.
17. Day, J., & Bobeva, M. (2005). A generic toolkit for the successful management of Delphi studies. *The Electronic Journal of Business Research Methodology*,*3*(2), 103-116.
18. Yoo, B., & Donthu, N. (2001). Developing a scale to measure the perceived quality of an Internet shopping site (SITEQUAL). *Quarterly Journal of Electronic Commerce*, 2(1), 31-47.
19. Loiacono, E. T., Watson, R. T., & Goodhue, D. L. (2002). WebQual: A measure of website quality. *Marketing theory and applications*, *13*(3), 432-438.
20. Barnes, S. J., & Vidgen, R. T. (2002). An Integrative Approach to the Assessment of E-Commerce Quality. *J. Electron. Commerce Res.*, *3*(3), 114-127.
21. Wolfinbarger, M., & Gilly, M. C. (2003). eTailQ: dimensionalizing, measuring and predicting etail quality. *Journal of retailing*, *79*(3), 183-198.
22. Parasuraman, A., Zeithaml, V. A., & Malhotra, A. (2005). ES-QUAL a multiple-item scale for assessing electronic service quality. *Journal of service research*,*7*(3), 213-233.
23. Bauer, H. H., Falk, T., & Hammerschmidt, M. (2006). eTransQual: A transaction process-based approach for capturing service quality in online shopping. *Journal of Business Research*, *59*(7), 866-875.
24. Li, H., & Suomi, R. (2009). A proposed scale for measuring e-service quality.*International Journal of u-and e-Service, Science and Technology*, *2*(1), 1-10.

25. Sam, M., Fazli, M., & Tahir, M. N. H. (2009). Website quality and consumer online purchase intention of air ticket. *International Journal of Basic & Applied Sciences*, *9*(10).
26. Ding, D. X., Hu, P. J. H., & Sheng, O. R. L. (2011). e-SELFQUAL: A scale for measuring online self-service quality. *Journal of Business Research*, *64*(5), 508-515.
27. Papadomichelaki, X., & Mentzas, G. (2009). A multiple-item scale for assessing e-government service quality. In *Electronic Government* (pp. 163-175). Springer Berlin Heidelberg.
28. Alanezi, M. A., Kamil, A., & Basri, S. (2010). A proposed instrument dimensions for measuring e-government service quality. *International Journal of u-and e-Service*, *3*(4), 1-18.
29. Zaidi, S. F. H., & Qteishat, M. K. (2012). Assessing e-Government Service Delivery (Government to Citizen). *International Journal of eBussiness and eGovernment Studies*, *4*(1), 45-54.
30. Hien, N. M. (2014). A Study on Evaluation of E-Government Service Quality. *International Journal of Social, Management, Economics and Business Engineering*. 8(1).

webBPMN: a language to design Web Applications regulated by workflows

Riccardo Cognini [b], Michelangelo Marani [b], Alberto Polzonetti [a,b], Barbara Re [a]
[a] *Computer Science Division, School of Science and Technologies*
University of Camerino 62032 – Camerino (MC), ITALY
{*firstname.lastname*}*@unicam.it*
[b] *Research Unit, E-LInked Online System (e-Lios)*
Camerino (MC), ITALY
{*firstname.lastname*}*@e-lios.eu*

Abstract. In recent years many web applications regulated by workflows were developerd in order to permit the collaboration between many stakeholders during the execution of Business Processes. Generally, these kind of systems are implemented using web technologies in order to be easily designed, implemented and to be available in different operative systems and platform. Standard general purpose Business Process Modeling languages such as BPMN can be used to design the workflow of these systems, but they lack in the definition of which web technology has to be used to implemented each single business activity. In this paper, we propose a novel business process modeling notation named webBPMN including elements that can be used to model web applications regulated by workflows. We experimented the notation designing the Business Process of the internship web application of the University of Camerino.

Keywords. Business Process Management, Business Process Modeling, Web Application

1. Introduction

Inter-organizational Business Processes (BPs) permit to different stakeholders to successfully cooperate in order to reach a common target goal [1]. Each stakeholder involved in the BP pursues its objectives within the cooperation and shares its competencies and processes to provide the integrated functionality. Implementing a software system that allow that cooperation among different stakeholders is not an easy task. It requires a deep analysis of requirements, activities flow and how the actors interact.

Furthermore, many software systems are web based applications in which there are many stakeholders that collaborate in the same environment [2]. In several cases these software systems are based on a BP, it means that stakeholders have to perform in a specific way a predefined set of activities in order to reach goals. For instance, in an e-commerce web site there is a specific BP that drive the buyer and the seller in order to complete the purchasing of goods.

One of the main issues during the design phase of a software system is the definition of the flow of activities that have to be performed by stakeholders [3]. Languages such as Business Process Modeling and Notation (BPMN) [4], UML Activity Diagram (UML

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_54

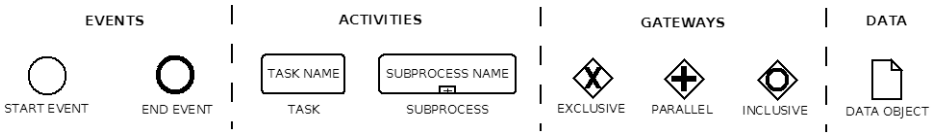


Figure 1. BPMN 2.0 Core Elements.

AD) [5], Yet Another Workflow Language (YAWL) [6] or EPC [7] are used to define the flow of activities in imperative way. The main problem of these languages is that they are general purpose and do not provide specific elements to design workflows for web based applications.

In this paper, we propose webBPMN, a BPMN 2.0 variation, in order to include elements that can be used to design web application based on BP. In particular, we consider new types of tasks and sub-processes assuming that a single atomic activity can be performed in single *Web Page Task* and that a web page can be used in order to perform many activities, then it is a *Web Page Sub-Process*. Other elements to specify client/server side functions and events are also designed. The proposed language was used to design the BP of the internship procedure of the University of Camerino. Its software system was implemented starting from a webBPMN model.

The paper is structured as follow. Section 2 provides background material related to BP modeling, the in Section 3 the novel notation is explained. Section 4 demonstrates the wellness of approach using a real use case, then Section 5 is about related works and, finally, in Section 6 we treat some conclusions.

2. Background on Business Process Management

Business Process Management (BPM) "includes concepts, methods, and techniques to support the design, administration, configuration, enactment, and analysis of Business Processes" [8]. "A BP is a collection of related and structured activities undertaken by one or more organizations in order to pursue some particular goal. Within an organization a BP results in the provisioning of services or in the production of goods for internal or external stakeholders" [9]. Public services structure, their input and output, the interdependencies among different elements can be modeled and implemented using notations and tools supporting the BP abstraction.

The accuracy of the BP modeling phase is critical for the success of an organization in particular in scenarios in which it is necessary to adapt to changing requirements. In order to design a BP different classes of languages have been investigated and defined.

In our work we refer to BPMN 2.0 an Object Management Group standard [4]. It is the most used language by domain experts due to its intuitive graphical notation. We have mainly used process diagrams, focusing on the point of view of system users. The following BPMN 2.0 elements (Figure 1) are the core elements of the language and those we will use on the approach.

- **Events**, which are used to represent something that can happen. An Event can be *Start Event* represents the points in which the BP starts, and *End Event* is raised when the BP terminates. Events are drawn as circles.

- **Activities**, which are used to represent a generic work that a company performs within a BP. An Activity can be atomic - *Task* - or not - *Sub-Process*. Activities are drawn as rectangles with rounded corners.
- **Gateways**, which are used to manage the flow of BP both for parallel activities and choices. Different types of gateways are available, the most used are followed reported. *Parallel Gateway* has to wait all their input flows to start and then all the output paths are started in parallel, it can behave as a fork respects to output paths or as a merge respects to input paths. *Exclusive Gateway* gives the possibility to describe choices both in input and output, it can be activated each time the gateway is reached and when executed it can activate exactly one output path. *Inclusive Gateway* gives the possibility to select among multiple output paths each time they are reached, it can behave also as inclusive merge. Gateways are drawn as diamonds.
- **Data Objects**, which permit to model documents, data, and other objects used and updated during the BP. Objects can also be characterized by a state. An activity can require or can generate a data object in a particular state, whereas if the state is not explicitly reported the activity is state independent. A data object cannot be in two different states at the same time. If the same object is linked to the same activity specifying two different states, this means that states are exclusive with respect to each other, therefore when the activity is executed it needs the data object in one of the available states. A Data Object is represented by a portrait-oriented rectangle that has its upper-right corner folded over. States are represented using text within squared brackets located under the object name.

Using BPMN it is also possible to define the participants (or stakeholders) involved in a BP. *Pools* can be used as elements containers in order to specify the activities that have to be executed by a single participant, they are represented via rectangle containers. Participants can communicate each other using *Message Flow* that specify that a particular task or event can be performed only if a message from another participant is received. *Message Flow* are graphically represented via a dotted arrows. An example of BPMN model in which participants communicates is shown in Figure 2. The BP shows that there are two participants, they are *Participant 1* and *Participant 2*. *Participant 1* starts the execution of the BP and then he sends a message to *Participant 2* executing the task *Send a Message*. *Participant 2* starts the execution of his BP when he receives the message from *Participant 1*, it is why there is a *Start Message Event*. Then, *Participant 2* executes the tasks *Check the Message* and *Responde* in order to send a message to *Participant 1* and ending his BP. When *Participant 1* receives this message, he has to choose if execute the task *Do Action 1* or *Do Action 2*. After the execution of the chosen task the BP execution ends.

3. WebBPMN

The proposed language named webBPMN is a BPMN 2.0 variation in which standard BPMN tasks and sub-processes are replaced with activities designed for web based applications implementing workflows. A new type of data object is also introduced in order to model the type of data used by web pages to communicate. These kinds of elements are described as follow.

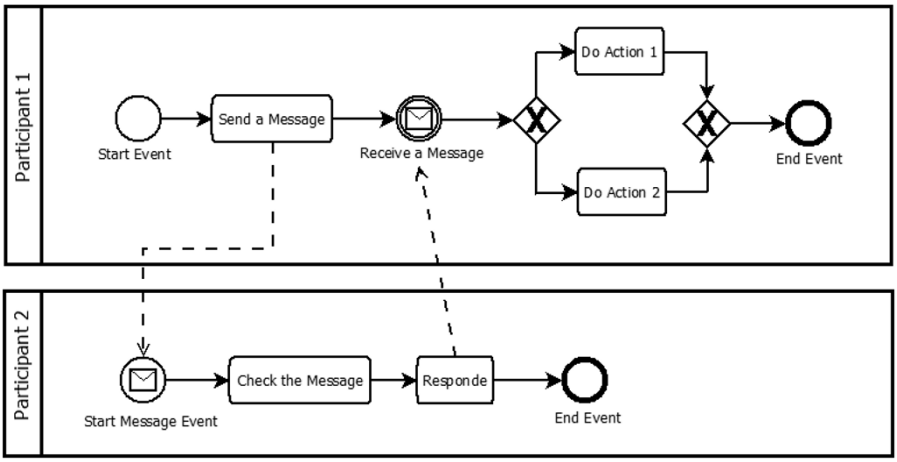


Figure 2. BPMN 2.0 Model Example.

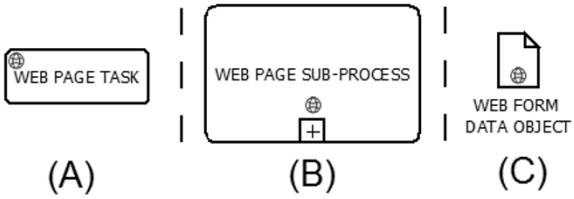


Figure 3. webBPMN Main Elements.

- **Web Page Task** is an atomic activity performed in a generic single web page (Figure 3-A). When the activity is performed a new page will be open. In this kind of task the stakeholder has to interact with the software system via a web page. For instance a *Web Page Task* can be related to a search page or a form that the stakeholder has to fill;
- **Web Page Sub-Process** is a composed activity performed in a complex web page (Figure 3-B). In this kind of activity the stakeholder should perform more that one activities in a single page beside client side technologies (such as Javascript/AJAX) or/and some events can happen. For instance a *Web Page Sub-Process* can be used to represent a page in which a web chat is implemented. A *Web Page Sub-Process* may contain a set of specific BP elements that are able to specify the behaviours of the activity. Such as in many others BPMN sub-processes a start and and end event should be insert. The list of elements that can be inserted inside are described as follow.
  - ∗ **Web Function Task** is an atomic activity that can be performed in a web page without open a new page (Figure 4-i). It can be performed automatically or manually by an user, it can be client or server side. For instance, it can be used to call a web service in asynchronous way or to perform any server side request via AJAX;

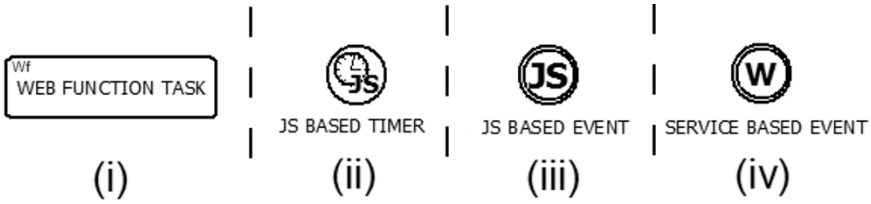


Figure 4. webBPMN Elements that can be used in a Web Page Sub-Process.

- **JavaScript Based Timer** is an event that is trigged by a timer for 1 or more times (Figure 4-ii). For instance, it can be used to refresh the page or to update the list of messages and users connected in a web chat;
- **JavaScript Based Event** is a generic client side event that can be trigged by an user action such as change the value in a dropdown list (Figure 4-iii). For instance, it can be used to represent the event that is trigged when there is an error in a Web Form input field. When an event like that is trigged a *Web Function Task* should be performed;
- **Service Based Event** is a generic event that is trigged when a Web Service respondes to a call (Figure 4-iv). For instance, it can be used to start activities when a login server responds to a request;

- **Web Form Data Object** is a particular type of data that can be generated by a web form (Figure 3-C), it means that it can be generated only by a *Web Page Task* or a *Web Page Sub-Process*. A *Web Form Data Object* is composed by a set of values and eventually by a set of data files. This data object is generated by a web page and it can be consumed by another web page. For instance, this data object can be generated by a form in which an user has to log into the web application and then it can be consumed in another page in order to verify the credentials.

Using webBPMN a BP designer can use all the standard BPMN 2.0 elements except tasks and sub-processes. Pools should be used to define which web pages can be accessible by a specific stakeholders. The interaction between stakeholders can be defined via standard BPMN *Message Flows*. Gateways are used to drive the route of the flow and define which pages should be open for each stakeholder.

4. Use Case

The described language has been applied to model the Web Application of the Students Internship Business Process of the University of Camerino. This is a service that the Univeristy has to put in place in order to permit studens to start an internship in Italian Companies - in University of Camerino each Bachelor student must do an internship to graduate. The proposed webBPMN is shown in Figure 5, it is just a simplied version of the real one.

Three stakeholders are involved in this business process, the student that has to apply for an internship, the related company and the Internship office of the University.

The trigger of a process instance is the student that has to do an internship. First, the student accesses to the Login Page that is modeled as a Web Page Sub-Process since

several function are needed to verify the identity of the student. The Web Function Task *Request ESSE3 credentias* is delegated to request username and password of the student, then the Web Function Task *Connect to ESSE3 (LDAP Server)* connects the user to ESSE3 system in which credentials are stored. The response arrives in the Service Based Event, if the credentials are correct the page related to the *Select an Internship in the List* Web Page Task is open. In this page the student can see the list of available internships, he/she can choose one of them in order to open the detail page of the internship specified by the *See Internship Details* Web Task Page. The student can candidate to the internship or return to the page in which there is the list.

When the student applies for an internship the related company receives a communication. Then, the company will log to the system via the *Log to the System* Web Page Task in order to check the student application in the *Check Application* Web Page Sub-Process. In this page the company checks the information about the student (*Check the Applicant Student* Web Function Task) and, optionally his CV (*Check the Student CV* Web Function Task). The company can choose the student for the internship of not, in case the student is chosen the *Send Confirmation of Selection* Web Page Sub-Process is open. In this page, e-mails are sent to the student and to the Internship office of the University via *Send the Mail to the Student* and *Send the Mail to the Internship Office* Web Function Tasks. These tasks are performed automatically by an JavaScript Based Timer that repeat the execution until mails are sent correctly.

When the company chooses a student for an internship, the Internship office receives a mail. The office has to log to the system via the *Log to the System* Web Page Task and then upload the P7M file related to the internship via the *Upload the P7M of the training project* Web Page Task.

Notwithstanding the complexity of the Web Application modeling of the scenario has revealed that webBPMN permits to define which activities have to be performed in each web page.

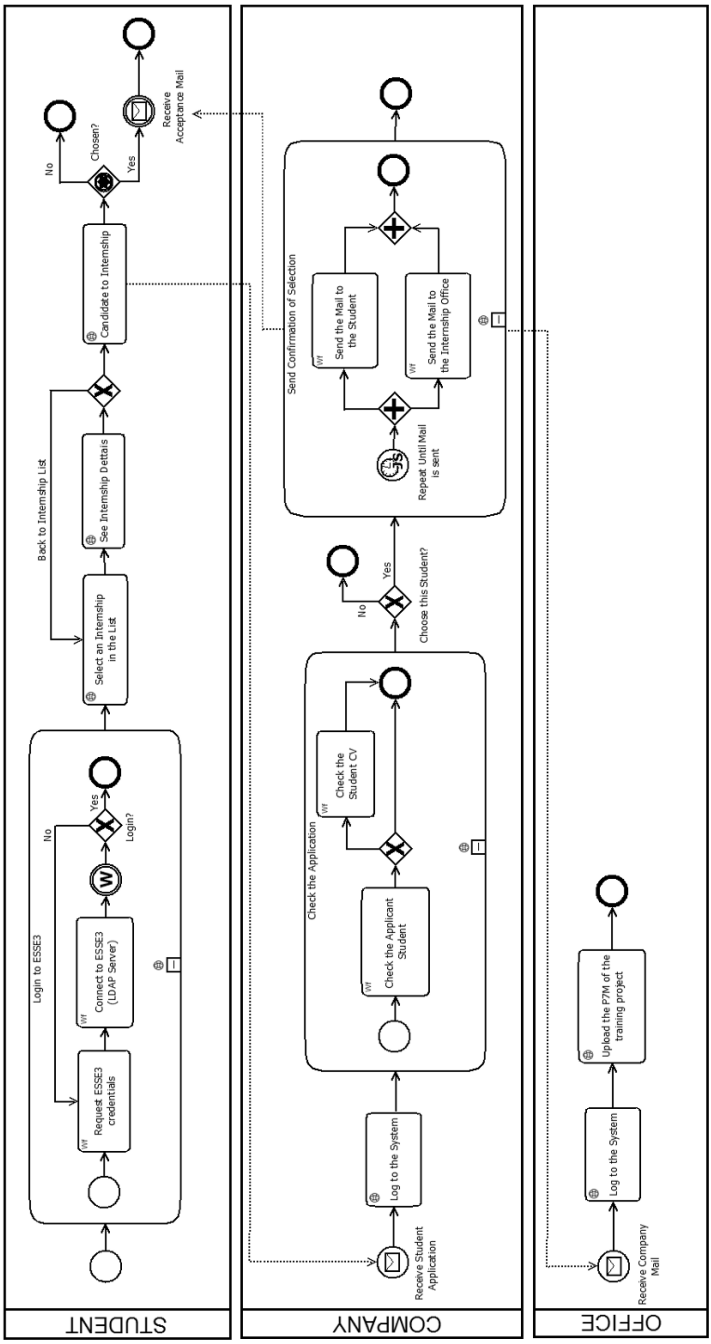


Figure 5. Internship BP of University of Camerino.

5. Related Work

In literature, there are just few languages to model web applications. Usually, languages provide few models to design different requirements of the web the applications.

The model Object Oriented Hypermedia (OO-H) is used to design generic web applications [10]. In particular, OO-H provides a navigation model named Navigation Access Diagram (NAD) that provides the necessary constructs to represent how web site user navigates between links. It is similar to the concept explained in this paper in which web pages are represented as business activities, but the used semantics is not able to represent the activities that can be performed in each web page. There are some language similar to OO-H such as Object-Oriented Hypermedia Design Method (OOHDM) [11], they share the same base approach.

Another interesting language is UML-based Web Engineering (UWE) that is an object oriented and iterative approach based on UML [12]. Also in this language there is a navigation model to specify how users navigate between links of the web site. Also in this case, the activities that users have to perform in each page are not defined by the model.

Web Modeling Language (WebML) is a language to design web sites [13]. It provides an high-level graphical representation providing different models in order to design several aspects of the designed web application. In this case there is the Composition Model that specifies the pages provided by the web application, instead the Navigation Model specifies how pages are linked together.

The main issue of these language is that they are not focused on the BP modeling. They can be used to design a generic web site also if it is not regulated by a BP. It means that they do not provide a full specification to manage all the possible situations that can happen in a BP. Instead, thanks to BPMN base notation webBPMN provides a set of elements that can be used to describe many situation and, thanks to the variation of the semantics of the BPMN activities it is possible to adapt the language for the web application modeling.

A language similar to webBPMN is WebWorkFlow that is an object oriented workflow modeling language [14]. It can be used to design simple activities flows for web application. The main lack of the language is that it does not provide a graphical representation since it is mainly used to generate an executable application. It means than also the elements provided by the language are not so much and their semantics are more related to programming languages than BPs.

6. Conclusion and Further Work

In this paper we present a notation to design Business Processes implemented via Web Technologies. The notation seems particularly suitable to specify which functions have to be implemented in which web page. The first experiment related to University of Camerino Internship BP provides encouraging results.

In the next future we plan to extend the notation including new elements in order to specify in a better way web technologies and functions. For instance, we will include the concepts of Session and Cookies extending again the BPMN data objects. We are imple-

menting a modeling environment to use the webBPMN notation, we are using ADOxx[1] to design the webBPMN meta-model. At the end, we will continue the experimental work considering other use cases in the e-government scenario.

References

[1] Vathanophas, V.: Business process approach towards an inter-organizational enterprise system. Business Process Management Journal **13**(3) (2007) 433–450

[2] Ginige, A., Murugesan, S.: Web engineering: an introduction. MultiMedia, IEEE **8**(1) (2001) 14–18

[3] Dumas, M., van der Aalst, W.M., ter Hofstede, A.H.: Process-aware Information Systems: Bridging People and Software Through Process Technology. John Wiley & Sons, Inc., New York, NY, USA (2005)

[4] OMG, B.P.M.: Notation (bpmn) version 2.0 (2011). Available on: http://www. omg. org/spec/BPMN/2.0 (2011)

[5] OMG: OMG Unified Modeling Language (OMG UML), Superstructure, Version 2.4.1 (2011)

[6] Van Der Aalst, W.M., Ter Hofstede, A.H.: Yawl: yet another workflow language. Information systems **30**(4) (2005) 245–275

[7] Mendling, J.: Event-driven process chains (epc). In: Metrics for Process Models. Volume 6 of Lecture Notes in Business Information Processing. Springer Berlin Heidelberg (2008) 17–57

[8] Weske, M.: Business process management concepts, languages, architectures. 1 edn. Springer (2007)

[9] Lindsay, A., Downs, D., Lunn, K.: Business process - attempts to find a definition. Information and Software Technology **45** (2003) 1015–1019

[10] Plessers, P., Troyer, O.D., Casteleyn, S.: Event-based modeling of evolution for semantic-driven systems. In: Advanced Information Systems Engineering, 17th International Conference, CAiSE 2005, Porto, Portugal, June 13-17, 2005, Proceedings. (2005) 63–76

[11] Schwabe, D., Rossi, G.: An object oriented approach to web-based applications design. Theor. Pract. Object Syst. **4**(4) (1998) 207–225

[12] Koch, N., Kraus, A.: Towards a common metamodel for the development of web applications. In Lovelle, J., Rodrguez, B., Gayo, J., del Puerto Paule Ruiz, M., Aguilar, L., eds.: Web Engineering. Volume 2722 of Lecture Notes in Computer Science. Springer Berlin Heidelberg (2003) 497–506

[13] Ceri, S., Fraternali, P., Bongio, A.: Web modeling language (webml): a modeling language for designing web sites. Computer Networks **33**(1) (2000) 137–157

[14] Hemel, Z., Verhaaf, R., Visser, E.: Webworkflow: an object-oriented workflow modeling language for web applications. In: Model Driven Engineering Languages and Systems. Springer (2008) 113–127

[1] http://adoxx.org/

Verification of Business Processes Against Business Rules Using Object Life Cycles

Ralph Hoch, Michael Rathmair, Hermann Kaindl, and Roman Popp

TU Wien, Institute of Computer Technology, Vienna, Austria
{hoch, rathmair, kaindl, popp}@ict.tuwien.ac.at

Abstract. While formal verification of business process models (BPMs) can be done through *model checking* (also known as *property checking*), formalizing corresponding properties having the process model available may negatively influence the formulation of properties to be checked. In addition, properties should be checkable for several processes. So, we address the problem of formalizing properties without knowing the process model.
The solution proposed in this paper employs additional models of *object life cycles*. The new key idea is to formulate properties referring to these additional models, which together can represent certain business rules. These models have to be connected with the BPM to be checked in the formalism used for model checking. This combination facilitates more rigorous model checking with a better decoupling of the specification of the original BPM from the properties to be checked. In summary, this paper presents how a combination of conventional business process models (given, e.g., in BPMN), models of business object life cycles, and formalized business rules can be used for verification through model checking.

Keywords: Verification, business process, business rule, object life cycle, model checking, property formalization

1 Introduction

Business processes need to have certain properties, e.g., given in business rules. This is difficult to verify, however, and requires business process models (BPMs), ideally formally represented. Having also the properties formally represented facilitates the use of *model checking* for formal verification, which can, in principle, show that there are no errors with regard to these properties (see, e.g., [18]).

Business process models such as those expressed in BPMN [16] typically are behavioral models, which can be compared to visual programs. Formal model checking actually has its roots in software verification and the potential for finding errors that even careful testing cannot, for principal reasons. There is, however, a lesson learned from testing, which we try to carry over to model checking. It is well known that testing your own code should be avoided. We assume that formulating properties for your own BPM has similar cognitive influence. We even observed that knowing the BPM influences the formulation of properties to be checked. It appears to be seductive to formulate properties that are more or less obviously fulfilled in the model, such as temporal sequences.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_55

Still, property formulas need to refer to a model for specifying what is actually checked. So, if the BPM is not known, e.g., for formulating properties according to a business rule, another model is required. We propose to use additional models of object life cycles for this purpose. Their states typically correspond to achievements with regard to these objects in the course of the overall business process.

Of course, these models need to be connected with the given BPM to be checked. In addition, both models need to be available in a formal representation that a given model checker can use for formal verification against properties adequately formalized as well. So, we propose a systematic transformation of a (restricted) BPMN 2.0 model to asynchronous finite state machines (FSMs) synchronized by signals. Already in the course of this transformation, the models are connected as well.

The remainder of this paper is organized in the following manner. First, we present some background material on model checking in order to make this paper self-contained. Then we discuss related work. After that, we explain our approach to formalizing properties to be checked with the help of additional models of object life cycles. For the actual verification through model-checking business processes against a business rule, we show how a process model in (restricted BPMN) can be transformed to asynchronous FSMs, and how these FSMs are connected through signals with FSMs representing object life cycles, so that a given model checker tool has been able to verify the connected FSMs against the properties formalized using the FSM representing an object life cycle.

2 Background on Model Checking

Model checking (or property checking) is a formal verification technique based on models of system behavior and properties, specified unambiguously in formal languages (see, e.g., [3]). The behavioral model of the system under verification is often specified using a Finite State Machine (FSM), in our case using synchronized FSMs. Their expressiveness is sufficient for the purpose of this paper, but Petri nets, e.g., could be used as well, if needed (depending on the given BPM and the tool used). The properties to be checked on the behavioral model are formulated in a specific property specification language. Several tools (such as SPIN [22] or NuSMV [15]) exist for performing these checks by systematically exploring the state-space of the system. When such a tool finds a property violation, it reports it in the form of a counterexample.

In this work, we make use of temporal logics such as *Linear Temporal Logic* or *Linear-time Temporal Logic* (LTL) for property specification. More precisely, we use PLTL (LTL with past). Since a rough understanding of some of their operators is needed for understanding our formalization approach, let us briefly sketch these here. PLTL provides expressions of relations between states (path formulas) using operators referring to behavior over time. In PLTL, the set of traditional propositional logic operators is extended by time operators such as:

- G (Globally): an expression p is true at time t if p is true at all times $t' \geq t$.
- F (Future): an expression p is true at time t if p is true at some time $t' \geq t$.
- O (Once): an expression p is true at time t if p is true at some previous time $t' \leq t$.

3 Related Work

Previous related work made it absolutely clear that some representation with defined semantics is a prerequisite for formal verification, also of business processes. Ligeza et al. [12] consider a specification of business processes and business rules to a certain degree complementary. They tried to reconstruct BPMN in the logic programming language PROLOG to provide formal requirements on model correctness.

Given such a representation, checking correctness properties inherent in the business process itself is possible. Wynn et al. [23] verify business processes against four defined properties (soundness, weak soundness, irreducible cancellation regions and immutable OR-joins). Sbai et al. [20] show how a model checker can be used to identify problems with a specification of a business process to be automated as a workflow, and how a verification of certain correctness properties can be accomplished. Kherbouche et al. [11] propose an approach for using model checking as a mechanism to detect errors such as deadlocks or lifelocks. They describe how a BPMN model can be translated to a Kripke structure and how this kind of model checking works with SPIN.

Some previous work addressed the question of what to verify a business process model against, to determine possible violations of certain properties given in addition to the process model itself. Fisteus et al. [8] propose a framework for integrating BPEL4WS and the SPIN and SMV verification tools. This framework can verify a process specification against properties such as invariants and goals through model checking. Armando et al. [2] show how model checking can be used for automatic analysis of security-sensitive business processes. They propose a system that allows the separate specification of the business process workflow and of corresponding security requirements. In more recent work [1], they show how model checking can be specifically used to check authorization requirements that are implemented in parts of business processes. Barros et al. [4] propose to check business processes against execution rules incorporated in workflows with model checking techniques.

We also think that rules are a major source of properties to check a business process against. The Business Rule Group defines *business rules* in the report [9] as statements that define or constrain the business of an organization. Lovrencic et al. [19] describe business rules as essential parts in today's business system model and the need for their formalization. So, we use a business rule in a running example below for illustrating our approach for model checking.

Lohmann et al. [13] present an approach based on compliance rules, which are used to automatically create artefact-centric business processes that are compliant by design. The building blocks are life cycles of the involved artefacts.

Meyer et al. [14] define a "weak conformance" between process models and synchronized object life cycles. Their algorithm for soundness checking verifies whether each time an activity needs to access a data object in a particular state, it is guaranteed that the data object is in or can reach the expected state. In contrast to our approach, they do not verify against additionally specified business rules.

Estãnol et al. [7] propose a verification approach based on artefact life cycles modeled in UML. It checks certain intrinsic properties such as liveliness of a class or an association.

The focus of our work as presented in this paper is, however, formalizing properties corresponding to business rules, as required for their automatic verification through model checking. In particular, our approach strives for decoupling property formulas from BPMs given in BPMN. Still, no previous work in the context of model checking of business process models addressed this to our best knowledge, including model-based business process compliance-checking approaches [5].

4 Formalizing a Business Rule as Properties Related to an Object Life Cycle

There are several options how a business rule can be formalized. For the purpose of model-checking, a formula in temporal logic would typically refer to the states of the BPM, but this requires that the property modeler knows the BPM he is supposed to check. However, as argued above, our formalization approach involves additional life cycle models of business objects, so that the formulas can refer to their states instead.

Let us explain this approach with a certain kind of business rule in the context of payments, as suggested as an example by our industrial project partner. It can be paraphrased as follows: *"If the amount of a received invoice is greater or equal than a threshold level, its payment has to be authorized."*.

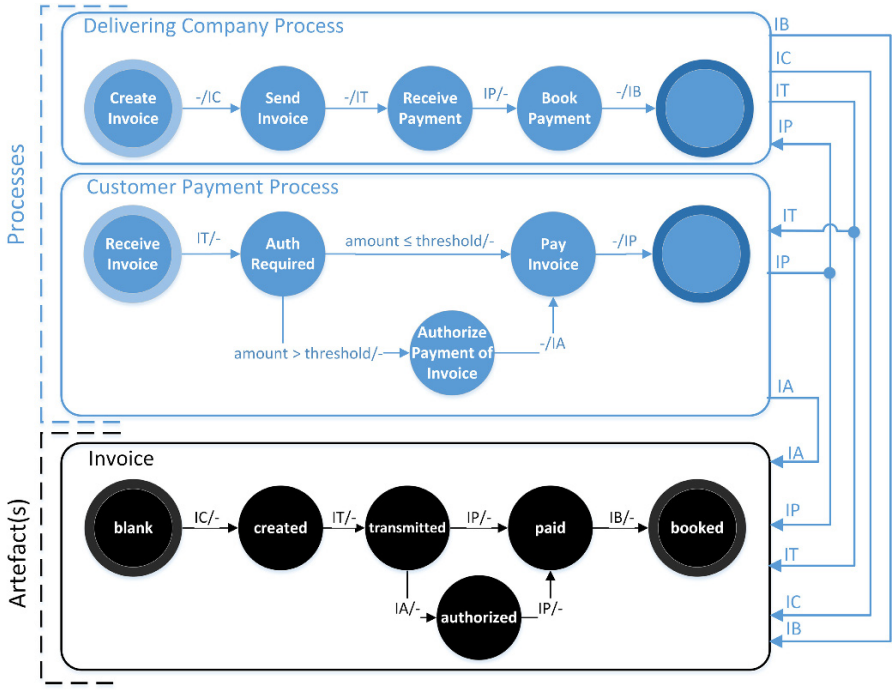
Strictly speaking, this business rule defines a characteristic of the data object Invoice. So, relating its formalization to a model of the Invoice object life cycle seems to be straight-forward. However, such a model needs to be available in the first place. We assume that in an enterprise architecture, also the life cycle of business objects should be available. Otherwise, it would have to be modeled jointly with the process owner.

For our running example, we created the life cycle model of an Invoice object ourselves, purely based on our naive understanding for illustrative purposes of this paper. It is represented in the FSM drawn in black at the bottom of Figure 1, labeled as "Artefact(s)". Apart from a start state, it has the states *created*, *transmitted*, *paid* and *booked*, as well as the state *authorized*. The latter can be reached only through the transition labeled with the Boolean variable IA, which stands for InvoiceAuthorized. Additional Boolean variables label the other state transitions and are given in the legend of Figure 1.

We use such a life cycle model to specify the business rule, without any additional knowledge of the process itself and especially its control flow. Still, variables for specifying characteristics of the Invoice object may be relevant, in our example $amount$. In addition, the threshold value defined in the customer company is needed, which is defined as an additional constant. The following PLTL formula defines a property corresponding to the business rule as

$$\mathbf{G}(((Invoice.state{=}transmitted)\ \&\ (Invoice.amount{>}customer\_company.threshold)) \rightarrow \mathbf{F}(Invoice.state{=}authorized)) \quad (1)$$

Still, the business rule is not precisely specified, since it actually involves a piece of tacit knowledge, i.e., the authorization has to be done before the payment, since it obviously does not make much sense otherwise. Unless this is formalized, however, some



IA = InvoiceAuthorized; IB = InvoiceBooked; IC = InvoiceCreated;
IT = InvoiceTransmitted; IP = InvoicePaid.

Fig. 1. Connected FSMs Including Transformation from BPMN and Object Life Cycle

process model including authorization after payment would not violate the business process in the course of its formal verification. So, we have to additionally express in another property formula that the authorization state must be reached before the Invoice has been paid:

$$\mathbf{G}(((Invoice.amount{>}customer\_company.threshold)\ \&\ (Invoice.state{=}paid)) \rightarrow \mathbf{O}(Invoice.state{=}authorized)) \quad (2)$$

So, while the object life cycle on its own does not represent the business rule, of course, these properties together with it do.

5 Model-Checking Business Processes Against a Business Rule

For a formal and automatic verification of a business process model defined in BPMN like the one shown in Figure 2, we transform it into FSMs. Since the business rule properties to check it against are formalized with references to FSMs representing object life cycles, we have to connect all these FSMs. For their actual verification against the properties formalizing the business rule, we used the model checking tool NuSMV.

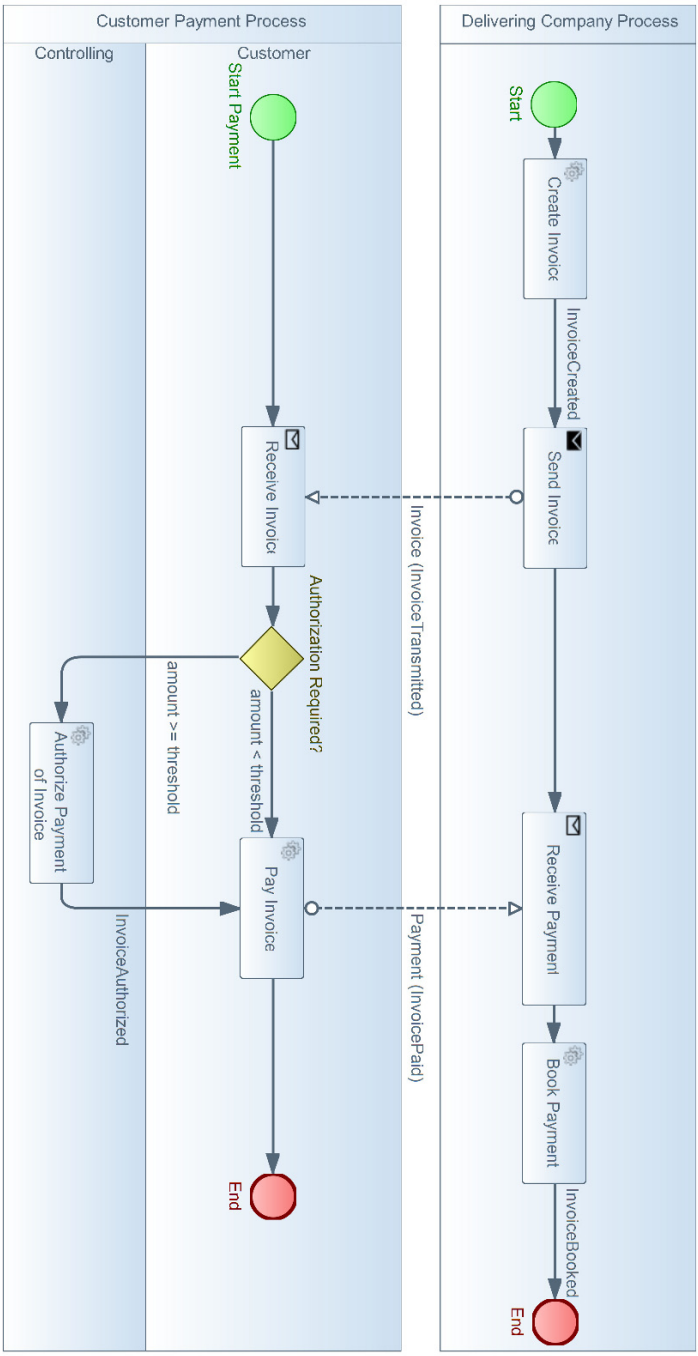


Fig. 2. Payment Handling Process in BPMN, Including Authorization

The process model to be checked in our running example as shown in BPMN in Figure 2 is based on a simplified version of the "payment handling" process of [21, p. 108], which we use here as a reference process. This payment handling process starts with the creation of an Invoice. This Invoice is then sent to the Customer. After the Customer has received the Invoice, she makes the payment of the Invoice. Once the payment is received, it is booked as paid. After that, this example reference process is finished.

While the payment is unconditional in this reference process, ours in Figure 2 actually includes a conditional authorization according to our informally given business rule. This authorization replaces the simple Payment Activity of the reference process with a whole process part as shown in Figure 2.

For connecting this process with the object life cycle(s), additional information is needed in the control flow definition of the former on the state changes in the latter. For this purpose, we annotate the control flow representation accordingly. For example, after the Task *Create Invoice*, the annotation *InvoiceCreated* provides such information. It is used in the course of the transformation of the BPM to FSMs for interleaved establishment of connections through signals with the FSM(s) representing the object life cycle(s).

Let us sketch first how to transform the BPMN model of Figure 2 to the two FSMs given at the top of Figure 1 labeled as "Processes". In fact, the overall process based on the reference process as sketched above consists of two sub-processes, one in each Pool of the BPMN model. These two Pools are transformed to two asynchronously scheduled FSMs. Each of their States, represented by circles in the diagram, corresponds to a Task in the BPMN model. The control flow as given by the arrows between Tasks in BPMN is represented through corresponding state transition relations.

In addition, for synchronizing the two FSMs representing the process parts of the two Pools in Figure 1, Boolean synchronization signals are defined: IT (InvoiceTransmitted) and IP (InvoicePaid). They represent the communication messages shared between the Pools in the BPMN model. The Customer Payment Process is held in State *Receive Invoice* until an Invoice is transmitted from the Delivering Company Process in State *Send Invoice*, and the Delivering Company Process is held in State *Receive Payment* until the Invoice is paid in the Customer Payment Process, in its State *Pay Invoice*.

More generally, such a transformation from (restricted) BPMN models to FSMs and their interleaved establishment of connections with the FSM(s) representing object life cycles works systematically according to the following steps:

1. For each Pool in BPMN create an FSM.
2. For each Task or Gateway in this Pool create a State in this FSM.
3. If this Task has an outgoing message, create a corresponding signal setting on each outgoing transition of this State.
4. If this Task has an incoming message, create a signal trigger on the corresponding outgoing transition of this State.
5. For each BPMN control flow element create a corresponding transition.
6. For each annotated BPMN control flow element (additionally) create a corresponding signal setting.

7. For each condition specified on a control flow element (from a Gateway) create a corresponding signal trigger on the corresponding outgoing transition of the State (of this Gateway).

In our running example, the FSMs of Figure 1 and their connections result. The signal handling between the FSMs consists of raising and catching events, where the particular connections in the figure automatically arise.

Given all these connected FSMs and the property formulas, the model checking tool NuSMV can do formal and automatic verification. Technically, it schedules the Delivering Company and Customer FSMs in a random way. For fair execution, i.e., each FSM is scheduled for execution at least once after a dedicated time interval, a so-called fairness constraint has to be added in the code.

For the FSMs representing the object life cycle and the business process of Figure 2, NuSMV cannot find any violation. However, NuSMV finds counterexamples showing violations of the properties of Formulas 1 and 2 in the FSMs representing the object life cycle and the reference business process of [21, p. 108] (as also sketched above).

6 Discussion

So, it is actually possible to formulate additional properties to be checked without knowing the BPM model that is to be verified. The link is given by models of object life cycles. Still, the question arises whether the additional effort is worth it. Through the separation of concerns, cognitive influence on the formulation of properties to be checked by knowing the BPM is avoided. While this was our initial motivation, there is another advantage of our new approach. It allows the verification of each BPM connected with the related object life cycle(s) against the same set of properties (modeling business rules) due to this decoupling.

As presented in this paper, we explain our approach to verifying BPMN business process models against business rules specified on object life cycles based on FSMs, actually synchronized ones, primarily for didactic reasons due to their simplicity. In fact, most of the existing model checkers at least originally worked with FSMs.

FSMs (including synchronization through signals) are sufficient for our example, but certain more complex processes cannot be translated to FSMs at all, due to their inherent limitation of expressiveness. For example, BPMN multi-instance tasks, which can create a potentially infinite number of parallel task instances, cannot be translated to FSMs, also not to a fixed number of FSMs that are synchronized with signals.

Instead of FSMs, however, Petri nets may be used. BPMN models can be transformed (automatically) to Petri nets according to, e.g., Raedts et al. [17] and Dijkman et al. [6].

Still, our approach intrinsically needs additional object life cycle models. These can be represented in Petri nets as well (possibly even translated from FSMs). As already indicated above, the approach by Meyer et al. [14] can integrate process models with object life cycles in Petri nets.

For using model checking tools, yet another transformation from Petri nets to their specific input languages is needed. For example, Raedts et al. [17] also propose auto-

matic translation from Petri nets to mCRL2 to facilitate the use of model checking tools based on this language for the verification of process models.

Based on this related work, our new approach of formalizing properties using object life cycles can be easily generalized for unrestricted BPMN. Due to the change of the formalism, the formulation of properties representing a business rule has to be changed as well. Since Petri nets focus on *transitions* and *places* rather than states, small adaptations in these property formulas are necessary (i.e., references to places instead of states).

7 Conclusion and Future Work

In this paper, we address the problem of formulating properties according to business rules for formal verification of business processes given in BPMN, without knowing them. Such BPMs focus on the control flow rather than the business objects involved. Our new approach builds on additional models of object life cycles.

We demonstrate this approach by representing (and extending) a process excerpt from a book in BPMN, and by formalizing a business rule informally given by our industry project partner. The corresponding property formulas refer to an additional object life cycle model, which is connected with the BPM.

For establishing this connection, we currently use informal annotations of BPMN models. Instead of them, we plan to investigate the use of *semantic* annotations like the ones we used in another approach for V&V of service composition and business processes [10].

This approach follows the principle of separation of concerns by decoupling the formalization of properties corresponding to business rules from the BPM. As a result, properties can be checked, in principle, for each BPM connected with the related object life cycle(s).

8 Acknowledgment

Part of this research has been carried out in the ProREUSE project (No. 834167), funded by the Austrian FFG.

References

1. Armando, A., Ponta, S.E.: Model checking authorization requirements in business processes. Computers & Security 40(0), 1 – 22 (2014)
2. Armando, A., Ponta, S.: Model checking of security-sensitive business processes. In: Degano, P., Guttman, J. (eds.) Formal Aspects in Security and Trust, Lecture Notes in Computer Science, vol. 5983, pp. 66–80. Springer Berlin Heidelberg (2010)
3. Baier, C., Katoen, J.P.: Principles of Model Checking. MIT Press (2008)
4. Barros, C., Song, M.: Automatized checking of business rules for activity execution sequence in workflows. Journal of Software 7(2) (2012)
5. Becker, J., Delfmann, P., Eggert, M., Schwittay, S.: Generalizability and applicability of model-based business process compliance-checking approaches — a state-of-the-art analysis and research roadmap. BuR — Business Research 5(2), 221–247 (2012)

6. Dijkman, R.M., Dumas, M., Ouyang, C.: Semantics and analysis of business process models in BPMN. Inf. Softw. Technol. 50(12), 1281–1294 (Nov 2008)
7. Estañol, M., Sancho, M.R., Teniente, E.: Verification and validation of UML artifact-centric business process models. In: Zdravkovic, J., Kirikova, M., Johannesson, P. (eds.) Advanced Information Systems Engineering, Lecture Notes in Computer Science, vol. 9097, pp. 434–449. Springer International Publishing (2015)
8. Fisteus, J.A., Fernández, L.S., Kloos, C.D.: Applying Model Checking to BPEL4WS Business Collaborations. In: Proceedings of the 2005 ACM Symposium on Applied Computing. pp. 826–830. SAC '05, ACM, New York, NY, USA (2005)
9. Group, T.B.R.: Defining Business Rules – What Are They Really? (July 2000), http://www.businessrulesgroup.org/first_paper/BRG-whatisBR_3ed.pdf
10. Hoch, R., Kaindl, H., Popp, R., Ertl, D., Horacek, H.: Semantic Service Specification for V&V of Service Composition and Business Processes. In: Proceedings of the 48nd Annual Hawaii International Conference on System Sciences (HICSS-48). IEEE Computer Society Press, Piscataway, NJ, USA (2015)
11. Kherbouche, O., Ahmad, A., Basson, H.: Using model checking to control the structural errors in BPMN models. In: Research Challenges in Information Science (RCIS), 2013 IEEE Seventh International Conference on. pp. 1–12 (May 2013)
12. Ligeza, A., Kluza, K., Potempa, T.: AI approach to formal analysis of BPMN models. Towards a logical model for BPMN diagrams. In: Computer Science and Information Systems (FedCSIS), 2012 Federated Conference on. pp. 931–934 (Sept 2012)
13. Lohmann, N.: Compliance by design for artifact-centric business processes. Information Systems 38(4), 606 – 618 (2013)
14. Meyer, A., Weske, M.: Weak conformance between process models and synchronized object life cycles. In: Franch, X., Ghose, A., Lewis, G., Bhiri, S. (eds.) Service-Oriented Computing, Lecture Notes in Computer Science, vol. 8831, pp. 359–367. Springer Berlin Heidelberg (2014)
15. NuSMV: NuSMV: a new symbolic model checker. http://nusmv.fbk.eu/, [Online; accessed 01-December-2014]
16. (OMG), T.O.M.G.: Business Process Model and Notation (BPMN) (Jan 2011), http://www.omg.org/spec/BPMN/2.0, [Online; accessed 08-February-2015]
17. Raedts, I., Petković, M., Usenko, Y.S., Werf, J.M.V.D., Groote, J.F., Somers, L.: Transformation of BPMN models for Behaviour Analysis. In: Verification and Validation of Enterprise Information Systems, 2007 Conference on. pp. 126–137 (2007)
18. Rathmair, M., Hoch, R., Kaindl, H., Popp, R.: Consistently formalizing a business process and its properties for verification: A case study. In: Ralyté, J., España, S., Pastor, O. (eds.) The Practice of Enterprise Modeling - 8th IFIP WG 8.1. Working Conference, PoEM 2015, Valencia, Spain, November 10-12, 2015, Proceedings. Lecture Notes in Business Information Processing, vol. 235, pp. 126–140. Springer (2015)
19. Sandra Lovrencic, Kornelije Rabuzin, R.P.: Formal Modelling of Business Rules: What Kind of Tool to use? (2006), hrcak.srce.hr/file/32935
20. Sbai, Z., Missaoui, A., Barkaoui, K., Ben Ayed, R.: On the verification of business processes by model checking techniques. In: Software Technology and Engineering (ICSTE), 2010 2nd International Conference on. vol. 1, pp. V1–97–V1–103 (Oct 2010)
21. Schumacher, J., Meyer, M.: Customer Relationship Management strukturiert dargestellt: Prozesse, Systeme, Technologien. Springer Berlin Heidelberg (2003)
22. SPIN: SPIN Verifying Multi-threaded Software with Spin. http://spinroot.com/spin/whatispin.html, [Online; accessed 01-December-2014]
23. Wynn, M., Verbeek, H., van der Aalst, W., ter Hofstede, A., Edmond, D.: Business process verification – finally a reality! Business Process Management Journal 15(1), 74–92 (2009)

Promoting Modularity in a Requirements Engineering Process for Software Product Lines

Dorgival Netto[1 2], Carla Silva[2]

[1] Center of Informatic - Federal University of Paraiba (UFPB)
João Pessoa, Brazil
[2] Center of Informatic - Federal University of Pernambuco (UFPE)
Recife, Brazil
{dpsn2@cin.ufpe.br, ctlls@cin.ufpe.br}

Abstract. Goal models can capture similarities and the variability of a Software Product Line (SPL), but they cannot describe the detailed behavior of the SPL functionality. Due to this limitation, a process called GS2SPL was defined to systematically obtain, from goal models, feature models and the specification of use case scenarios with variability. However, the variability and the configuration knowledge of the SPL are tangled in the scenarios description, jeopardizing the maintenance and reuse of this artifact. In order to handle with this problem, it was proposed a technique called MSVCM. It specifies the SPL variability and the configuration knowledge separately from the common behavior present in the scenarios, as well as it defines a process to configure the specification of a product. However, there is a lack of traceability between the MSVCM scenarios and the goals and quality that the stakeholder expects to achieve. Thus, this work proposes to obtain, systematically, the specification of MSVCM scenarios from goal models. Using goals in SPL allows a systematic derivation of the SPL requirements from these goals. This new approach is called GAS2SPL and it is illustrated by using the TaRGeT example.

Keywords: Software Product Lines; Goal Models; Aspectual Scenarios; Requirements Engineering

1 Introduction

Requirements Engineering (RE) is a sub-area of Software Engineering, which involves the activities related to the definition of the system requirements [1]. A Software Product Line (SPL), according to [2], is a set of software systems with a shared common and managed set of features. The feature is a system property or functionality that is relevant to some stakeholders [3]. In RE for Software Product Lines, feature models are used to capturing both similarities and variability of the product line [4]. However, it remains a challenge to establish a relationship between the features of a software product and the stakeholder's goals that originated these features [4]. Likewise, it is not possible systematically to define which features should be selected for a specific product [6]. In this scenario, Goal-Oriented Requirements Engineering approaches or GORE [1] can be used as a way to discover both variables and common requirements of SPL, besides making more systematic the configuration of a specific product. Therefore, some GORE approaches have been proposed to support requirements variability modeling and have been well accepted in the Software

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_56

Engineering community, such as Aspectual i* [7], Asadi [8], Yu [19], PLAOVGraph [20] and GS2SPL (Goals and Scenarios to SPL) [6].

According to [6], although goal models are able to represent both common and variable features of a product line, they cannot capture the dynamic behavioral aspects of the product line. Scenarios represent a proper technique to describe the behavior of a system [5]. Thus, Souza et al. [6] defined the GS2SPL approach that integrates goal models, features models and use case (UC) scenarios with variability specified using the PLUSS (Product Line Use Case Modeling for Systems and Software Engineering) technique [13]. However, according to Bonifacio et al. [10], regarding the benefits of variability representation in scenarios, most approaches for SPL do not present a clear separation between variability management and the UC scenario specification. Many techniques produce a specification tangling product variants with configuration information. In this case, the configuration information is considered a crosscutting concern, i.e., a behavior that impact or influence multiple modules or system components [11]. Separation of Concerns is the foundation of the aspect-oriented paradigm that promotes the modularization of crosscutting concerns into aspects to separate them from other system concerns. In the RE area, an aspect encapsulates a requirement that affects other system requirements and this encapsulation facilitates the understanding of the system and the reuse of system components [12]. The modularization of crosscutting concerns in scenarios can be handled by the MSVCM (Modeling Scenario Variability as Crosscutting Mechanisms) technique [10]. According to [9], this technique improves the separation of concerns between variability management and SPL scenario specifications. It uses different modules to represent common and variable behavior, and annotations in scenarios to show where the advice will be placed. MSVCM defines a new way to specify variability in UCs for SPL, a new representation of the configuration knowledge (CK) and a new process to derive product specifications, named weaving process. A comparison among several scenario specification techniques was presented in [9] and the MSVCM was evaluated as the most proper technique to produce separation of crosscutting concerns in UCs scenarios. For the best of our knowledge, there are not approaches that support both GORE and aspectual scenarios for SPL. Therefore, this paper presents an extension of the GS2SPL approach to address this issue by supporting the specification of aspectual scenarios using the MSVCM technique. This new approach, named GAS2SPL (Goals and Aspectual Scenarios to SPL), obtains aspectual scenarios from goal and feature models.

This paper is organized as follows. Section 2 describes the GAS2SPL approach. Section 3 summarizes our work.

2 GAS2SPL

The GAS2SPL (Goals and Aspectual Scenarios to Software Product Lines) process covers RE activities of both Domain Engineering (DE) and Application Engineering (AE) defined in the Pohl's et al. framework [14]. GAS2SPL extend the GS2SPL approach [6] to include aspectual scenarios, described using the MSVCM technique [10]. MSVCM represent separately the SPL variability and the CK that contains information to generate members of the SPL. The process consists of eight activities being the first seven related to DE, and the last, a subprocess related AE. The first five activities were inherited from GS2SPL [6] (**Creation of SR model**, **Identification of candidate elements to be features**, **Reengineering the SR model**, **Elaboration of the feature model**, **Feature model refinement**). We use the SPL TaRGeT (Test and Requirements Generation Tool) [15] to exemplify the activities created to obtain and configure the MSVCM scenarios. TaRGeT is

an SPL of tools that automatically generate test suites from requirements documents. In the following, the activities for the **elaboration of scenarios, advice, and intertype declaration**, as well as **CK** are presented. The intertype declarations allow you to enter new attributes and methods in basic classes of the program and can also change the hierarchy of classes. An advice adds steps in the scenarios of the base UC. For the complete description of GAS2SPL, please refer to [21].

2.1 Elaboration of Scenarios

The activity **Elaboration of Scenarios** aims to identify UCs from the i* model to elaborate their scenarios, advice, and intertype declarations. The i* framework [22], is a Goal-Oriented approach, that stakeholders are represented as actors that depend on each other to achieve their goals, perform tasks and provide resources. Each goal is analyzed from its actor point of view, resulting in a set of dependencies between pairs of actors.

It is the main modification in relation to the GS2SPL process [6]. Instead of using the PLUSS [13] technique to specify UC scenarios, the GAS2SPL specifies scenarios using the MSVCM [10] technique, aiming at promoting separation of crosscutting concerns. In the case of SPL, crosscutting concerns refer to the SPL variability and the CK that must be specified separately from the UC scenario. This activity is also responsible for elaborate the CK through the relation of features to alternative scenarios, intertype declarations and advice. CK relates features expression to transformations in charge to configure the scenarios of a specific product [10]. A feature expression can be understood as a set of constraints that must be satisfied. To elaborate the CK, it is required to get the feature model as well as the descriptions of scenarios, advice, and intertype declarations. CK defined in MSVCM uses three transformations to handle the different types of variability: evaluate advice, select scenario and bind parameter [10].

The original set of transformation, defined in [10], did not consider the inclusion of secondary scenarios in the product configuration. To overcome this limitation, we have included the intertype declaration scenario. This can be considered as an extension of the MSVCM technique. To select the intertype declaration in a product configuration, we should use select scenario transformation.

The activity **Elaboration of Scenarios** uses the SR model with cardinality (Fig. 1) as an input artifact. This model depicts five actors (Tester, Test Engineer, Company, Requirements Engineer and TaRGeT) and their dependencies. The boundary of the TaRGeT actor provides information on how this actor can fulfill its dependencies and why it depends on other actors. The main goal of TaRGeT is the Generation of Test Suite, attending the dependence Generated Test Suite from the Test Engineer actor. This goal (end) is met by implementing either Generate Test Suite or Generate Detailed Test Suite Directly tasks (means) that are related to the goal by a means-end relation. Engineer Requirements expects TaRGeT contributes to Quality [Artifacts] and this, in turn, depends on Engineer Requirements for your goal Obtained Requirements Document be attended. Obtaining Requirements Document, which meets the Requirements Document Provided dependence, can be satisfied by the Upload Document or Write in the Tool Editor tasks.

In the following, we present the guidelines of the GAS2SPL approach to obtain scenarios from i* models with cardinality.

Dependencies between an actor mapped to a UC actor and the system-to-be actor can generate UCs; Goal dependencies in i* are mapped to UCs. Task dependencies should be investigated if they need to be decomposed into sub-tasks.

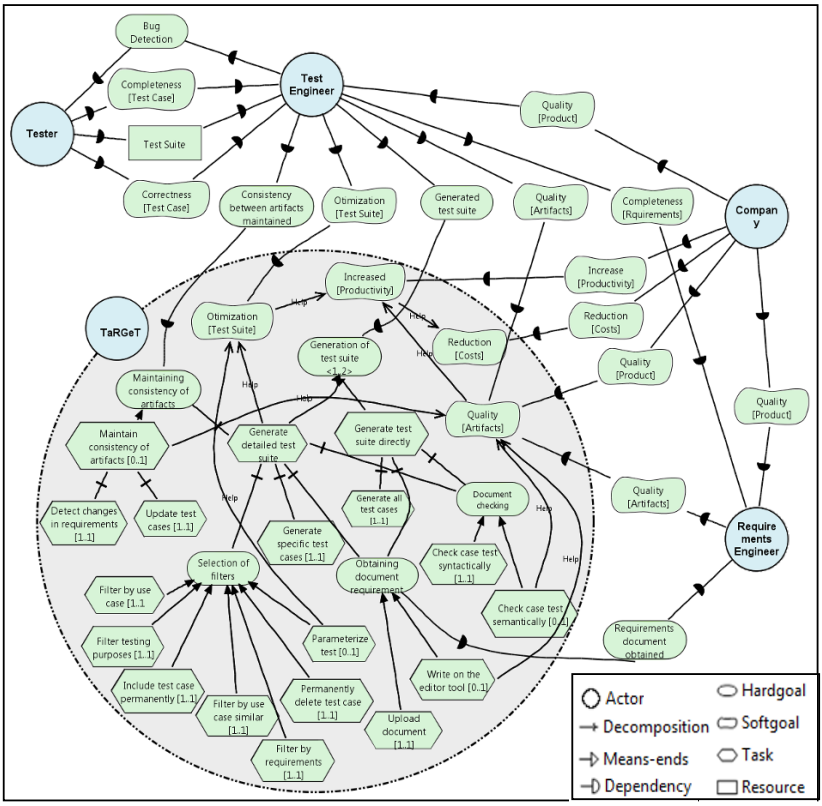


Figure 1. SR model with cardinality of TaRGeT

If a task requires many steps to be executed, then it can be mapped to a UC; Resource dependencies should be investigated if they can only be obtained after many interaction steps between the external actor and the system-to-be. If so, the action to get the resource can be mapped to a UC.

In relation to the original guidelines defined in the GS2SPL approach, these previous guidelines were changed to analyze dependencies in both directions between an external actor and the actor representing the system-to-be. Guidelines from GS2SPL which deals with the creation of the UC diagram were removed because GAS2SPL does not use this diagram. It is worth to mention that the guidelines defined by Sousa et al. [6] were adapted from the guidelines that Santander [16] has defined to obtain traditional UC scenarios from i* models. According to the guideline 5, the UCs obtained from the TaRGeT SR model are Maintain Consistency of Artifacts, Generated Test Suite, and Obtain Document Requirements. Due to lack of space, only the *UC Obtain Document Requirements* is shown in Fig. 2.

UC02 - Obtain Document Requirements		
Main Scenario 01	**Description:** Document Requirement Obtained	
ID	**User Action**	**System Response**
MS01.01		

Figure 2 Use Case Obtain Document Requirement

Analyzing the scenario from Fig. 2 it is noticed that the scenario generated by using the guideline is incomplete, this occurs due to i* framework limitations. This occurs because goal models are not tailored to capture behavioral aspects. Thus, we inherit from GS2SPL [6] the activity **Refinement of UC Scenarios** to generate a complete description of the UCs. This activity is realized after the activity elaboration of scenarios and can be performed several times by the domain engineer until it is satisfied with the details of the descriptions scenarios obtained. This activity is not detailed for the sake of space.

Guideline 5.6: UC derived of the main goal from SR model will be mapped, in the CK, through select scenario transformation, as this is a mandatory UC. The remaining UCs will not be mapped in the CK because they depend on the existence of their parents elements to exist. Applying the 5.6 guideline, the CK is shown in Table 1. Thus, select scenario transformation should follow the template <idUseCaseScenario.idMainScenario>.

Table 1 Version 1 Configuration Knowledge of TaRGeT

Feature Expression	Transformation
Generated Test Suite	*select scenario* UC01.MS

Guideline 6: Analyze the system-to-be actor to extract information that may generate more UCs, advice and intertype declarations of the SPL.

Guideline 6.1: Each internal goal of the system-to-be actor, which has no direct link with a dependency, will be mapped to a UC of the system. Applying this guideline to the TaRGeT, we obtain the UCs *Document Checked* and *Filter Selected*. The *UC Document Checked* is shown in Fig. 3.

UC04 - Document Checked		
Main Scenario 01		**Description:** Check Document
ID	**User Action**	**System Response**
MS01.01		

Figure 3 Use Case Document Checked

Guideline 6.2: Elements with cardinality [1..1], in the SR model, which are sub-elements of an element with cardinality [1..1], represent the common part of SPL and can be captured as the main scenario and alternative scenarios of the UC related to the root element (henceforward called the base UC). The sub-guidelines this guideline were not presented because they do not apply to TaRGeT example, for your SR model has no element with cardinality [1..1] to be a sub-element of another element with cardinality [1..1].

Guideline 6.3: The sub-elements with cardinality [0..1] or involved in a means-end relationship with cardinality <i..j> represent the variability of SPL and can be captured as an advice or an intertype declaration. The intertype declarations create alternative scenarios and point out the step where they should happen in the main scenario of the UC representing the root goal from the means-end relationship (henceforth called base UC). An advice adds steps in the scenarios of the base UC.

Guideline 6.3.1: If the cardinality is in the means-end relationship, the sub-elements will be mapped to intertype declarations responsible for creating at least i and at most j alternative scenarios in the base UC, following the <i,j> cardinality defined in the means-end relationship. Applying this guideline to the TaRGeT, the intertype declarations obtained is *Generate Detailed Test Suite* (Fig. 4).

Guideline 6.3.2: An intertype declaration must have a unique identifier and suggests that you follow the ITDnumberOfIntertypeDeclaration format. In addition to the identifier, the template should contain a description, which may be the goal scenario. The steps of the intertype declaration must be identified by a unique number, following the

ITDnumderIntertypeDeclaration.numberOfStep format. The creation of the Alternative scenario will be performed by adding the annotation @create in the steps of the main scenario and the identifier intertype declaration. This information is in the knowledge configuration and the inclusion will only be carried in the product configuration of SPL. Applying the guidelines 6.3.1 and 6.3.2 to the TaRGeT, the intertype declaration obtained is shown in Fig. 4.

ITD01		**Description:** Generate Detailed Test Suite
ID	**User Action**	**System Response**
ITD01.01		

Figure 4 Intertype declaration Generate Detailed Test Suite

Guideline 6.3.3: Intertype declaration must be mapped, in the CK through the application of select scenario transformation, adapted from [17]. Applying this guideline to the TaRGeT, we obtain the following CK (Table 2).

Table 2 Version 2 Configuration Knowledge of TaRGeT

Feature Expression	Transformation
Generated Test Suite	*select scenario* UC01.MS
Generated Detailed Test Suite	*select scenario* ITD01.UC01.MS

Guideline 6.3.4: If a means-end relationship has more than one sub-element and the cardinality is in the sub-elements, each sub-element with cardinality [0..1] will be mapped to an intertype declaration. Applying the guideline 6.3.4 to the TaRGeT, the intertype declarations generated is Parameterize Test. Applying the 6.3.3 guideline to the TaRGeT, we obtain the following CK (Table 3).

Table 3 Version 3 Configuration Knowledge of TaRGeT

Feature Expression	Transformation
Generated Test Suite	*select scenario* UC01.MS
Generated Detailed Test Suite	*select scenario* ITD01.UC01.MS
Parameterize Test	*select scenario* ITD04.UC05.MS

Guideline 6.3.5: If a means-end relationship has only one sub-element and this sub-element has cardinality [0..1], it will be mapped to an advice. Applying this guideline, we obtain the advice *Maintain Consistency of Artifacts* (Fig. 5).

Guideline 6.3.6: Each sub-element with cardinality [0..1] of a relation task decomposition will be mapped to an advice that will add steps to the main scenario of the base UC. This guideline does not apply to TaRGeT example, for your SR model has no sub-elements with cardinality [0..1] of a task decomposition.

Guideline 6.3.7: An advice varies according to the moment of its execution. Therefore, the TypeOfAdvice can have a modifier before, after or around [18]. In addition to the modifier, the pointcut must have a name following @nameOfPointcut format. Therefore, the advice can be added before, after or around the joinpoint indicated in the base UC. Applying the guidelines 6.3.4 and 6.3.6 to the TaRGeT, the advice generated is shown in the figure Fig. 5.

ADV01		
Description: Maintain Consistency of Artifacts		**After @consistency**
ID	**User Action**	**System Response**
ADV01.01		

Figure 5 Advice of the Use Case Maintain Consistency of Artifacts

Guideline 6.3.8: Advice must be mapped, in the CK, through the transformation evaluate advice, defined by [17]. This transformation makes the composition of advices to joinpoint specific and is used to modularize optional and alternative steps that are tangling with common specifications of a scenario [17].

Table 4 Version 4 Configuration Knowledge of TaRGeT

Feature Expression	Transformation
Generated Test Suite	*select scenario* UC01.MS
Generated Detailed Test Suite	*select scenario* ITD01.UC01.MS
Parameterize Test	*select scenario* ITD04.UC05.MS
Maintain Consistency of Artifacts	*evaluate advice* ADV01

Guideline 6.4: Elements with cardinality [1..1] that are not sub-elements of elements with cardinality [1..1] also represent the SPL variability and can be mapped to advices, intertype declarations or optional UCs.

Guideline 6.4.1: The sub-elements with cardinality [1..1] in a decomposition of an optional (root) task (with cardinality [0..1] or an alternative task in a means-end link with cardinality) will be mapped to steps of an advice or an intertype declaration obtained from the root task. To define if this root task is an advice or an intertype declaration, we must apply the sub-guidelines 6.3. Applying the guidelines 6.4.1 to the TaRGeT, we obtain a new version of some scenarios previously identified, as shown in Fig. 6 and Fig.7.

ADV01		
Description: Maintain consistency of artifacts		**After @consistency**
ID	**User Action**	**System Response**
ADV01.01	Detect change in requirements	Detects that there was a change in requirements from the previous version of the document
ADV01.02	Update UC	Updates test cases related to the UCs modified

Figure 6 Advice of the Use Case Maintain Consistency of Artifacts

Guideline 6.4.2: If a means-end link has more than one sub-elements and the cardinality is in the sub-elements, each sub-element with cardinality [1..1] will be mapped to an alternative scenario of the base UC. The description of the alternative scenario should contain the name of the element that originated it. The base UC is optional because the element that originated it is not sub-element of an element with cardinality [1..1] (i.e., it is not a sub-element of a mandatory element of the SPL). To each alternative scenario created, we must update the main scenario of the base UC, indicating the step where the alternative scenario can to occur. The indication must use the format [CA.<numberOfScenario>].

ITD01		**Description:** Generate detailed test suite
ID	**User Action**	**System Response**
ITD01.01	Generate specific test cases	

Figure 7 Version 2 ITD Generate Detailed Test Suite

Applying the **guideline 6.4.2** to the TaRGeT, we obtain a new version of scenario previously identified, as shown in Fig. 8.

UC02 - Obtaining Document Requirement		
Main Scenario		**Description:** Obtaining document requirement
ID	**User Action**	**System Response**
MS01	[AS01]	

Figure 8 Version 2 of the Obtaining Document Requirement

The alternative scenarios generated are *upload document*, *document checked* and *check test case syntactically*. Due to lack of space, only the first is shown in Fig. 9.

UC02 - Obtaining Document Requirement		
Alternative Scenario 01		**Description:** Upload document
ID	**User Action**	**System Response**
AS01.01	Upload document	Asks the user to enter the path of the requirements document

Figure 9 Alternative Scenario Obtaining Document Requirement

Guideline 6.4.5: Alternative scenarios, according to [10] should be mapped in the CK, through applying the transformation select scenario, adapted from [17].

The following guidelines are in charge to analyze other internal relationships not considered in the previous guidelines.

Table 5 Version 5 Configuration Knowledge of TaRGeT

Feature Expression	Transformation
Generated Test Suite	*select scenario* UC01.MS
Generated Detailed Test Suite	*select scenario* ITD01.UC01.MS
Parameterize Test	*select scenario* ITD04.UC05.MS
Maintain Consistency of Artifacts	*evaluate advice* ADV01
Make Upload Document	*select scenario* AS01.UC02.MS
Document Checked Syntactically	*select scenario* AS01.UC04.MS
Filter by Testing Purpose	*select scenario* AS01.UC05.MS
Include Test Case Permanently	*select scenario* AS02.UC05.MS
Exclude Test Case Permanently	*select scenario* AS03.UC05.MS
Filter by Similar Use Case	*select scenario* AS04.UC05.MS
Filter by Requirements	*select scenario* AS05.UC05.MS
Filter by Use Case	*select scenario* AS06.UC05.MS

Guideline 6.5: Analyze sub-elements of a task-decomposition that are goals. These goals are UCs that must be included in other ones by using the @include annotation (it has the same semantics as the <<include>> relationship of the UML use case).

Guideline 6.5.1: If a task has a goal as sub-element, the UC correspondent to that goal will be included by using @include <UCnumberOfUseCase> <nameOfUseCase> annotation in the scenario associated with the task that was decomposed. This task may be a step of the scenario of a UC, can be an ITD or an advice, mappings obtained by applying the previous guidelines. The <UCnumberOfUseCase> <nameOfUseCase> represent the UC to be included.

Applying the guideline 6.5.1 to the TaRGeT, a new version of intertype declaration previously identified is shown in Fig. 10.

The steps order is decided by the analyst, according to the knowledge she has about the problem/solution being specified. Some guidelines of the approach were omitted due to lack of space and because they do not apply to TaRGeT.

At the end this activity, the commonalities, and SPL variability are defined. Thus, we end up activities related to Domain Engineering in approach. The next activity is the product configuration sub-process that supports Application Engineering of SPL, responsible for selecting requirements that will be part of a specific product and develop their artifacts. This sub-process is not presented due to lack of space.

ITD01		**Description:** Generate detailed test suite
ID	**User Action**	**System Response**
ITD01.01	@include UC02 Obtained Document Requirement	-
ITD01.02	@include UC04 Document Checked	-
ITD01.03	@include UC05 Filter Selected	-
ITD01.04	Generate Test Case Specific	Generate test cases for specific use cases of the requirements document
ITD01.05	@include UC03 Maintain Consistency of Artifacts	-

Figure 10 Version 3 ITD Generate Test Suite Detailed

3 Conclusion and Future Works

This work is an extension of the GS2SPL approach [6] to include a technique that produces scenarios with improved modularization in the SPL requirements specification. This technique, named MSVCM, represents the variability of the SPL separately from the CK. Our approach, named GAS2SPL, produces a more detailed requirements specification for SPL since it guides the systematic obtaining of feature model and scenario description from goal models. In this work, we introduced the guidelines adapted from the GS2SPL approach to systematically obtain aspectual scenarios specified in MSVCM from i* goal models. The CK inherited from [10] was also presented to make it explicit how scenarios of specific products could be configured. To illustrate the applicability of the process in an example, we used the SPL TaRGeT [16]. The quality and consistency of the artifacts produced have a strong dependence on the level of detail associated with the information described in the models requirements in *i**, as well as the experience of the software engineer in relation to concepts related to the *i** framework, aspect oriented, GS2SPL and MSVCM approaches.

A quantitative evaluation was conducted of TaRGeT artifacts produced by GAS2SPL and GS2SPL approaches to identify which approach generated more modularized sets and had the most expressive configuration knowledge. Were evaluated using metrics of modularity, adapted from [10], and expressivity, adapted from [9]. Modularity metrics were degree of scattering features and degree of tangling scenarios. As a result, we found that there are no scattering of features in GAS2SPL through the modularization of features in the scenarios with the help of aspect-oriented. There is no tangling of features in the scenarios obtained with GAS2SPL. Thus, we found that the GAS2SPL improved modularity of the scenarios of SPL. Metrics to the expressivity of configuration knowledge measures the amount of symbols required to specify the configuration of knowledge [9]. As a result, we found that the GS2SPL approach is more detailed than the GAS2SPL, therefore, less expressive to describe the configuration knowledge. The details of this evaluation can be found in [21].

To reduce the effort to use the process, it is required a tool capable of making a semi-automatic application of the guidelines generate the feature model and the aspectual scenarios from goal models. This tool should also support the selection of features (product configuration) by using softgoals, as stated by the GS2SPL, and the configuration of scenarios by using the CK, as stated by the MSVCM.

4 Acknowledgments

This research was supported by a CAPES-Brazil research grant.

References

1. Lamsweerde, A. Goal-oriented requirements engineering: a guided tour. In: Proc. Of the 5th IEEE Intl. Requirements Engineering Conf (RE'01), Washington, DC, USA, pp.249-263, 2001.
2. Clements, P. Northrop, L. Software Product Lines: practices and patterns. 1th ed, Adson-Wesley, 2002.
3. Czarnecki, K.; Eisenecker, U. *Generative Programming: Methods, Tools, and Applications*. Boston, MA: Addison-Wesley, 2000.
4. Borba, C. Silva C. A comparison of goal-oriented approaches to model software product lines variability. In: LNCS, vol. 5833, pp. 184-253, Springer-Verlag, 2009.
5. Maiden, N. Alexander, I. Scenarios, stories, use cases: through the systems development life-cycle. 1th ed, Wiley, 2004
6. Souza, G. et al. GS2SPL: Goals and Scenarios to software product lines. In: SEKE - Knowledge Systems Institute Graduate School. [S.l.: s.n.], 2012. p. 651– 656.
7. Silva, C. et al. Tailoring an Aspectual Goal Oriented Approaches to Model Features. 20th Intl. Conf. on Software Eng. ad Knowledge Engineering (SEKE'08). San Francisco Bay, USA, 2008.
8. Asadi, M. et al. Goal-Driven Software Product Line Engineering. Proc. of SAC'2011, TaiChung, China, Março 2011. 21-25.
9. Alferez, M.; Bonifacio, R.; Teixeira, l.; Accioly, P.; Kulesza, U.; Moreira, A.; Araujo, J.; Borba, p. Evaluating scenario-based SPL requirements approaches – the case for modularity, stability and expressiveness. Requirements Engineering, p. 1–22, 10. 2013.
10. Bonifacio, Rodrigo; Borba, Paulo. Modeling Scenario Variability As Crosscutting Mechanisms. Proc. of the 8th ACM Intl. Conf. on AOSD. Charlottesville, Virginia, USA: [s.n.]. 2009.
11. Whittle, J.; Araujo, J. Scenario Modeling with Aspects. IEEE Proc. Software, v.151, n.4, 157-171, 2004.
12. Rashid A.; Sawyer P.; Moreira A. & Araujo J. Early Aspects: A Model for Aspect-Oriented Requirements Engineering. In Proc. of the 10th Anniversary IEEE Joint Intl. Conference on Requirements Engineering. RE. 2002. Washington, DC, 199-202.
13. Eriksson, M.; Börstler, J.; Borg, K. The pluss approach - domain modeling with features, use cases and use case realizations. In: Software Product Lines. Springer Berlin Heidelberg, 2005. p. 33–44.
14. Pohl, K.; Böckle, G.; Linden, F. J. V. D. Software Product Line Engineering: Foundations, Principles and Techniques. Secaucus, NJ, USA: Springer- Verlag New York, Inc., 2005.
15. TARGET. Target product line. In: . [s.n.], 2011. Available in: <http://twiki.cin.ufpe.br/twiki/bin/view/TestProductLines/TaRGeTProductLine>
16. Santander, V. F. A., Castro, J. F. B. Deriving Use Cases from Organizational Modeling In: IEEE Joint Conf. on Requirements Eng. - RE02, 2002, Los Alamitos, California, USA. p.32 – 39.
17. Bachmann, F.; Bass, L. J. Managing variability in software architectures. In: SIG-SOFT, Softw. Eng. Notes 26(3). [s.n.], 2001. p. 126–132.
18. Bodkin, r.; laddad, R. Zen and the art of aspect-oriented programming. In: . [S.l.: s.n.], 2004. Linux Magazine, April.
19. Yu, Y. et al. Configuring features with stakeholder goals. Proc. of the 2008 ACM symposium on Applied computing, 2008. 645-649.
20. Santos, L.; Silva, L.; Batista, T. On the integration of the feature model and PLAOVGraph. Proc. of the 2011 Intl. Workshop on Early Aspects, 2011. 31- 36.
21. Netto, D. Promovendo modularidade em um Processo de Engenharia de Requisitos para Linhas de Produto de Software. Dissertation (MSc), Center of Informatics, UFPB, Brazil (2015).
22. E. Yu, "Modeling strategic relationships for process reengineering," in Social Modeling for Requirements Engineering, E. Yu, P. Giorgini, N. Maiden, J. Mylopoulos, 1st ed., MIT Press, 2011, ch. 2, pp. 11-152.

Core Ontology to Aid the Goal Oriented Specification for Self-Adaptive Systems

Monique Soares[1], Jéssyka Vilela[1], Gabriela Guedes[1,2], Carla Silva[1] and Jaelson Castro[1]

[1] Center of Informatic, Federal University of Pernambuco, Recife, Brazil
{mcs4, ctlls, jffv, ggs, jbc}@cin.ufpe.br
[2] IFPB/ Campus Cajazeiras – Cajazeiras, Brazil
{mcs4, ctlls, jffv, ggs, jbc}@cin.ufpe.br

Abstract. [Context] Self-adaptive systems are able to modify their own behavior according to the environment in which they are inserted. Ontology is a set of concepts and relations about a specific domain and can help in the requirements communication. The core ontology for self-adaptive systems does not cover the four groups goal-oriented modeling dimensions for self-adaptive systems (goal, change, mechanism and effects). [Objective] This paper aims to complete the core ontology for self-adaptive systems in order to facilitate the requirements elicitation and specification. [Method] We had performed a comparative study in order to realize the modeling dimensions supported by the goal-oriented approaches for self-adaptive systems. So, we complete the core ontology for self-adaptive systems with the modeling dimensions concepts. [Results] As result, we present some concepts and relationships required when modeling a self-adaptive systems. [Conclusion] We obtained more complete core ontology to assist the requirements elicitation and specification for self-adaptive systems.

Keywords: Goal-oriented modeling approaches, Self-Adaptive Systems, Modeling dimensions, Ontology.

1 Introduction

Self-Adaptive Systems (SAS) are capable of dealing with a continuously changing environment and emerging requirements that may be unknown at design-time. The "self" prefix indicates that the systems decide autonomously (i.e., without or with minimal interference) how to adapt or organize themselves to accommodate changes in their contexts and environments [1].

Requirements for SAS are difficult to be elicited and specified because of their adaptable characteristics and the inherent uncertainty. Systems operating in dynamic environments need to deal with anticipations, but not everything can be anticipated. So, it is necessary that the system can deal with requirements can change at runtime.

In recent years, some works have been proposed to specify requirements for SAS through goal-oriented modeling approaches (GORE) [2]. For instance, we can cite

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_57

Tropos4AS [7], Adaptive RML [6] and Design Goal Model (DGM) [8]. These approaches were proposed by experienced research groups in GORE and SAS. They involve the construction of a modeling language specifically for SAS, i.e. they are not general purpose goal modeling approaches, and they were developed for the SAS domain. Such approaches allow the specification of self-adaptive systems requirements but do not guide the discovery of these requirements. An ontology presenting the concepts and relationships may facilitate the discovery of requirements to be specified through these approaches.

In this context, there is a growing interest in the use of ontology-driven approaches to support requirements engineering (RE) activities, including elicitation and specification [15]. The contributions of ontologies to self-adaptive systems are reported by [14][4]. A core ontology for SAS [14] proposes the concept of context and resource. But this core ontology does not cover all goal-oriented modeling dimensions for SAS.

It is important to set a group of concepts and relations that allow modeling oriented goals of SAS requirements. This modeling also need to portray the changes happening in the goals and on operating environment as well as the mechanisms to make the changes and the effects arising from the change.

In this paper, we investigate whether the core ontology requirements for SAS proposed by [14] can represent the main concepts and relationships necessary to support the elicitation and specification activities in the SAS requirements engineering process. In order to achieve this, we investigate whether the modeling dimensions of self-adaptive systems [3] is supported by three GORE modeling approaches [6][7][8]. We realize that the goal-oriented approaches for SAS can represent the majority of modeling dimensions for SAS. As the self-adaptive systems are context-aware, we also review the requirements for SAS core ontology [14] and use the 5W1H technique [5] to capture the context information, in order to facilitating the communication and specification of the context. Due to this, we propose some extensions in this core ontology, in order to it can portray the main concepts in SAS and the modeling dimensions.

The remainder of this paper is organized as follows. In Section 2, we present the comparative study for the purpose of evaluate the SAS modeling dimensions supported by the GORE approaches. We present the approaches proposed for modeling requirements for SAS and a comparative table with the modeling dimensions for SAS. Section 3, we propose some extensions in the core ontology for requirements for SAS. Section 4 outlines the related works. Later, we discuss the ongoing and the venues for future works in Section 5.

2 Comparative Study

This section presents the comparative study performed in order to evaluate whether the goal modeling approaches proposed to model SAS (Tropos4AS, Adaptive RML and Design Goal Model) cover the modeling dimensions for SAS proposed by [3].

These modeling dimensions are the evaluation criteria that were presented in the first research roadmap from software engineering for SAS [11]. The roadmap

summarizes the state-of-the-art and to presents critical challenges for the systematic software engineering of SAS. Cheng et al. [11] advocate that there is a lack of consensus among researchers and practitioners on the variation points among SAS, so they refer to these variation points as modelling dimensions. Each dimension describes a particular aspect of the system that is relevant for self-adaptation. The dimensions are presented in term of four groups: Goals, Change, Mechanisms and Effects. It is important that these modeling dimensions be present at the models of self-adaptive systems, so that these systems can ensure a more complete representation of its features.

Goals - Goals are objectives the system under consideration should achieve. The dimensions related to *goals* are: evolution, flexibility, duration, multiplicity and dependency.

Change - Changes are the cause of adaptation. Whenever the system's context changes, the system has to decide whether it needs to adapt. The dimensions related to *change* are: source, type, frequency, anticipation.

Mechanisms - This set of dimensions captures the system's reactions towards change, which means that they are related to the adaptation process itself. The dimensions of *mechanisms* are: type, autonomy, organization, scope, duration, timeliness and triggering.

Effects - This set of dimensions captures what is the impact of adaptation upon the system. The *effects* dimensions are: criticality, predictability, overhead and resilience.

The detailed description of the above dimensions can be found in [3]. In the next section, we present an overview of the goal modeling approaches we evaluate in this work.

2.1 Tropos4AS

This subsection presents the Tropos4AS [7] approach.

Tropos4AS constitutes of a process and a tool-supported design framework that complement the Tropos methodology in order to help the requirements engineer to capture, specify characteristics specific to SAS. These characteristics include the detailed specification of goals, the relationship with the environment the system will be deployed in, and taking into account possible failures and corresponding recovery actions. It introduces several different goal types, namely maintain-goals, achieve-goals, and perform-goals. Besides, one new basic relationship, the inhibition, is defined. Figure 1 shows the Tropos4AS elements.

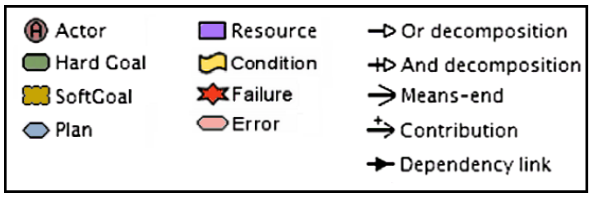


Fig. 1. Tropos4AS Elements (adapted from [12]).

2.2 Adaptive RML

This subsection presents the Adaptive RML [6] approach.

The Adaptive RML uses the core ontology for RE [9] to extend the GORE perspective allowing to model optional requirements, preferences, and to treat non-functional requirements in terms of approximations and quality constraints. The Adaptive RML is built on Techne [10] by adding two new concepts, namely, *context* and *resource*, and two relations, i.e. *relegation* and *influence*.

The adaptive RML allows model information about context, resources and domain assumptions that need to be monitored by the SAS in order to enable adaptation; candidate solutions can be ranked and evaluated via quality constraints over measurements that may be collected by the SAS and they can be associated with contexts and requires resource. The Figure 2 presents the Adaptive RML elements.

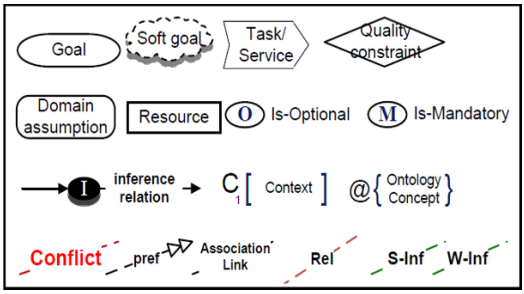


Fig. 2. Adaptive RML Elements (adapted from [6]).

2.3 Design Goal Model

This subsection presents the Design Goal Model [13] approach.

The Design Goal Model (DGM), proposed by [13], allows the representation of requirements as goals, tasks, domain assumptions (DAs) and quality constraints (QCs) as illustrated in Figure 3. The space of alternatives for goal satisfaction is represented by Boolean AND/OR refinements with obvious semantics.

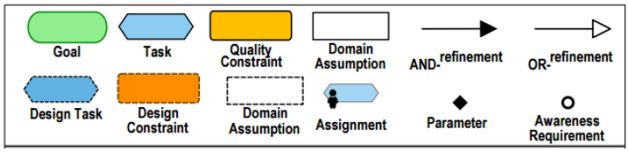


Fig. 3. Design Goal Model Elements [12].

DGM allows to specify software systems' adaptation based on high level concerns expressed by stakeholders and on the low level, technical aspects of the system. It includes design representations as design tasks, design constraints, and design

assumptions. Besides goals, tasks, quality constraints, parameters and awareness requirements, the Design Goal Model contains design tasks, design constraints, assignments and behavioral annotations.

2.4 Comparative Table

Table 1 shows all modeling dimensions (rows) and the goal-oriented modeling approaches to SAS (columns). Each pair modeling dimension and goal-oriented modeling approach is divided into two columns. The first column, labeled as "S" (Satisfy), indicates if the approach attends or not the dimension. The second column, labeled as "C" (Concept), indicates the concept that represents that dimension in the approach (in the case of the "S" column is marked with "Y").

The cell marked with "Y" indicates that the goal modeling approach has elements capable of representing the modeling dimension. The cell marked with "N" indicates that the goal modeling approach has no elements capable of representing the modeling dimension. The cell is marked with a "-" indicates that it is not clear if the goal modeling approach is capable of representing the modeling dimension.

To perform the analysis, first, we investigated each dimension modeling with the intention of fully understand the concept presented for them. Then, the elements and concepts of Tropos4AS [7], Adaptive RML [6] and Design Goal Model [13] were considered. The results of the comparative study are presented in Table 1. From the general analysis of this table, we can notice that none of the goal modeling approaches can represent all modeling dimensions of the four groups (Goals, Change, Mechanisms, and Effects).

The modeling dimensions set of Goals has representative elements and concepts for almost dimensions (not surprising since they are GORE approaches). Some change and effects modeling dimensions can be represented by these approaches, since the **Mechanisms** modeling dimensions do not have a clear element in the three goal-oriented modeling approaches investigated.

Some concepts' descriptions of the goal-oriented modeling approach look like with the modeling dimension's description, but do not cover every details that the description represent (presented in [3]), because of this, these concepts were marked with "-". Accordingly, it is not clear whether it can be represented or they depend of the software engineer experience to model the dimension, compromising the documentation and evolution of the system.

With this comparative study is possible conclude that the three goal modeling approaches studied here have difficulties in represent the Mechanism dimensions group, but the others groups (Goal, Change and Effects) have great representation. However, it necessary to know what information needs to be elicited to model the goals of the system for the product model to be the picture of the system.

In the next section, we describe the extensions of the core ontology for self-adaptive systems we proposed to address these issues.

Table 1. Comparative Table.

Goal Modeling Approaches / Main SASs Features	Tropos4AS		AdaptiveRML		Design Goal Model	
Goals	S	C	S	C	S	C
Evolution	-		-		-	
Flexibility	Y	Softgoal	Y	Soft goal	Y	Softgoal
Duration	Y	Condition	Y	Quality Constraint	Y	Quality Constraint
Multiplicity	Y	Hard goal	Y	Goal	Y	Goal
Dependency	Y	Dependency	Y	Inference Relation	Y	AND-Refinement
Change	S	C	S	C	S	C
Source	Y	Hard goal	-		-	
Type	Y	Goal	Y	Goal	Y	Goal
Frequency	Y	Condition	Y	Quality Constraint	Y	Quality Constraint
Anticipation	Y	Failure/Error	N		N	
Mechanisms	S	C	S	C	S	C
Type	-		-		-	
Autonomy	-		N		N	
Organization	-		-		-	
Scope	-		Y	Context	-	
Duration	-		-		-	
Timeliness	N		N		N	
Triggering	N		N		N	
Effects	S	C	S	C	S	C
Criticality	Y	Contribution	Y	Influence Relation	Y	AND/OR-Refinement
Predictability	Y	Error/Plan	-		-	
Overhead	Y	Contribution	Y	Influence Relation	Y	AND/OR-Refinement
Resilience	Y	Error/Plan	N		N	

3 Core Ontology to elicitation and specification for SAS

Ontologies are an explicit specification of a conceptualization and they can be logically reasoned and shared within a specific domain. So, ontologies are a standard form for representing the concepts within a domain, as well as the relationships between those concepts in a way that allows automated reasoning [15].

The core ontology to requirements engineer for SAS [14] is formed by the following concepts: *Goal*, *Softgoal*, *Quality Constraint*, *Task*, *Evaluation*, *Context*, *Resource* and *Domain Assumption*; and the following relationships: *Is-a*, *Depend-on*, *Refer-to*, *Relegate* and *Influence*. It added two new concepts (*Context* and *Resource*) and two new relations (*Relegation* and *Influence*) to the core ontology for Requirements Engineering. These extensions were performed to accommodate the changes that might occur at runtime, which not only demands adaptation (i.e. dynamically changing from one requirements problem to another) but also requires an update to the specification (i.e. refinement of requirements) [14].

The core ontology for SAS presented in [14] does not present all the key concepts related to the requirements specification for self-adaptive systems, it does not contemplate the modeling dimensions presented in [3]. So, in order to complement this core ontology with the core and general concepts of SAS, we propose to add the concepts of *Change*, *Mechanism* and *Effects*.

The work presented in [5] proposes the CA_{5W1H}Onto, an Ontological Context-Aware Model Based on 5W1H. This model presents concepts, instances and contexts. The Context Model is based on 5W1H, i.e. Who (Role), Why (Goal), How (Action), What (Status), Where (Location), When (Time).

As SAS are context-dependent, we propose to include the concepts related to *Context* in the core ontology for SAS. The *Context* is part of a *Has-a* relationship with *Role*, *Action*, *Location*, *Status* and *Time*. We also included the *Change* concept with a *Has-a* relationship with *Mechanism* and *Effect*. The Figure 4 presents such extensions, highlight in grey blocks, in the core ontology for requirements for SAS.

The main objective of our extension of the core ontology for SAS is complement with the main and more general concepts related to SAS and aid the identification and elicitation of the requirements in the SAS context. This core ontology complement was proposed aiming to support the requirements engineers to discovery requirements during the elicitation activity on a development process to SAS. In this way, the modeling of this systems as well as creation and extension of modeling languages can be facilitated with the addition of these new key concepts. It facilitates mainly a more complete requirements specification, allowing obtaining a more complete goal model.

The scope of this ontology is the SAS domain, its requirements (functional, non-functional, and referring to changes) and relations between then.

To knowledge acquisition, we reused the core ontology to requirements engineering for SAS, we analyzed the CA_{5W1H}Onto and the modeling dimensions for SAS adding context, changes and mechanisms concepts to core ontology for self-adaptive systems previously proposed by [14].

With the intent to better guide the concepts related to the context, we direct the context concept to the model presented in CA_{5W1H}Onto [5]. Besides, some concepts were added in order to represent the modeling dimensions for SAS. Following, we present the concepts of the core ontology for SAS that they have the same concepts presented in [14].

- *Goal* is a concept that represents a functional goal, a quality constraint and a softgoal.
- *Task* is an activity performed by the stakeholder.
- The *evaluation* can be comparative or individual.
- *Domain Assumption* is a property that describes the environment as it is.

- The *Resource* concept is referred by a *task*, a *domain assumption* or a *context* proposition.
- The *Context* concept is a set of information that is presupposed by the stakeholders to hold when they communicate particular requirements.

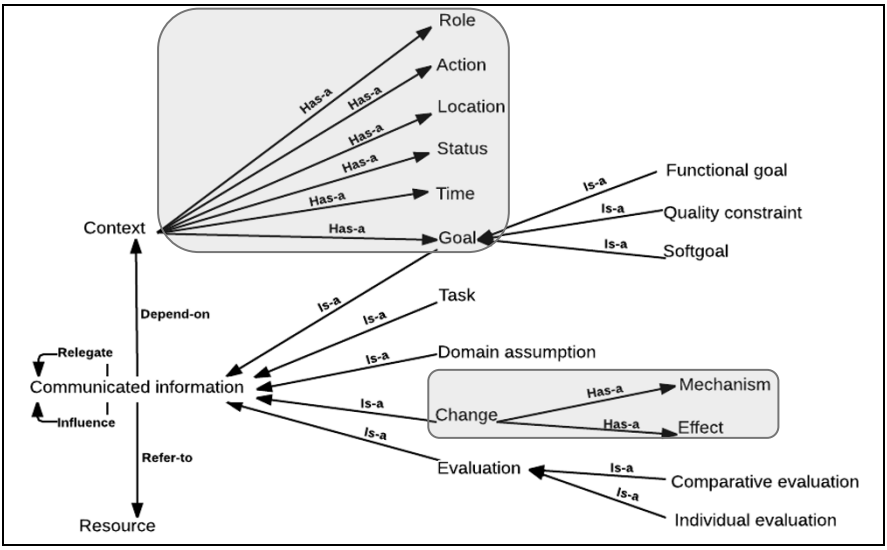


Fig. 4. Design Goal Model Elements [12].

The core ontology to requirements engineering for SAS presents three kinds of relationships: *Is-a*, *Relegate* and *Influence*. A *functional goal*, a *quality constraint*, or a *softgoal* is a (*Is-a) Goal*. A *domain assumption*, a *goal*, a *task* or an *evaluation* is a (*Is-a) Communicated information*. An *individual evaluation* or a *comparative evaluation Is-a Evaluation*. The *influence* relation is when some information influences some other information.

Relegation is a relation between a requirement and others sets of requirements. It can only be defined for requirements that we know how to satisfy in different ways [14].

In order to facilitate the goal modeling of SAS, we argue that modeling dimensions are very important in the specification of self-adaptive systems and need to be considered in the existing core ontology Requirements Engineering for SAS. We added a *Has-a* relation on the ontology to aggregate three of the four modeling dimensions groups, for example, *change*, *mechanism* and *effects*. The *change* is the cause for adaptation. The *mechanisms* is the reaction of the system towards *change* and the *effects* is the impact of adaptation upon the system. Every change is performed through a mechanism and generates effects on the system.

The systems are dependent on context and undergo changes, so it is essential that the software engineer to specify these systems considers these concepts, to the resulting model be more efficient and stay closer to the system image. Since it is an

core ontology, these concepts are more general and may have sub-concepts or be specialized.

In order to include the particularities of the context through the CA_{5W1H}Onto, we create some *Has-a* relationship with context concept. So, context *Has-a goal*, *role*, *action*, *location*, *status* and *time*.

4 Related Works

The objective of the work presented in [4] is to support the system analyst to engineer adaptive requirements at requirements-time and to make software able to reason on requirements at run-time enabling a goal-oriented adaptation. Qureshi and Perini [4] present an investigation of the role from goal-oriented modelling languages and knowledge representation techniques (ontologies) to analyze source of variability which motivate the specification of requirements for adaptive software systems. This approach deals with variability design methods based on goal-oriented modeling and research on the use of ontology techniques for requirements engineering. What differentiates this work of our, it is that this work does not deal with core concepts to SAS and it does not cover the goal-oriented modeling dimensions for SAS.

The study presented at [5] proposes an ontology-based context-aware modeling technique. This technique enable specification of contextual information and providing context-aware services for context management and reasoning. This approach is a context-aware ontological model based on five *Ws* and one *H* as a method of interpreting and abstracting semantic context. It deals with context, but it does not cover neither goal-oriented modeling or requirements for SAS.

5 Ongoing and Future Work

This is an ongoing research and we are currently investigating the approaches to specify SAS to investigate how an ontology can help in a requirements elicitation for self-adaptive systems.

This paper presented a review of approaches for goal modeling for self-adaptive systems with the intent to know which modeling dimensions these approaches can represent. The paper also shows core ontology that adds the modeling dimensions for self-adaptive systems and guidance with regard to context specification by 5W1H technique.

For future works, we expect implement and validate an ontology for SAS. The implementation will be performed using the Protégé tool and OWL (Web Ontology Language). The OWL is a language recommended by the W3C (World Wide Web Consortium). In order to perform the validation, we intend to perform a survey with software engineers that develop SAS and also it is in our interest to conduct an experiment intended to evaluate the performance of our core ontology, to see whether the engineers make better SAS requirements and design better SAS if supported by the core ontology.

References

1. Brun, Y., Di Marzo Serugendo, G., Gacek, C., Giese, H., Kienle, H., Litiou, M., Müller, H., Pezzè, M., Shaw, M.: Engineering self-adaptive systems through feedback loops. In: Cheng, B.H., de Lemos, R., Giese, H., Inverardi, P., Magee, J. (eds.) Software Engineering for Self-Adaptive Systems. Lecture Notes in Computer Science Hot Topics, vol. 5525 (2009).
2. Ahmad M., Araújo J., Belloir N., Laleau R., Bruel J-M., Gnaho C., Semmak F. Self-Adaptive Systems Requirements Modelling: four Related Approaches Comparison. In Comparing *Requirements* Modeling Approaches Workshop (CMA@RE), RE 2013, Rio de Janeiro Brazil, 2013.
3. Andersson, J., Lemos, R., Malek, S., Weyns, D. Modeling Dimensions of Self-Adaptive Software Systems. In: Cheng, B.H.C., Lemos, R., Giese, H., Inverardi, P., Magee, J. eds. (2009) Software Engineering for Self-Adaptive Systems. Springer, Heidelberg, pp. 27-47.
4. Qureshi, N., & Perini, A. (2009). "Engineering adaptive requirements". In Software Engineering for Adaptive and Self-Managing Systems, 2009. SEAMS'09. ICSE Workshop on (pp. 126-131). IEEE.
5. Kim, J. D., Son, J., and Baik, D. K. (2012). CA 5W1H Onto: Ontological Context-Aware Model Based on 5W1H. International Journal of Distributed Sensor Networks, 2012.
6. Qureshi, N.A., Jureta, I.J., Perini, A.: Towards a requirements modeling language for self-adaptive systems. In: Regnell, B., Damian, D. (eds.) REFSQ 2011. LNCS, vol. 7195, pp. 263–279. Springer, Heidelberg (2012).
7. Morandini M., Penserini L., Perini A., Towards goal-oriented development of self-adaptive systems, Proceedings of the 2008 international workshop on Software engineering for adaptive and self-managing systems, May 12-13, 2008, Leipzig, Germany [doi>10.1145/1370018.1370021]
8. Pimentel, J., Castro, J., Mylopoulos, J., Angelopoulos, K., & Souza, V. E. S. (2014, March). From requirements to statecharts via design refinement. In Proceedings of the 29th Annual ACM Symposium on Applied Computing (pp. 995-1000). ACM.
9. Jureta, I.J., Mylopoulos, J., Faulkner, S.: Revisiting the core ontology and problem in requirements engineering. In: 16th IEEE Int. Requirements Eng. Conf., pp. 71–80 (2008).
10. Jureta, I.J., Borgida, A., Ernst, N.A., Mylopoulos, J.: Techne: Towards a new generation of requirements modeling languages with goals, preferences, and inconsistency handling. In: 18th IEEE Int. Requirements Eng. Conf., pp. 115–124 (2010).
11. Cheng, B.H., Lemos, R., Giese, H. Software engineering for self-adaptive systems: A research roadmap. In: Cheng, B.H., Lemos, R., Giese, H., Inverardi, P., Magee, J. eds. (2009) Software Engineering for Self-Adaptive Systems. Springer, Heidelberg.
12. Morandini, M., Perini, A., & Marchetto, A. (2011). Empirical Evaluation of Tropos4AS Modelling. iStar, 766, 14-19.
13. Pimentel, J. H. C. Systematic Design of Adaptive Systems - A Control-Based Framework. 2015. Ph.D. Thesis. Center of Informatics, Federal University of Pernambuco, Brazil.
14. Qureshi, N. A., Jureta, I. J., & Perini, A. (2011). "Requirements engineering for self-adaptive systems: Core ontology and problem statement." In Advanced Information Systems Engineering (pp. 33-47). Springer Berlin Heidelberg.
15. Dermeval, D., Vilela, J., Bittencourt, I. I., Castro, J., Isotani, S., Brito, P., and Silva, A. (2015). "Applications of ontologies in requirements engineering: a systematic review of the literature". Requirements Engineering, p. 1-33.

Business Process Modeling Languages: A Comparative Framework

José Luís Pereira[1] and Diogo Silva[1],

[1] Universidade do Minho, Departamento de Sistemas de Informação,
Campus de Azurém, Guimarães, Portugal
jlmp@dsi.uminho.pt, a58899@alunos.uminho.pt

Abstract. Underlying any Business Process Management (BPM) project is the need to represent business processes, using an appropriate language. In this paper, based on a thorough review of the relevant literature, we made a comparative analysis of five business process modeling languages, widely used in the context of BPM projects. The main objective is to understand the strengths and major limitations of each one, in order to draw a comparative perspective between them. For this purpose, we have created a comparative framework in which each one of the languages are characterized regarding a number of relevant criteria. Finally, a prototype specifically developed to support this framework, is presented. The purpose of this prototype is to assist users in choosing a suitable business process modeling language, according to their specific needs.

Keywords: Business Process Management, Business Process Modeling, Process Modeling Languages.

1 Introduction

This paper aims to analyze and compare some of the major languages for modeling business processes, which are used in the context of *Business Process Management* (BPM) projects in organizations. The set of business process modeling languages in use today is already quite extensive, which creates difficulties to modelers when they need to choose one of them to use in their BPM projects. These projects are increasingly valued by organizations, as they need to improve their business processes, thus ensuring the adequate implementation of their business strategies, a better alignment between those strategies and their IS/IT solutions and, in general, improving their business management capabilities [1].

Among the various existing languages for business process modeling, there are five which are the most influential these days: the BPMN language (*Business Process Model and Notation*), currently in version 2.0, is the most widely used today and considered by some as the standard [2]; the EPC (*Event-driven Process Chain*), used within the well-known ARIS toolset [3]; the UML-AD (*Unified Modelling Language – Activity Diagrams*), created by the OMG (*Object Management Group*), initially to support the development of software, and recently with a more widespread context of

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_58

use [4]; the IDEF (*Integration DEFinition*), also known for being a family of languages with several distinct purposes [5]; and finally the RAD (*Role Activity Diagram*) language, with a special focus on the participants in a business process, manly their interactions [6].

Among the panoply of languages for business process modeling that exist today it is important to clarify the aspects in which they are distinct, highlighting their strengths and limitations. Thus, allowing for a more informed choice by business analysts (who use them to document and define processes), or by users (who have to validate the models built by the former), when it is necessary to choose a language.

Concerning the structure of this paper, first we identify and describe the set of criteria for characterizing modeling languages that our literature review, and our own experience in the field, has pointed out as the most relevant. Next, we evaluate each one of the five business process modeling languages against the mentioned set of criteria, creating a comparative framework. Finally, we present a prototype of a system that implements the comparative framework. This prototype has been prepared to receive and incorporate feedback from experienced business process modelers and analysts in order to improve the contents of the comparative framework. The objective is to assist users in choosing the most suitable process modeling language, taking into account the specificities of the BPM project they have in hands.

2 Characterization of Business Process Modeling Languages

The modeling of business processes has a great impact on the success of any BPM project. Therefore, the choice of the business process modeling language to use in a particular BPM project is very important and should depend on its specific objectives. For instance, the purpose of the project is:

- Modeling of business processes for simple documentation, regarding its communication and dissemination among stakeholders?
- Modeling of business processes to support the optimization of its operation?
- Modeling of business processes regarding their implementation using IT?

On the other hand, the choice of the business process modeling language to use should also take into account the characteristics of the processes themselves, such as:

- Involving predominantly human resources?
- Or integrating automated processing systems?
- Consisting of well-structured workflows?
- Or involving predominantly interactions among people?

Nowadays, the offer in terms of languages/notations for business process modeling is considerable and, although all of them share the same goal – to model business processes – each one has its own specificities. The five languages that we have selected for this study, although being representative of what one can find in this area, have different characteristics, strengths and limitations. Thus, it is important to have a mechanism to compare them in order to systematize their differences and similarities. To this end we have carried out a thorough review of the relevant literature which focuses on the characterization of process modeling languages.

Different authors use distinct criteria to evaluate business process modeling languages, although some criteria tend to receive more attention in the literature:

- **Expressiveness** - the capability of the language to represent the many different organizational situations, both in terms of the behavioral, functional, structural or informational perspectives;
- **Readability** - the greater or lesser ease for people to understand and interpret the process models defined with the language;
- **Usability** - although related with readability, this criterion focuses mainly on the complexity of the use of the language;
- **User Friendly** - also somewhat related to readability, this criterion refers to a greater or lesser attractiveness of the language, in the sense that its use can be more or less pleasant and intuitive;
- **Formality** - the rigor with which the semantics of the language is defined, reducing/removing the ambiguities in the interpretation of the models;
- **Versatility** - if the language is suitable only for the documentation and analysis of processes, or does it allows the execution/simulation of models;
- **Universality** - the greater or lesser disclosure of the language among users, with implications in terms of support for their use;
- **Tools Support** - the greater or lesser availability of suitable tools to support the use of the language;
- **Flexibility** - the greater or lesser capability of the elements of a language to be used in different scenarios and to represent distinct features.

The following table (Table 1) systematizes the criteria mentioned above as well as the authors found in the literature that used those criteria to compare business process modeling languages.

Table 1. Comparison Criteria vs Process Languages: Coverage in the existing literature.

Languages / Criteria	BPMN	EPC	UML-AD	RAD	IDEF
Expressiveness	[7], [8], [9], [10], [11], [12]	[7], [8], [9], [10], [11]	[7], [8], [9], [10], [11],	[7], [8], [10], [12]	[7], [8], [9], [10]
Readability	[11], [12], [13]	[11], [13]	[11], [13]	[12], [13]	[12], [13]
Usability	[12], [13]	[13]	[13]	[12], [13]	[13]
User Friendly	[12]			[12]	
Formality	[10]	[10]	[10]	[10]	[10]
Versatility	[10]	[10]	[10]	[10]	[10]
Universality	[11]	[11]	[11]		
Tools Support	[11]	[11]	[11]		
Flexibility	[12]			[12]	

Unfortunately, as Table 1 illustrates, there are few examples of authors who have compared all the five languages against the same criterion. The exceptions are [7], [8] and [10] (regarding the expressiveness criterion), [13] (regarding the usability criterion) and [10], (regarding the formality and versatility criteria).

As one can see, the expressiveness of the process modeling language is, by far, the one that has attracted more attention until now. The other eight criteria have had some attention, but not as much as the expressiveness one.

To these nine criteria we have added a few more, as a result of our own experience in the business process modeling field:

- **Concision** - the greater or lesser capability of the language to represent the various facets of a business process using a smaller set of elements;
- **Ease of Learning** - the greater or lesser effort required to master and be productive in the use of language;
- **Innovation Inducer** - the greater or lesser ease with which the language induces modelers to discover new solutions and modeling practices;
- **Evolutionary** - directly linked to the probability of a language to be updated and improved in the future;
- **Collaborative Work** – the greater or lesser suitability of the language to support the modeling of collaborative work situations in a process (e.g. meetings).

Regarding these five criteria, we simply were not able to find any reference to them in the research literature dedicated to the comparison of process modeling languages. These clearly represent "work to do" that deserve and will have our attention in the near future.

3 Evaluation of the Business Process Modeling Languages

Once identified the criteria for the comparative analysis of business process modeling languages we have evaluated the selected five languages against those criteria, taking into consideration the opinions produced by the authors that have made comparisons (Table 1), filtered by our own opinions as users of those process modeling languages.

In the following table (Table 2) we systematize the results of our study. Each cell of the table represents a question like "*How do you evaluate the language **X** regarding its support of the criterion **Y**?*" receiving a value in a scale from 0 (meaning that language **X** do not support the criterion **Y**) to 5 (meaning that language **X** fully support the criterion **Y**).

As Table 2 illustrates, while there are criteria which every business process modeling language supports, although with different capabilities, there are also some criteria which are very distinctly supported by different modeling languages, with values from 0 (no support) to 5 (full support). Regarding modeling languages, the IDEF family is the one with major limitations, while BPMN stands out as the language that offers the best support in the majority of the criteria, which is not surprising considering its widespread use in the area of business processes modeling.

Table 2. Process Modeling Languages vs Criteria: Evaluation.

Languages / Criteria	BPMN	EPC	UML-AD	RAD	IDEF
Expressiveness	4	3	4	3	2
Readability	5	4	4	4	3
Usability	4	4	4	4	3
User Friendly	5	5	5	5	3
Formality	5	5	5	1	5
Versatility	5	5	4	3	3
Universality	5	4	5	3	3
Tools Support	5	2	5	2	3
Flexibility	4	4	4	4	3
Concision	4	4	4	4	3
Ease of Learning	5	5	5	4	3
Innovation Inducer	4	4	3	5	2
Evolutionary	4	4	4	2	3
Collaborative Work	2	2	2	5	0

Expressiveness was the criterion that best allowed a consolidated comparison between the five process modeling languages, due to its coverage by several authors. In general, they argue that the IDEF family of languages (in particular IDEF0 and IDEF3) is unable to model the organizational context in which business processes exist and therefore are quite limited in their expressiveness. Regarding the BPMN and UML-AD languages, both exhibit more expressiveness as they allow us to represent the four essential perspectives of business processes (organizational, functional, behavioral and informational), standing out from the other two process modeling languages – EPC and RAD.

Readability is another criterion that has also been treated by some authors. In general all of them argue that BPMN is the language that best serves the two communities interested in business process modeling - business analysts and IT specialists - as BPMN models can easily be understood by both, which is a plus. This fact distinguish and justify the maximum valuation of BPMN in this criterion. On the contrary, the low level elements of IDEF leaves this language again in last place.

Regarding **usability**, due to the scarcity of literature comparing process modeling languages against this criterion, its assessment was carried out manly based on the author's experience. This is a criterion in which there is a balance between the different process modeling languages, with IDEF showing again some difficulties, in particular when we have to deal with more complex processes.

While IDEF is also the least interesting modeling language regarding the **user friendly** criterion, based in our experience with the other four modeling languages we claim that they are equally friendly, and very simple and pleasant to use. So, they earn the maximum value in this criterion.

Concerning the **formality** criterion, noticeably there is a modeling language in clear inferiority when compared to the other languages - RAD. This is a language that, contrarily to all the others, does not have a formal definition of its semantics, nor a standardized representation of its elements.

In the **versatility** criterion once again the BPMN and EPC languages stand out. These two modeling languages, besides allowing the documentation and analysis of business processes, at the present, are the only ones that may have their models directly executed by BPMS (*Business Process Management System*), without requiring any translation or mapping to another language. UML-AD is making the same route but, for now, is not already there. At the present, RAD and IDEF's only allow the development of models for documentation and analysis purposes.

In the **universality** criterion, maybe due to their affiliation to the OMG, the BPMN and UML-AD languages are the most visible and recognized at a global level. In this context EPC, although the fact that it is limited to the ARIS family of tools, also has a significant level of recognition at a worldwide level. In the case of RAD and IDEF, their user base is very limited.

Regarding **tools support**, also as a reason for or as a consequence of the previous criterion, BPMN and UML-AD languages have the large base of tools to support those languages. At a lower level of tools support stands IDEF and at an even lower level appears RAD. The case of EPC is very singular because, being a proprietary language of the ARIS family, the tools support is naturally limited.

In the case of the **flexibility** and **concision** criteria, with the exception of IDEF, all the process modeling languages receive the same valuation. On the one hand, all of them might be adapted to different contexts of use. On the other hand, with a small set of modeling elements one might represent a large number of different organizational situations.

Generally speaking, with some minor differences, the **ease of learning** may be considered true to all of the process modeling languages. In fact, with the exception of IDEF, which can be a little bit more cumbersome, anyone can become a productive modeler after a few days of learning and experimentation with any of the languages.

Regarding the **innovation inducer** criterion, the process modeling language that we think is more capable to stimulate users in finding new solutions is RAD. Not being a formal language, RAD gives users the freedom to search for new ways of doing things and innovate. The other languages, more or less impose restrictions, and so reduce the creativity of modelers.

The **evolutionary** criterion tries to represent the probability of a language to be upgraded and improved in the future. There are no doubts that BPMN, EPC and

UML-AD will evolve, integrating more and more features. In the case of IDEF, and particularly RAD, the perspectives of evolution are much more limited.

The **collaborative work** as a criterion to compare business process modeling languages will be more and more relevant in the future. Indeed, there are many situations during the execution of processes in which two or more people have to collaborate (synchronously or asynchronously) in order to execute some work. These situations have to be properly represented in process models. In this context, RAD has major advantages as it allows the representation of collaborative work very easily. BPMN, EPC and UML-AD also allow the representation of collaborative work, but not in a direct manner. Once again, IDEF completely misses the point because, as we mentioned earlier, it cannot represent the organizational perspective of processes.

4 Comparative Framework Tool Development

Having defined a framework to compare business process modeling languages, the next step is to develop a tool to implement this framework. To be useful, the tool has to support several requirements:

- First of all, the contents of the framework (Table 2) must be dynamic. Indeed, the current values of Table 2 are only the result of a limited study, in which the opinions of some authors, and our own opinions, are reflected. It would be convenient that the framework could evolve, incorporating the opinions of experienced business process modelers and analysts in order to improve its content. In that sense, at each moment the contents of Table 2 would represent the weighted opinions of specialists that have contributed to the framework until that moment;
- Second, the framework should be extensible in the sense that other business process modeling languages could be added to it, and also the list of criteria could be extended, if needed;
- Finally, the framework should assist users in choosing the most adequate process modeling language, taking into account the specificities of their BPM projects. To do that, in the course of choosing a language, users should have the possibility to give weights to each of the criteria, in order to best describe their needs in terms of process modeling.

A functional prototype, whose user interface, at the moment, is mainly in Portuguese, has already been developed, incorporating the three requirements above. It is available as a web portal which is open to the community of experts in process modeling languages, waiting to receive their contributions in order to improve the contents of the framework. So, the platform is prepared to continuously evolve and improve its content, giving solid results to users who need to choose a process modeling language, adequate to the characteristics of their BPM projects.

The next three figures present some of the user interactions with the web portal involved in the course of choosing a process modeling language. In the next figure (Fig.1) a user selected the criteria **expressiveness** (in Portuguese, Expressividade) and **readability** (in Portuguese, Legibilidade) as the more relevant criteria to his next BPM project.

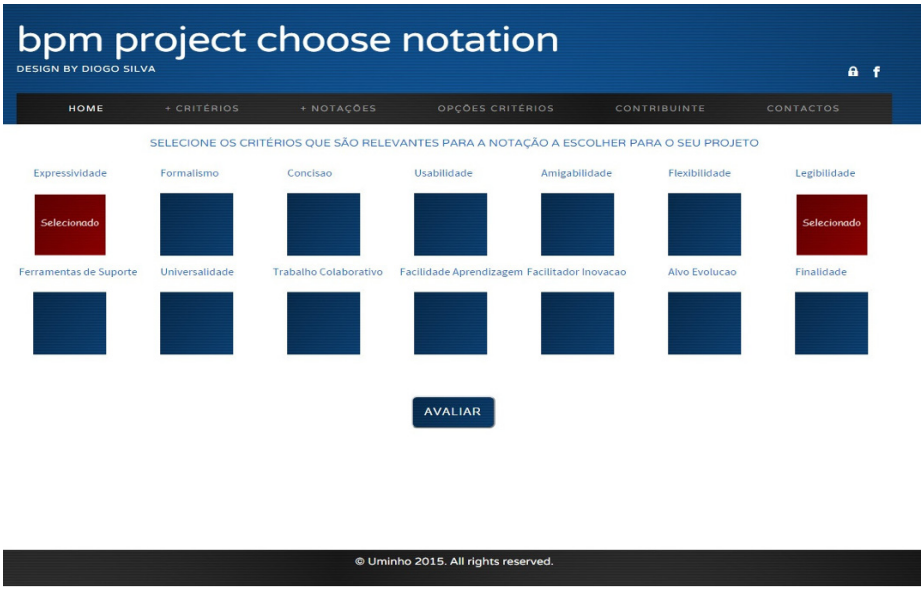


Fig. 1. Selecting the relevant criteria

Next the user is invited to weight each one of the criteria selected in the previous step, choosing one of three values (1 – Low, 2 – Medium, 3 – High). This way a user indicates the level of importance attributed to each criterion. In Fig. 2, the **expressiveness** criterion waits to be characterized.

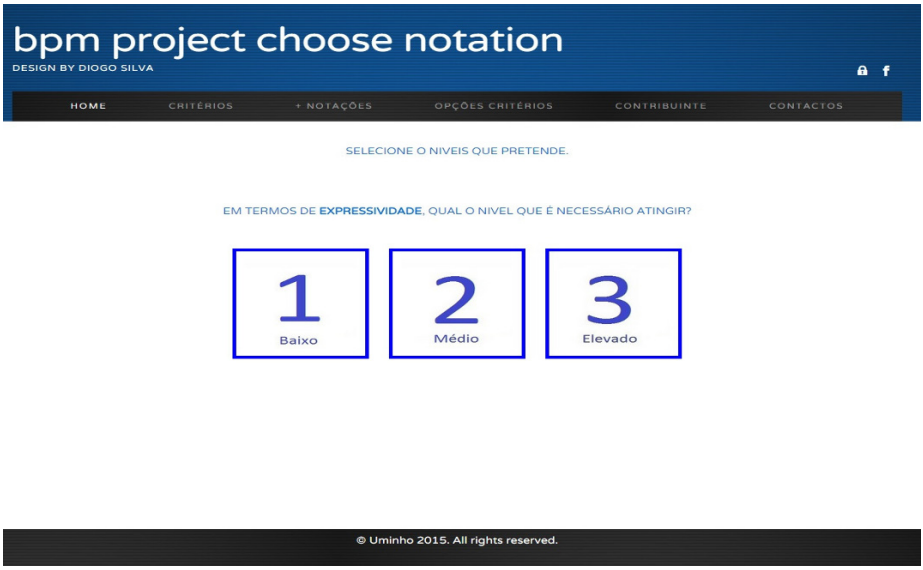


Fig. 2. Weighting the “expressiveness” criterion

Finally, the results are presented (Fig. 3)

Fig. 3. Final results

In this example, having weighted the two criteria (**expressiveness** and **readability**) with high importance, BPMN results as the best process modeling language, followed successively by UML-AD, EPC, RAD and IDEF. One can also check the score of each modeling language by passing the cursor over the corresponding bar. The confidence level for each criterion (which depends on the number of existing contributions in the knowledge base at that time) is also displayed.

5 Conclusions

Due to the widespread recognition of the Business Process Management (BPM) approach, the modeling of business processes has recently gained increased importance. Nowadays, there is a considerable list of business process modeling languages one can use in the context of a BPM project. The fact is that each one of those languages has their own strengths and limitations. So, which one should we use in a specific BPM project?

In this paper, taking into account the available literature about business process modeling languages comparisons, complemented with our own experience in modeling business processes, we developed a framework that compares several languages (BPMN, EPC, IDEF, RAD and UML-AD) against a set of criteria. This

framework evaluates quantitatively the level of support that each process modeling language offers to each criterion.

The goal of the comparative framework is to provide users with the means to select the most suitable business process modeling language, taking into account the characteristics of the BPM project. To facilitate the selection task we developed a tool that implements the comparative framework, allowing users to easily describe their needs in terms of the characteristics that the process modeling language should support.

The comparative framework is available as a web platform, open to users who need to select a process modeling language, and to modeling experts who might contribute with their evaluation to the content of the framework. In order to accommodate future requirements, the framework is completely extensible, allowing the addition of new process languages and criteria.

References

1. van der Aalst, W. M. P. (2013). Business Process Management: A Comprehensive Survey, ISRN Softw. Eng., vol., pp. 1–37.
2. Freund, J. & Rücker, B. (2014). Real-Life BPMN: Using BPMN 2.0 to Analyze, Improve, and Automate Processes in Your Company (2nd Ed), CreateSpace Independent Publishing Platform.
3. Davis, R. (2008). ARIS Design Platform: Advanced Process Modelling and Administration, Springer.
4. Podeswa, H. (2009). UML for the IT Business Analyst (2nd Ed), Cengage Learning PTR.
5. Costin, B. & Fox, C. (2004). Hybrid IDEF0 / IDEF3 Modelling of Business Processes : Syntax, Semantics and Expressiveness, Concurr. Eng., pp. 3–5.
6. Ould, M. (1995). Business Processes: Modelling and Analysis for Re-Engineering and Improvement, Wiley.
7. Heidari, F., Loucopoulos, P., Brazier, F. & Barjis, J. (2012). A Unified View of Business Process Modelling Languages 1, Vol. 004.
8. Korherr, B. (2008). Business Process Modelling - Languages, Goals and Variabilities, Vienna University of Technology, PhD Thesis.
9. Mohammadi, M., & Mukhtar, M. B. (2012). Business Process Modelling Languages in Designing Integrated Information System for Supply Chain Management. International Journal on Advanced Science Engineering Information Technology, 54–57.
10. Mili, H., Tremblay, G., Jaoude, G., Lefebvre, É., Elabed, L., & El Boussaidi, G. (2010). Business process modeling languages: Sorting Through the Alphabet Soup, ACM Comput. Surv. vol. 43, no. 1, pp. 1–56.
11. Kelemen, Z. D., Kusters, R., Trienekens, J., & Balla, K. (2013). Selecting a Process Modeling Language for Process Based Unification of Multiple Standards and Models, 1–14.
12. Aldin L., & De Cesare, S. (2009). A comparative analysis of business process modelling techniques, UKAIS 2009, Oxford, UK, pp. 1–17.
13. Van Wel, R. (2013). Business Best practices in Agile software development, Leiden University, Master's Thesis.

An Analysis Of Opinions About Tourist Services Based On The Semantic Orientation Of Texts

Rosario Estefania Sanchez Cevallos[1], Susana Alexandra Arias Tapia[2], Alex Paúl Ludeña Reyes[1], Victor Hernandez del Salto[3]
[1]Departamento de Ciencias Empresariales, Sección de Hotelería y Turismo, Universidad Técnica Particular de Loja, Marcelino Champagnat S/N, 1101608, Loja, Ecuador
Email:{resanchez,apludena}@utpl.edu.ec
[2]Departamento de Ciencias de la Computación y Electrónica, Sección de Inteligencia Artificial, Universidad Técnica Particular de Loja, Marcelino Champagnat S/N, 1101608, Loja, Ecuador
Email:saarias@utpl.edu.ec
[3]Universidad Técnica de Ambato, Decanato Facultad de Ciencias Humanas y de la Educación
vhernandez@uta.edu.ec

Abstract. The analysis of opinions provided by international travellers is fundamental to promoting a successful Tourism Package (*TP*). In this study, we propose a methodology that can be used both with semantic orientation and with the classification of consumer opinions, that is, as either excellent or poor. The results from this classification can be provided to tourism operators with the aim of facilitating decision making with regard to what the clients want and say. In order to obtain the desired results, we utilized text mining algorithms and vectorial support machines - processes that enabled us to obtain acceptable level of precision and recall. In addition, it helped us obtain conclusions and gather data for new research projects in this area.

Keywords. Tourism, Consumers, Opinion, Tourism Package.

1. Introduction

The analysis of customer opinions within the field of tourism is of vital importance when making improvements or when seeking to offer an appealing tourism package. Both market surveys and visitor's books provide travellers with the opportunity to express their views and opinions using text.
In fact, many global travellers aim to ensure that their travel experiences have a certain level of comfort. Such basic facilities and service include a reliable

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_59

Internet services as well as refreshments such as tea and coffee - all of which are considered indispensible for any successful Tourism Package (*TP*). What is more, these services help the customer to feel like they are at home.

In the majority of study cases these are used to help to identify a market segment or "niche" are frequently based on the person's individual travel requirements. This includes factors such as price, length of stay, proximity to bus or train stations, and overall travel experience, which includes aspects such as comfort and quality.

In fact, for tourism managers this task requires creativity and analysis, as well as good decision-making skills [1]. Moreover, the designing a *TP* facilitates exchanges and transactions. Nevertheless, this process culminates with the sale of a *TP*. What is most important, however, is the follow-up after the purchase, that is, the way in which the information obtained from the client experience is used.

The text phrases examined in this research contain information that can be processed with text mining algorithms. With this method, we can identify the level of the customer's contentment/discontentment with a tourism service or product. This is more commonly known as semantic orientation. In tourism marketing it is very important to take into consideration customer opinions.

Mainly these types of roles focus on textual classification. In this study, we propose a methodology that is based on Point Mutual Information (*PMI*), which helps to obtain the semantic orientation (*SO*) of set phrases (*f*) that contain an opinion. The selection of phrases was achieved by obtaining the pattern known as part of speech, which resembles the non-supervised classification proposed by [2].

In this study, the *SO* is based on the orientation of words and phrases that can be consulted by means of Google *APIs*. The *f* and the *SO* are used to train Vectorial Support Machines (*VSM*), which is an algorithm that will be utilized to classify the clients' opinions about new or improved tourism packages. This is the basis of our proposal.

Although the manual analysis of the opinions described in a given text could be a tedious task, it serves as an adequate tool to obtain semantic orientation and to later classify customer opinions, and especially written information related tourists' opinions in where there are various forms of expressing an opinion and various types of clients.

The following section describes the State of the Art related to our research proposal. Demonstrates our theory of combining patterns and algorithms of supervised classification to identify and classify the opinions of travellers. The results obtained from the experimentation stage can be provided to tourism operators, with the aim of taking better decisions based on the classifications of Excellent and Poor.

2. State of the art

Research by [3] focuses on affective spaces with the aim of carrying out a text-based sentiment analysis. Liu [2], focus on identifying the polarity of written responses based on linguistic merges, common sense computing and machine learning.

This method requires the inter-dependency of concepts. That is, the identification of an emotion (attached to a concept), which may be transmitted to other concepts according to the strength of the rules of dependency. In this case, it was not only a syntactic dependency (syntactic ngrams), but also a semantic dependency.

The overall result of this work is that it provides a framework that can be used with concepts, which can be later analyzed in a common vectorial space. The classification of these concepts (linked to sentiments) facilitates the categorization of emotions and therefore text polarity. As with non-supervised classification, the "valid" concepts are identified by means of patterns that consist of language, *for example: ADJ + NOUN*. Here, an adjective and a noun comprise a concept.

This way of obtaining concepts by means of clauses (or rules of dependency) requires two concepts to meet the suggested characteristics (patterns) in the clause, which it is understood as being valid. Moreover, as each concept is linked to a sentiment, and since there is a dependency between the concepts, a network of sentiments is created "implicitly", which is called *AffecNe*t.

In order to work with *AffecNet* (affective spaces), a vectorial space has been used, which can be reduced by using the main components or *SVD*, or a version known as *TSVD. TSVD* helps to obtain a positive or negative valence of the concepts.

The series of concepts with similar characteristics and equal valence comprise the affective spaces. *For example, beautiful day, birthday party and make person happy are found in the same directional vectorial space and have the same characteristics.* For this reason, they are found in the same vectorial space [3].

In this work, the first affective space is that which provides Google *APIs*. Consequently, we developed an algorithm that enabled us to obtain the number of hits- i.e. with the aim of classifying a phrase as Excellent or Poor, and according to the *PMI* results. The selection of phrases was carried out in accordance with the non-supervised classification patterns proposed by [2].

Table 1 shows the patterns that were taken into consideration in this work and for the selection of the set phrases:

Table 1. Patterns used for the selection of set phrases

	First Word	**Second word**	**Third word** (not extracted)
1	JJ	NN or NNS	anything
2	RB,RBR, or RBS	JJ	Not NN nor NNS
3	JJ	JJ	Not NN or NNS
4	NN or NNS	JJ	Not NN or NNS
5	RB,RBR, or RBS	VB,VBD,VBN, or VBG	Anything

The patterns in Table 1 help us to identify which phrases form part of the analysis as well as to identify the *SO* and to classify the text. The vectorial support machines can be used to classify text of different sources – and be performed almost automatically. For this reason, it was not been necessary to carry out various tests to configure the parameters of the algorithm [4].

One example of this methodology was proposed by [5], that is, where it was possible to classify examples of text that were randomly created to train algorithms and classify Reuters news items by means of SVM.

In social networks, tourist opinions generally appear in blogs. The analysis of text in blogs may aid the classification of the polarity of an opinion, and by so doing help us to identify the real feedback of a traveller. However, blogs can often be very long. For this reason, we used micro blogs, which are smaller extracts of text. When analyzed, these may provide better results in the classification of polarity than when using the entire text.

In the same way, for the classification we used *SVM*, thereby improving the calculation of precision. The latter was based on the calculation of confidence [6]. In this work, we use these authors' proposals, seeing that the f was selected according to patterns. Therefore, not all the phrases were analyzed. For our training grid, we used a micro-blog. The selection of phrases in this sense produced excellent results for the classification of the polarity of texts. *For example the elimination of stop words helped improve classification criteria in the analysis of tweets [7].*

The text used in tweets, however, was organized with *SVM*. They likewise produced excellent results when polarity was found within the range of classification [8].

In this study, we propose that the rating be considered as the number of hits that is determined for each phrase of the subjective text. In the following section, we describe our methodology. In which our main contribution was identifying the *SO* of the phrase. This was based on the number of hits and the building of a corpus through the selection of non-supervised classification patterns.

3. Methodology

The methodology proposed in this work focuses on the semantic orientation of affective spaces. We worked with a corpus comprised of: *sentiment_detection_hotel_reviews_dataset*[1]. Below is an example of the customer's opinions that are found in the training grid:

I stayed in this hotel for one night.
As this is a fairly new place some of the taxi drivers did not know where it was and/or did not want to drive there.
Once I have eventually arrived at the hotel, I was very pleasantly surprised with the decor of the lobby/ground floor area.
It was very stylish and modern.
I found the reception's staff getting me with 'Aloha' a bit out of place, but I guess they are briefed to say that to keep up the corporate image.
As I have a Starwood Preferred Guest member, I was given a small gift upon-check in.
It was only a couple of fridge magnets in a gift box, but nevertheless a nice gesture.

The following code helps us to obtain the semantic orientation of the phrase: *I stayed in this hotel for one night*, which is an example taken from a tourist's opinion about a hotel. This phrase meets the criteria for the second pattern of non-supervised classification.
Here, Code 1 is used to obtain the semantic orientation of the set phrase: *"I stayed in this hotel for one night"*. Despite there being a prior classification of the sentences, a previously compiled corpus[2] was comprised of syntactic dependency trees (syntactic n-grams) and semantic dependency- both of which are used to comprise the affective space.

[1] https://github.com/ucd-spatial/Datasets/tree/master/sentiment_detection_hotel_reviews_dataset
[2] http://ajax.googleapis.com/ajax/services/search/web?v=1.0&q=%s

```
def hits(word1,word2=" "):
query =
"http://ajax.googleapis.com/ajax/services/search/web?v=1.0&q=%s"
if word2 == "":
results = urllib.request.urlopen(query % word1)
else:
q = urllib.request.quote(word1+" "+"AROUND(10)"+" "+word2)
print(q)
print (query % q)
results = urllib.request.urlopen(query % q)
json_res = json.loads(results.readall().decode('utf-8'))
google_hits=int(json_res['responseData']['cursor']['estimatedResultCount'])
return google_hits
def so(phrase):
num = hits(phrase,"excellent")
#print num
den = hits(phrase,"poor")
#print den
ratio = num / den
#print ratio
sop = log(ratio)
return sop
print (so("I stayed in this hotel for one night")
```

Code 1. PMI

In order to obtain the *SO*, we used the *PMI* measurement. Proposed by [2]:

$$SO(\text{phrase}) = \log_2 ((\text{hits}(\text{phrase NEAR “excellent”})\text{hits}(\text{“poor”})/(\text{hits}(\text{phrase NEAR “poor”})\text{hits}(\text{“excellent”})) \quad (1)$$

The *SO* was based on *PMI*, which facilitates the classification of the phrase according to the number of hits that are found in the Google API enquiry.

Support Vector Machine

In our study, the application of *SVM* for the classification of texts obtained excellent results; the reason for this was that they could be activated with a

non-linear space that was separable from a linear space. The transferring of data from an initial space to another one of greater dimension is achieved by means of the kernel function. A nuclear function or kernel is an internal product within the sphere of characteristics. This has its equivalent in the input space; i.e.:

$$K(x,x') = \langle \Phi(x), \Phi(x') \rangle \quad (2)$$

Where *K* is a positive symmetrical function that meets the mercer conditions. With the selected phrases, the *SO* begins to classify the text. As with the new text for the test, only the phrases that meet the requirements of the pattern were selected. Once this classification had been analyzed by an expert or had been compared with the polarity of opinions, it could be included in the training grid. The results are then analyzed with Precision and Recall.

4. Experimentation

In order to obtain the training grid data, we utilized the opinions gathered in the dataset called: sentiment_detection_hotel_reviews. Two volunteers were selected for this were experts about tourism and could identify the phrases according to the set patters. The code described in this study could then be executed. The results were as follows:

Table 2. Results of the classification

Algorithm	TP	TN	FP	FN	Precision	Recall	F1Score
J48	60	46	14	12	0,81	0,76	0,78
Neural N	55	44	16	17	0,77	0,73	0,75
SVM	66	52	8	6	0,89	0,86	0,87

Table 2 shows the results of the classification. Three algorithms were analyzed to corroborate the results. This table indicates that *SVM* obtains better results than J48 and the neuronal network. This provides validity to our theory, which seeks to promote patterns that can be used to select phrases that are to be classified.

The kernel that was used for *SVM* was Regression Analysis since we also worked with an interval to define when it was necessary to use the rating of *Excellent* ad *Poor*. The following figure shows the results of working with different levels for the interval- being the one which provided a better result for the *Excellent* category*:* values between 80% and 90%. Figure 1 and Table 3 show the following results:

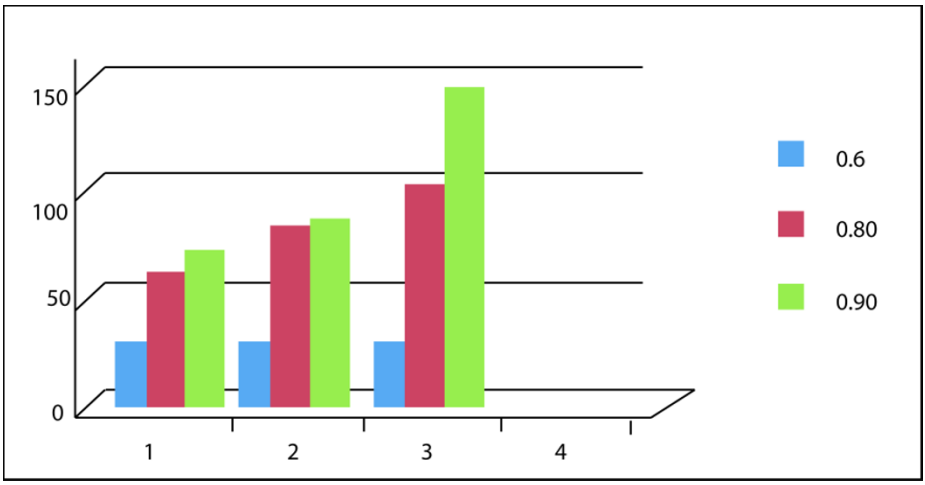


Figure 1. *SO* of the set phrases for the 'Excellent' rating

TP	TN	FP	FN	Precision	Recall	F1Score
96	44	16	4	0,85	0,73	**0,79**
101	52	8	19	0,92	0,86	**0,8**

Table 3. Results of 80 and 120 selected phrases.

The selection of the phrases with values of 0.80 and 0.90 for *SO* obtained an acceptable *F1* Score. Here we used various values for the excellent rating seeing that we did not have a referential value to identify the best phrases, which is why we needed to carry out various experiments.

5. Conclusions and Future Work

The creation of clauses (rules) can be converted to work with patterns. Patterns have polarity. However, in order to construct a syntactic dependency tress, one needs concepts and sentiments linked to these concepts, which would enable us to have an affective space.

While the concept can be linked to sentiment and polarity, we may also calculate the valence of a concept. Likewise, for dependency purposes, we can transfer this valence to the rest of the concept dependency according to the clauses or rules that are proposed.

One needs to remember, however, that in order to obtain polarity, one need to use dictionaries or lexicon where the concepts are already related (in advance) with a polarity as well as with an emotion. In our case, Google *APIs* help us to obtain a *SO*, which is related with polarity. The classification was carried out with various levels for the interval of *SO*, and demonstrated that the *SVM* were

adequate for our methodology. Moreover, these values may be corroborated in future work so as to be used as standards for classification.

The results of the *SO* and the classification may be provided to tourism operators so that they can classify the phrases of the clients as Excellent and Poor and to take better decisions in relation to creating tourism packages. In addition, one can also obtain the affective spaces seeing that we can link each phrase of the text (entity) to a polarity.

For this, it would be necessary to have labeling machines and apply the *Kappa C* coefficient with polarity, sentiment and emotion so as to apply the diffused classifier and identify the affective space pertaining to a new customer opinion. This classification may also be supervised.

For example, one could use a Bayesian network to classify the emotion linked to ngrams and syntactic n-grams. The latter provides considerable aggregate value to our research. All these aspects will be taken into consideration for future work related to this initial research proposal.

6. Bibliography

[1] María Eugenia Escudero Aragón, *Marketing en la actividad comercial*. Madrid: Editex, 2014.

[2] Bing Liu, *Sentiment Analysis and Opinion Mining*.: Morgan & Claypool , 2012.

[3] Soujanya Poria, Erik Cambria, Grégoire Winterstein, and Guang-Bin Huang, "Sentic patterns: Dependency-based rules for concept-level sentiment analysis," *Elsevier*, pp. 45-63, 2014.

[4] Thorsten Joachims, "Text Categorization with Support Vector Machines: Learning with Many Relevant," in *Proceedings of the 10th European Conference on Machine Learning*, London, 1998, pp. 137-142.

[5] Manabu Sassano, "Virtual examples for text classification with Support Vector Machine," in *Proceedings of the 2003 conference on Empirical methods in natural language processing*, USA, 2003, pp. 208-2015.

[6] Peiwen Chen, Xiufen Fu, Shaohua Teng, Sui Lin, and Lu Jingqiao, "Research on Micro-blog Sentiment Polarity Classification Based on SVM," *Human Centered Computing*, pp. 392-404, 2015.

[7] Eugenio Martínez-Cámara, M.Teresa Martín-Valdivia, Alfonso Ureña-Lopez, and Ruslan Mitkov, "Polarity classification for Spanish tweets using the COST corpus," *Journal of Information Science*, 2015.

[8] Olga Kolchyna, Tharsis Souza, Philip Treleaven, and Tomaso Aste, "Twiter Sentiment Analysis," *Computation and Language*, 2015.

Building a Generic Model for Early Warning Information Systems (EWIS)

Mohamed Saadeldin[1] and Hegazy M. Zaher[2]
[1] Decision Making Support Center, Dubai Police, Dubai, United Arab Emirates
mmsaad@hotmail.com
[2] Institute of Statistical Studies and Research, Cairo University, Egypt
hgsabry@yahoo.com

Abstract: Different EWSs have been developed for various categories of crises/disasters, which are based on specific models and cater to various decision support needs. There is no general methodology to be followed by organizations that are exposed to risks. Throughout this research, we aim to put a general methodology and set standard rules for risk-prone organizations or sectors that need an early warning system to prevent or at least reduce these risks. This research suggests a generic EWIS model that can be adapted to the dynamic needs of the field of crisis management. The generic model is made up of a series of sub-models, each of which consists of a set of processes that are connected together based on their functions. The generic model can be used - with some modifications- in any type of EWIS. The information systems that uses the proposed generic model will provide decision makers, governments and people with alerts to prevent or at least reduce the risks of crises and disasters.

Keywords: Early Warning, Model, Forecasting, Indicator

1 Introduction

A number of models have been developed for effective early warning information systems. These models are mostly deterministic, simplistic or inconsistent in application and assumption. Using the proposed generic model, we will be able to integrate the advantages of the previous models in an enhanced and effective one. Fawcett (1994) has defined the conceptual model as a set of concepts and statements that integrate the concepts into a meaningful configuration [1]. According to the business dictionary a model is defined as graphics, mathematical (symbolic), physical, or verbal representation or a simplified version of a concept, phenomenon, relationship, structure, system, or an aspect of the real world [2]. The generic EWIS model offers a more general framework than conventional models as it outlines standardized rules and guidelines that enable organizations in different sectors to build an effective EWIS. A generic model is developed as an approach to solve some of the shortcomings of conventional models. We can define the EWIS model as "A group of principles and general normative rules that can be applied to any EWIS, regardless of its specialization and functions". The proposed generic model is an integration of a number of different sub-models into a single composite logical model (Figure 1). The proposed approach depends on structured modeling; to simplify the design of the generic model, we have broken it down into a set of sub-models, each of

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_60

which has multiple processes grouped together according to their similar functions. The proposed model will be a guideline for any organization or any sector in the country that wants to have an EWIS for crises preparedness, Furthermore, there are other advantages for using the generic model, which can be summarized as follows:

1. Sharing information, knowledge and expertise between different organizations.
2. Reducing the time and effort required to build EWIS from scratch.
3. The model allows for iterative development and can evolve over time.
4. The generic model can be applied in different sectors with little modification.
5. The generic model can include multiple sectors at the same time.
6. The generic model will support any information system in producing more effective and accurate predictions for the future.
7. Eventually, new sectors (such as education, health, etc.) can be added on at a later stage and are nearly completely supported by the existing model.

2 Building the Generic Model

Various researchers have identified what they consider to be the essential components of a successful EWIS model; for example, a paper by Verstegen (1999) suggests that the EWIS model should have five components: selection of indicators; communication of warnings; reception of warnings; early warning education; and the generation and maintenance of awareness [3]. However, this model does not specify the methods or steps of data collection. Moreover, it does not explain how to measure the precursors, evaluate the event or specify the forecasting models. Along the same lines, Lundin (2008) suggests that an EWIS is responsible for issuing forecasts, warnings, and responses [4]. Yet, the model he proposes does not clarify how the data is collected and analyzed; or explain how to prepare future forecasts or how to select the most suitable model for forecasting. Obviously, there is no agreement on the ideal structure or function of an EWIS [5]. This means that the structure and functions of EWIS may vary from one organization to another and from one field to another. Therefore, after reviewing most of the previous studies about the major components of an EWIS model we suggest that any EWIS should take into consideration five essential models, The first model (Detecting the Risks) includes functions that capture and analyze the event/crisis information. The second model (Analyzing the Risks) determines the set of mathematical indicators that should be measured frequently. The third model (Choosing the Critical Factors) allows for the selection of the most important factors that affect or stimulate the crisis. The fourth model (Future Forecasting) provides future forecasts depending on the data calculated from the previous model and finally the fifth model (Issuance of Warnings) is concerned with sending warnings (alerts) to users. The proposed EWIS is based on the conceptual model, which consists of a set of ten sub-models; the major inputs of the proposed EWIS depend on heterogeneous information, which is gathered from different sources, including (news, statistics, reports, databases, radio, TV, data, etc.). The major outputs of the proposed system are a set of warnings. The generic model is constructed and refined through the incremental prototyping concept (iterative series of prototype). The proposed EWIS is built through multiple iterations of prototypes, which are used to progressively refine the design. The generic model will be divided into ten Sub-Models (see Figure 1,

Figure 2). The following flowchart can be implemented and tested by designing a powerful IS which can be used not only as a decision-support tool for emergency management personnel, but also as a planning tool that can assist any sector to better plan emergency preparedness and response activities.

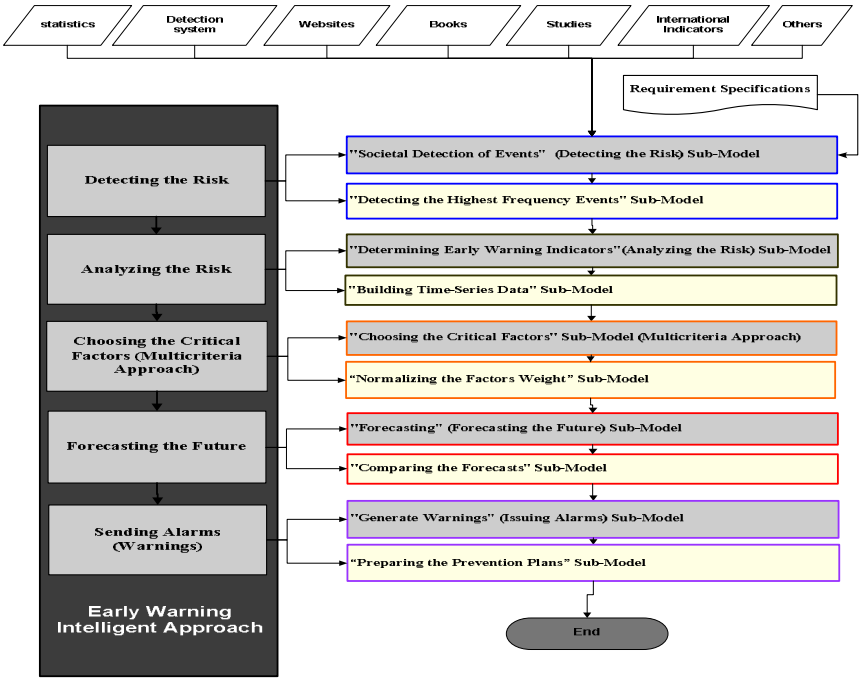


Figure 1: The Main Components of the Generic Model

The next pages will illustrate the components of each sub-model, as the followings:

1. Creating the Sub-Model "Societal Detection of Events"

The first sub-model is divided into a series of critical processes such as:

1. Designing a form to collect data from various sources.
2. Collecting data from different sources.
3. Filling the predefined form with the data obtained in the previous step.
4. Checking any missing values in the form.
5. Verifying and validating the data.
6. Classifying the data.
7. Analyzing the data.
8. Building a data entry module for the data.
9. Classifying the data (health, construction, crime, .etc.).
10. Choosing the best sector to group the data.
11. Adding a new sector if needed.
12. Saving the data.
13. Grouping relevant events.
14. Sorting of all relevant events.

2. Creating the Sub-Model "Detecting the Highest Frequency Events"

The sub-model is divided into a series of critical processes such as:

1. Collecting detailed data about the event.
2. Checking the frequency of each event.
3. Sorting the events according to the frequencies of their occurrence.
4. Creating the risk/threat agenda.
5. Choosing a risk/threat to study.

Example:

1. Event data is collected from various data sources.
2. The number of occurrences is calculated at a specific time (see Table 2).
3. The EWIS selects the most frequent event; "Drug Abuse among Youth" (see Table 2), because this event has the highest number of occurrences. This event was detected from multiple sources over the period from 2006 to 2010.
4. After analyzing the data, the system found that this event is increasing on an annual basis (see Table 4).

Table 1: Event Occurrences Table Format

Event/Phenomenon	No of occurrences	Time Frame
Event 1/ Phenomenon 1	----------	1/1/2010 to 31/12/2010
Event 2/ Phenomenon 2	----------	1/1/2010 to 31/12/2010
----------	----------	----------

Table 2: Event Occurrences Example

Event /Phenomenon	No. Of Occurrences	Time Frame
Drug abuse (youth)	34	1/1/2010 to 31/12/2010
Spinsterhood	24	1/1/2010 to 31/12/2010
The collapse of buildings	22	1/1/2010 to 31/12/2010
Hooliganism	21	1/1/2010 to 31/12/2010
Child molestation	20	1/1/2010 to 31/12/2010
Drug trafficking	14	1/1/2010 to 31/12/2010

Table 3: Drug Abuse Event Occurrences (2006-2010) Example

Year	2006	2007	2008	2009	2010
No of occurrences	12	16	20	25	34

Table 4: Indicators Time Series Data (2003-2010) Example

Year	Indicator A	Indicator B	Indicator C	Indicator D
2003	70	65	4%	40%
2004	80	80	5%	45%
2005	850	85	5.5%	48%
2006	105	100	7%	49%
2007	111	105	7.2%	55%
2008	120	120	7.7%	60%
2009	140	140	9%	62%
2010	160	165	10.6%	69%

** The sample data represented in the previous tables is not real data

3. Creating the Sub-Model "Determining Early Warning Indicators"

The value of indicators in EWIS is very important to evaluate the event/threat/risk [6]. Indicators are just what their name implies: conditions that, if observed, could be indicative of a threat's emergence or its potential for emergence,. The best indicator lists are those that address all the key threat components. There are two crucial questions that arise when the issue of identifying "early warning" indicators is posed. First is the question regarding the specific condition or situation for which we require early warning indicators (i.e., "Of what") and second is the question regarding "how early." The answers to these questions will determine which indicators we should examine and monitor.

Example: The system detected that the event "Widespread drug abuse among the youth" has the highest number of occurrences in the year 2012 and the early warning indicators for this event are:

1. Indicator (A): Total number of addicted youth.
2. Indicator (B): Total number of drug cases.
3. Indicator (C): The proportion of youth detained in drug cases to the total youth population = (total number of youth detained/ total youth population) * 100.
4. Indicator (D): The proportion of local people detained to the total number of arrests = (total number of local youth detained in drug abuse cases/ total youth detained from all nationalities in drug abuse cases) * 100

The sub-model is divided into a series of critical processes such as:

1. Determining the indicator.
2. Defining and describing the indicator.
3. Determining the variables involved in calculating the indicator.
4. Analyzing the links between the variables.
5. Determining the measuring unit.
6. Revision and validation of information.
7. Testing the indicator by using real data.
8. Applying the indicator.

4. Creating the Sub-Model "Building Time-Series Data"

The sub-model is divided into a series of critical processes such as:

1. Collecting historical data about the selected event.
2. Checking the validity of data.
3. Adding the time series data to the event (database).
4. Reviewing the missing values for each indicator.
5. Saving the data into the database.

5. Creating the Sub-Model "Choosing the Critical Factors"

The researchers have formulated their own methodology, which depends on ranking variables automatically and giving a weight to each variable according to its importance. The methodology also compares the different variables and selects the critical ones (the variables which have a great effect on increasing the risk). The main

element in, the weighting methods is how to determine the weights of the criteria, which reflects the decision maker's preferences to the highest degree. Many methods for criteria weighting have been previously developed. A value tradeoff method is proposed in [7]. Several versions of the analytic hierarchy process are developed in [8,9]. Using pairwise criteria comparison, a reciprocal pairwise comparison matrix is constructed. This method is generalized in [10] to reflect a decision maker's uncertainty about the estimates in the reciprocal matrix. Moreover, a direct ranking and rating method is proposed in [11], in which decision makers first rank all the criteria according to their importance. Based on this ranking, and under certain assumptions, the weights of the criteria, which define their relative importance, are obtained. A mathematical programming model with sensitivity analysis is used in [12] to determine the intervals of weights, within which the same ranking result is produced. The weighting method, as a decision maker's preferred model, which does not allow the existence of incomparable alternatives, and the preference information obtained by the decision maker (different types of criteria comparison) is sufficient to determine whether one of the alternatives must be preferred or whether the two alternatives are equal for the decision maker. If we consider the set of indicators C = {c1, c2,…, cn}., Then by using the procedure presented in this paper the weight of each value can be calculated through the position of the value of the indicator in the range (which is determined by the procedure proposed by the researcher), and hence the importance of any criterion (indicator) is determined by identifying the total weight of all the values of this indicator. If the net weight of any indicator is higher than the others, this means that the indicator has a higher importance in terms of increasing or stimulating the event/threat/risk. The challenge in this sub-model is how to take what has been a manual process that relies on "expert judgment" and turn it into a more automated system. The researchers have designed a new intelligent approach that selects the critical factors affecting or stimulating the event. This sub-model is divided into a series of critical processes such as:

1. Obtaining the time-series data for the indicator (n)
2. Calculating the total number of values for the indicator (n)
3. Determining the lowest value (L).
4. Determining the highest value (H).
5. Subtracting the lowest value from the highest value (D) = H - L
6. Setting the number of intervals (I) (from 0.1 to 1) = 10
7. Calculating the increment = D / I
8. Determining the ranges for the indicator (n).
9. Setting the weight according to the range and values
10. Calculating the total weight for each indicator
11. Repeating the above process for indicator (2)… to indicator (n)

6. Creating the Sub-Model "Normalizing the Factors Weight"

The sub-model is divided into a series of critical processes such as:

1. Normalizing the weight values by calculating the following formula:
    - Weight of indicator 1 / total weights (weight of indicator 1 + weight of indicator 2+…. weight of indicator n).

2. Ranking the indicators (1… n), the top indicators have a higher weight and will affect the risk or stimulate it.

7. Creating the Sub-Model "Forecasting the Future"

Crisis prediction is considered one of the most important processes in the structure of the EWIS. A crisis is often the result of a number of negative events that can ideally be monitored. In this case, the information about these events, combined with background data (structural data) about any given country can all be analyzed through an EWIS, resulting in predictions and warnings [4]. There are no perfect forecasts; they always contain some error. While perhaps that is obvious, it is nonetheless important to emphasize this fact at the outset [13]. Any forecasting model should have at least two major phases, one of them is the model-building phase and the other is forecasting phase time series, which is a chronological sequence of observations on a particular variable. Usually the observations are taken at regular intervals (days, months, years), but the sampling could be irregular. The choice of a particular forecasting model is dependent on the intelligence of the EWIS and its ability to choose the best model accurately. There are main pillars to choose from a particular forecast model, they are [14]: degree of accuracy, degree of correlation between data, and the availability of data. A forecast error is the difference between the actual or real and the predicted value of a time series or any other phenomenon of interest. This sub-model is divided into a series of critical processes, which are:

1. Selecting specific data for each indicator (year & value).
2. Checking the validity of data.
3. Model specification.
4. Building mathematical equations for different forecasting models.
5. Forecast generation.

8. Creating the Sub-Model "Comparing the Forecasts"

The sub-model is divided into a series of critical processes such as:

1. Obtaining the forecasting models
2. Checking the availability of data and the degree of correlation between data and accuracy of each model
3. Checking the validity of all the pillars
4. Choosing the best mathematical model based on specific criteria.

9. Creating the Sub-Model “Generate Warnings (Alerts)”

In this process, the system will generate alerts automatically based on the forecasts that are calculated using the system. Once alerts are generated, they can be distributed through different channels to many parties, such as decision makers, governmental sectors, and people who are exposed to hazards. We will use the five-level color-coded scale to reflect the likelihood of a threat occurrence, such as:

Dangerous	High	Medium	Low	Nil
Probability at or above 90%	Probability at or above 70% but below 90%	Probability above 55% but below 70%	Probability above 20%, but at or below 55%	Probability at or below 20%

The sub-model is divided into a series of critical processes such as:

5. Expecting the extreme values for the event: The EWIS may determine the extreme values by one of the following methods:
   - The organization may get the extreme value for each indicator from international indictors and add it to the EWIS database.
   - Using one of the descriptive statistical techniques called boxplot method, which is used to calculate the extreme values from the event's data.
   - The proposed EWIS chooses the following method which calculates the extreme values from the event's data through the following steps:
     a. Getting the time-series data for the indicator (n)
     b. Calculating the total number of values for the indicator (n)
     c. Sorting data values
     d. Determining the lowest value (L).
     e. Determining the highest value (H).
     f. Subtracting the lowest value from the highest value (D) = (H) – (L)
     g. Calculating the increment = 2* (D / I)
     h. Determining the ranges and setting the number of intervals (I) (from 0.1 to 1) = 10
     i. The extreme values will be any values greater than the last value in the range (probability = 1).
6. Calculating the probability of a danger/risk.
7. Determining the total probability value each year.
8. Determining the description for the level of danger/risk.
9. Converting the level of danger to the color coded scale.
10. Calculating the length of time remaining to the emergence of the danger/risk.
11. Setting the time frame for the frequent warning signals
12. Sending the warning signals to those concerned (the public, decision makers, government organizations, etc.) in a time frame according to the color of each variable (red, orange, green).

10. Creating the Sub-Model "Preparing the Prevention Plans"

The goal of the preventive plan is to reduce the risk discovered by the system. Prevention plans can help uncover hazards that might otherwise catch decision makers by surprise. In this process, anecdotal information is one important source of information, among many, for identifying principal drivers. The sub-model is divided into a series of critical processes such as:

1. Identifying the riskiest indicators or factors (Identifying the most critical factors/ indicators, which directly affect, increase or stimulate the risk/phenomena)
2. Choosing an event or factor that needs to be reduced or eliminated (Choosing which indicator has a higher priority to be decreased).
3. Brain storming to suggest a number of alternatives to decrease or eliminate the event or risk (having a brain storming session for all related users, and associating each indicator with the conclusions arrived at during that session)
4. Studying all alternatives
5. Choosing the best alternative to decrease or eliminate the event

6. Applying this alternative (applying the best alternative that has been chosen in the previous step).
7. Evaluating the work (the real results with the expected ones).

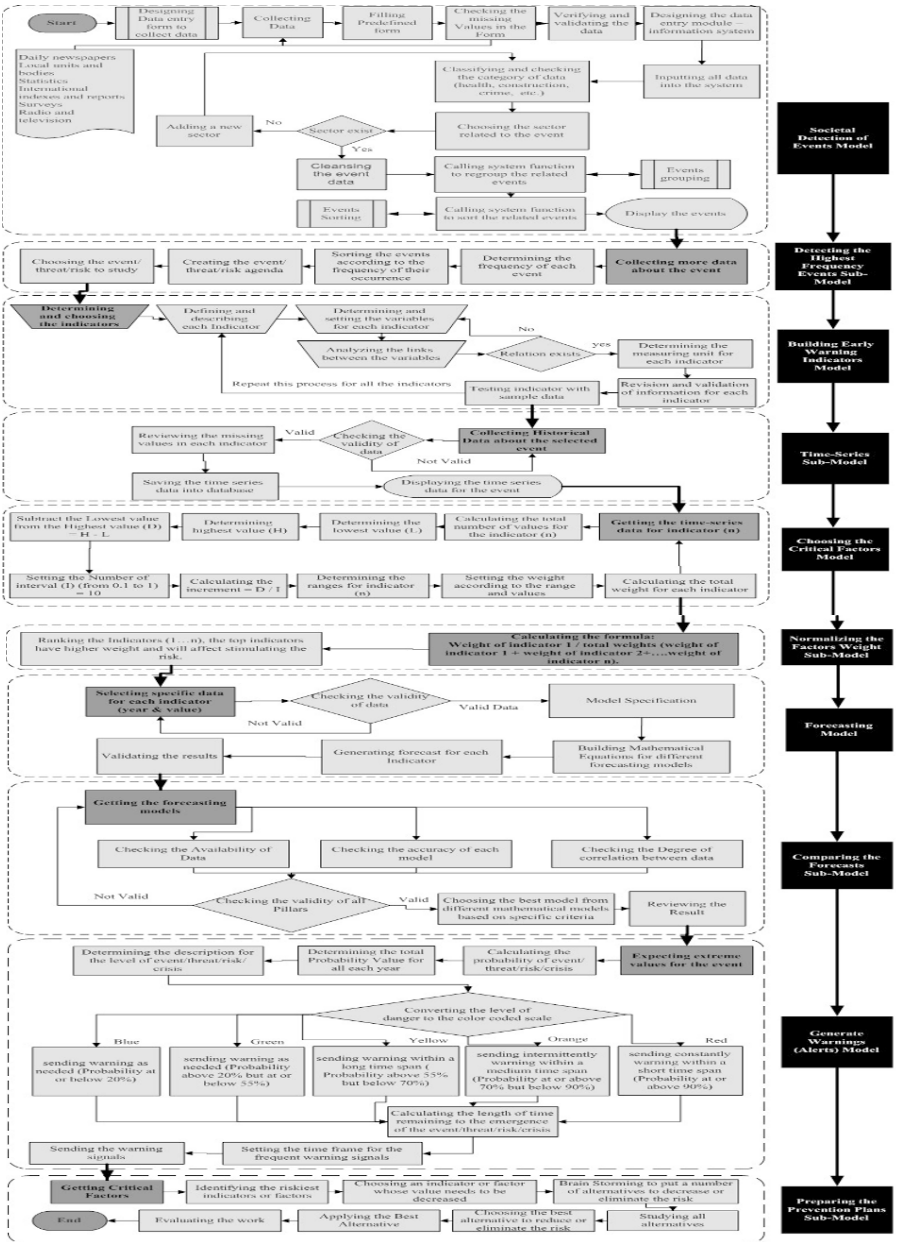


Figure 2: The Detailed Generic Model

3 Conclusions

There is a great need to build a generic model for early warning information systems; the generic EWIS model is a generalization of conventional models and contains the general normative rules that can be applied to any early warning information system, regardless of its specialization and functions. The generic model shares the information and expertise between different parties, Reducing the time and effort required to build an early warning system from scratch, the generic model can be developed over time and it can cover new and different subject areas (such as: education, health ….. etc.). This research explains the implementation procedure for building a generic model for early warning information systems. A generic model is developed as an approach to solve some shortcomings of conventional models that currently exist; which are mostly deterministic, simplistic or inconsistent in application and assumption; thus making them unreliable and impractical.

References

1. Fawcett, J. (1994). Analysis and Evaluation of Conceptual Models of Nursing. Philadelphia. PA: F.A. Davis
2. Model. (2013). Retrieved April 19, 2013, from Businessdictionary: http://www.businessdictionary.com/definition/model.html.
3. Verstegen, S. (1999). Conflict Prognostication: Toward a Tentative Framework for Conflict Assessement. Clingendael Institute.
4. Lundin H. (2008). Crisis and Conflict Prevention with an Internet based Early Warning System. Royal Institute of Technology (KTH). Sweden
5. Shrestha, B. K. (2009, November 2-5). Planning Food Security in Nepal. ADB-FAO workshop on Agricultural Statistics and Agriculture Census. Bangkok. Thailand.
6. Abdulla, M. M., & Saad Eldin, M. (2009). International Indicators and Their Role in Supporting Decision-Making Development. (Arabic Version). Dubai: Dubai Police Decision Making Support Center.
7. Keeney, R. and Raiffa. H. (1976). Decisions with Multiple Objectives. Preferences and Value Trade Offs. John Wiley & Sons. New York.
8. Saaty, T. S. (1980). The Analytic Hierarchy Process. McGraw-Hill. New York.
9. Saaty, T. L. (1994). Highlights and Critical points in the Theory and Application of the Analytic Hierarchy Process. European Journal of Operational Research. 74. 426-447.
10. Takeda, E., K.O. Cogger, P. L. Yu (1988). Estimating Criterion Weights Using Eigenvectors: A Comparative Study. European Journal of Operational Research. 29. 360-369.
11. Winterfeldt, Von. D., and Edwards, W. (1986). Decision Analysis and Behavioral Research. Cambridge University Press. London.
12. Mareschal, B. (1988). Weight Stability Intervals in Multicriteria Decision Aid. European Journal of Operational Research. 33. 54-64.
13. Evans, M. K. (2002). Practical Business Forecasting. United Kingdom: Blackwell Publishers Ltd.
14. Anurag, Prasad. (2008, March 15-18). Forecasting and Model Selection. India: REACH Symposium. Indian Institute of Technology Kanpur.

User and Context Information in Context-Aware Recommender Systems: A Systematic Literature Review

Sergio Inzunza, Reyes Juárez-Ramírez, and Alan Ramírez-Noriega

School of Chemical Science and Engineering, Autonomous University of Baja California, Calzada Universidad 14418, Tijuana, B.C. 22390, México
sinzunza@uabc.edu.mx, reyesjua@uabc.edu.mx, alan.david.ramirez.noriega@uabc.edu.mx

Abstract. Using contextual information inside recommendation systems is an effective approach to generate more accurate recommendations. This paper present a review conducted to identify what user's and context's information it's considered relevant by researchers to generate contextual recommendations from 2012 to 2015, based on Kitchenham systematic literature review methodology. The results indicated that there is a large set of possible user's and context's information that can be used to do recommendations. This review can be taken as basis for future context-aware recommender systems development, as well as development of contextual user models.

1 Introduction

During the last 20 years, the quantity of potentially interesting products (items) available to users through online services has been growing rapidly and now exceeds human processing capabilities [33]. As a result of this information explosion, users face situations where they would like to choose an item among a large set of alternatives but do not have sufficient knowledge, capabilities or time to make such decision [25], this created the need for intelligent systems that advice about what to buy, how to spend leisure time or what to watch in the TV, while taking into account their personal needs and interests. This type of systems is referred in the literature as personalization systems, which focus on provisioning of tailored products, services or information to individual users [34].

The type of personalization systems this works focus on are recommender systems, more specifically in the evolution of traditional recommender systems; Context-Aware Recommender Systems (CARS) [4]. While both types of systems provide users with recommendation about a product and services, CARS differ from traditional recommendation strategies because they predict how a given user will like an item, not only based on past user rating or item interactions, but also exploiting the context in which ratings/interactions were produced, and the user's aspects and context at request time [6] [14].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_61

An essential input for every personalization technique is the data about the user [7], specially in systems like CARS which base its functionality in the knowledge of the user [30]. Such information about the user is known in the literature as User Model. A user model (UM) is the knowledge about the user, explicitly or implicitly encoded, which is used by the system to improve the interaction [39].

As Recommendation systems evolve into CARS, User Modeling evolve too, and adopt context-awareness capabilities. A UM is considered context-aware if it can express aspects of the user's contextual information and such information is used to help the system adapt its functionality to specific user characteristics and context [40]. Despite the technique used in a CARS to generate recommendations, it can provide high quality recommendations to users only after having modeled their preferences, behavior and context information [2] [8] [27].

In CARS most of the existing research studies focus on proposing new recommendation algorithms or improving existing ones [37], validating such algorithms using a small set of context's and user's aspects. However, no systematic literature review of CARS has been published previously to describe the wide spectrum of user's and context's information that has been used to generate context-based recommendations. Therefore the main objective of this paper is to present a holistic overview of what user's and context's information has been used to generate context-based recommendations, according to recent publications. The rest of this papers is organized as follows. The methodology used to carry out the review is presented on Section 2. Next in Section 3 we report the results found trough the review. And finally Section 4 we present a short discussion of the findings and the ongoing and future work.

2 Research Method

Rather than using a traditional literature review, we used a Systematic Literature Review (SLR), following the methodology proposed by Kitchenham [29] since it is a rigorous and well-defined method in the field od software engineering. The SLR is a formalized and repeatable process to document relevant knowledge on a specific subject for assessing all available literature related to specific research question(s) [10]. The steps presented in the Kitchenham methodology are documented below.

2.1 Planning the Review (Phase 1)

Need for a Review As we determined before, there was no systematic review in the field of user model for CARS; however the increasing number of papers on CARS is appearing in many disciplines (such as ubiquitous and mobile computing, e-commerce, marketing, ect.)[12] can be taken as evidence that the importance of contextual information has been recognized by researchers and practitioners [3]. We consider that identifying what user's and context's information had been used in CARS to do context-based recommendations can

be beneficial for future development and CARS research. Hence, we identified the need for a SLR that enlist the user and context information past studies has used to generate recommendations.

Research Questions. The main focus of this papers is to identify the user and context information that has been used inside CARS to generate recommendations, the research questions addressed by this study are:

RQ1. Which user aspects has been used in CARS?
RQ2. Which context information has been used in CARS?
RQ3. What items are the CARS recommending?

Bibliographic Databases. We chose the following bibliographic databases as source of information for our reviews: ACM, IEEExplore (IEEE), Science Direct (SD) and Springer Link (SL). The search were limited to journal and conference proceedings papers that were published within January 2012 through July 2015.

2.2 Conducting the Review (Phase 2)

As we identified from previous studies, in literature, different terms has been used to refer to recommendation systems, user model and context-awareness, in order to retrieve the maximum number of relevant publication, we consider such synonyms in our research process. We chose tree synonyms for context-awareness (context-aware, context aware and contextual), two for recommendation (recommendation and recommender system) and tree terms referring to user models (user model, user profile and user aspect) as depicted in the Fig. 1. We carried out the research process manually, using the 12 possible combinations of the terms, and making an union operation of the 12 the results. We use this terms to search inside publication keywords, title, abstract and full text.

Topic 1		Topic 2		Topic 3	Search Results
context-aware		recommender system		user model	
OR				OR	
context aware	AND	OR	AND	user profile	175
OR		recommendation		OR	
contextual				user aspects	

Fig. 1. Search strategies

Selection of Primary Studies. We use the following strategy to identify the relevant publications out of the paper list retrieved from the search.

- Title-based exclusion: First we review the title of the publication to eliminate the publications that are clearly out of the scope of the review. After this stage we end up with 140 papers out of 175.
- Screening-based exclusion: Using abstract, keywords, sections titles, figures, tables, and conclusion (if present) we eliminate the publication out of this review interest. We shrink the list to 49 papers.
- Full text-base exclusion: Reading carefully the full paper, analyzing what it proposes and using the inclusion and exclusion criteria described below, we eliminate the papers that are out of the interest of this review. The results are 24 related papers.

Among the retrieved papers we select the written in English, published between January 1, 2012 and that met one of the following inclusion criteria:

- The papers discussed what user or context-information can be used to generate better recommendation results.
- The paper discussed a user and/or context model, and such model was used to CARS.
- The papers test or proposed data processing techniques or algorithms for CARS and mention what user or context information used to test their proposal.

We also considered a few additional exclusion criteria:

- We exclude books and posters.
- Personal expert opinions about what information can be used to generate recommendation but don't present experimental results.
- Publication related to CARS that don't describe what information about the user or context was used inside the CARS.

Data Extraction. Applying the aforementioned criteria and review strategies, 24 papers where selected as related literature that will be used to answer the proposed research questions. In our papers review, we consider context as any information that describe a person, or a situation of a person that can be used to generate recommendation.

3 Results

In this section we show the results, which correspond to Phase 3 (reporting the review) of the systematic review performed, in this section we also respond to the research questions. First Table 1 present the 24 papers selected as relevant publications as described by the later section. Also in Table 1, the last column (*Recommending*) refers to what type of item(s) the publication's CARS are recommending, such information responds to **RQ3**. The most common recommended items are *Movies* (10) and *Music* (6), although CARS are used to recommend an broad set of things.

Table 1. Resulting publications from data extraction

ID	Ref	Year	Database	Recommending
SL22	[1]	2015	SL	
SL25	[17]	2015	SL	News
SL27	[19]	2014	SD	Photos
SL33	[38]	2013	ACM	Music
SL43	[13]	2015	SL	Hotel, Restaurant
SL53	[35]	2014	IEEE	Movies
SL54	[36]	2014	SL	Movies
SL56	[26]	2012	SD	Music
SL69	[18]	2015	ACM	Music
SL64	[15]	2015	SL	Movies, Music, Places. Books
SL67	[43]	2015	ACM	Movies
SL83	[9]	2012	IEEE	Documents
SL89	[24]	2014	SL	Movies, Food, Shoes
SL91	[28]	2014	SL	Food
SL95	[31]	2014	SD	Smartphone Actions
SL98	[32]	2014	ACM	News
SL132	[16]	2015	SD	Movies
SL152	[11]	2014	SL	Movies, Music
SL155	[5]	2014	SL	Movies, Music
SL168	[21]	2014	SD	Movies
SL169	[21]	2014	SD	Movies
SL173	[20]	2013	ACM	Food
SL174	[41]	2012	SL	Places
SL175	[42]	2012	IEEE	Learning Material

3.1 Uses's Aspects Inside CARS

To organize the information about the user found in each of the papers reviewed, we started from the 'Basic user dimensions' proposed in GUMO [23] [22], we use 9 out of the 12 dimension proposed (*Mental state, Physiological state, Demographics, Contact information, Role, Emotional state, Personality, Ability and Proficiency and Nutrition*), living out *Characteristics and Facial expressions* as none of the reviewed papers use such dimensions to generate recommendations, we also leave out *Motion* as we consider this information as part of the Context information. Through the identification of the users aspects in the review, we realize that some papers consider information that lay out of the dimension list, therefore another 2 dimensions were added to the list (*Interest & preferences and Experience*). Table 2 responds to **RQ1** enlisting which user's aspects has been used in CARS.

Table 2: User's information considered in CARS

Dimension	Authors	Aspects

Mental	[42], [5], [38] [26], [15], [24], [28], [31], [16]	cognitive style, mental stress (elevated, neutral, relax), mood, objective, goals, habits, behavior
Physiological	[41], [38], [18], [24]	physiological aspects, needs, hear rate, blood pressure, respiration rate, skin conductivity, brain wave, EMA and ECG signals, physical information, disabilities
Demographics	[41], [42], [38], [36], [26], [15], [24], [28], [16]	age, personal information, gender, profession, socio-economic, culture, sex, hometown, show size, lives in, address(number, street, city, state, country), relationship status
Contact	[41], [42], [36], [24],	name. personal information
Role	[21]	role
Emotions	[42], [5], [1], [17], [26], [18], [24] [41]	emotions, affects, emotional situation, sentiments, emotional state
Personality	[26]	personality
Interest and Preferences	[41], [43], [13], [21], [1], [17], [38], [18], [9], [32], [21], [20]	interest, desire, opinions, preferences
Experience	[18]	experience
Abilities and Proficiency	[41]	capabilities
Nutrition	[41], [28], [20]	nutrition, food, taste

3.2 Context's Aspects Used in CARS

For organizing the context information found in the review we use Verbert [42] proposal, where the context is form by 7 contextual dimensions (*Computing, Location, Time, Physical conditions, Activity, Resource and Social relations*). Table 3 responds to **RQ2** showing what context's information has been used inside CARS.

Table 3: Context's information considered in CARS

Dimension	Authors	Aspects

Computing	[42], [21], [17], [19], [38], [35], [31], [41], [16]	network (GPS, Wi-Fi, Bluetooth, RFID, RF, 3G, 4G), hardware, software, device, incoming calls, system service, notification, battery charge, PC, mobile phone, network bandwidth, display resolution, display resolution, storage capacity, RAM memory, OS,
Location	[41], [42], [21], [38], [35], [36], [26], [26], [18], [9], [24], [28], [31], [16], [21]	location (in-door, out-door), place (home, shops, coffee shops, bus station, train station, office, school, sport center, store, movie theater, restaurant), surroundings, services
Time	[41], [42], [43], [13], [11], [1], [17], [19], [35], [36], [26], [15], [18], [9], [24], [28], [32], [41], [16], [21], [20]	time (morning, lunchtime, afternoon, evening, night), time of day, time of week, time of year, season, hour, minute, period
Physical Conditions	[41], [42], [21], [1], [17], [19], [38], [36], [26], [15], [24], [28], [16], [21]	environment, physical conditions, temperature, weather, traffic, noise level, light level, humidity, crowd
Activity	[41], [1], [17], [38], [35], [36], [26], [9], [31], [41], [16]	activity, event, walking, jogging, lying, running, standing, driving, sitting, ascending stairs, descending stairs, ascending in elevator, descending in elevator, charging cell, meeting, shopping, writing, cooking, swimming, reading, computing, exercise, travel, working, transit, walking, guided tours, movie show times
Resources	[42]	resource
Social Relations	[42], [21], [17], [38], [35], [26], [15], [18], [9], [24], [41], [16], [21], [20]	social relation, companion, relationship with, friends, family

4 Discussion and Future Work

Context-aware recommender systems take advantage of the information available about the user and the context, as well as previous user-system interactions, there is an almost infinite number of possible user's and context's aspects that can be used to generate contextual recommendations. In this paper we conducted a systematic literature review based on Kitchenham methodology in

order to identify what user's and context's information has been used in CARS publications between 2012 and 2015. We end up analyzing 24 papers and enlist what user's aspects (Table 2) and context's aspects (Table 3) such papers considered as relevant information to generate contextual recommendations. It's interesting to note that when recommending music the most commonly user's aspects considered (SL33, SL56, SL64 and SL69) are *Emotional states* and *Mood*, in case of context's aspects, *Time* is the most common information considered in recommendations followed by *Location* and *Social Relations*.

The ongoing research, that lay out of the scope of this publication, is focused on building a generic user and context model specifically designed for context-aware recommender systems, so that the resulting model can serve as basis for future CARS developments.

References

1. Abbas, A., Zhang, L., Khan, S.U.: A survey on context-aware recommender systems based on computational intelligence techniques. Computing (2015)
2. Adomavicius, G., Tuzhilin, A.: Context-aware recommender systems. Recommender systems handbook pp. 67–80 (2011)
3. Adomavicius, G., Jannach, D.: Preface to the special issue on context-aware recommender systems. User Modeling and User-Adapted Interaction 24(1-2), 1–5 (2014)
4. Adomavicius, G., Tuzhilin, A.: Context-aware recommender systems. Recommender systems handbook pp. 67–80 (2011)
5. Alhamid, M.F., Rawashdeh, M., Al Osman, H., Hossain, M.S., El Saddik, A.: Towards context-sensitive collaborative media recommender system. Multimedia Tools and Applications (2014)
6. Baltrunas, L., Ludwig, B., Peer, S., Ricci, F.: Context relevance assessment and exploitation in mobile recommender systems. Personal and Ubiquitous Computing 16(5), 507–526 (2012)
7. Berkovsky, S.: Ubiquitous User Modeling in Recommender Systems. Um 2005 pp. 496–498 (2005)
8. Berkovsky, S., Kuflik, T., Ricci, F.: Mediation of user models for enhanced personalization in recommender systems. User Modelling and User-Adapted Interaction 18(3), 245–286 (2008)
9. Bouneffouf, D., Bouzeghoub, A., Gançarski, A.L.: Following the user's interests in mobile context-aware recommender systems: The hybrid-e-greedy algorithm. Proceedings - 26th IEEE International Conference on Advanced Information Networking and Applications Workshops, WAINA 2012 pp. 657–662 (2012)
10. Breivold, H.P., Crnkovic, I., Larsson, M.: A systematic review of software architecture evolution research. Inf. Softw. Technol. 54(1), 16–40 (2012)
11. Campos, P.G., Díez, F., Cantador, I.: Time-aware recommender systems: a comprehensive survey and analysis of existing evaluation protocols. User Modeling and User-Adapted Interaction 24(1-2), 67–119 (Feb 2013)
12. Champiri, Z.D., Shahamiri, S.R., Salim, S.S.B.: A systematic review of scholar context-aware recommender systems. Expert Systems with Applications 42(3), 1743–1758 (Sep 2014)
13. Chen, G., Chen, L.: Augmenting service recommender systems by incorporating contextual opinions from user reviews. User Modeling and User-Adapted Interaction (2015)

14. Codina, V., Mena, J., Oliva, L.: Context-Aware User Modeling Strategies for Journey Plan Recommendation. In: User Modeling, Adaptation and Personalization, pp. 68–79. Springer (2015)
15. Codina, V., Ricci, F., Ceccaroni, L.: Distributional semantic pre-filtering in context-aware recommender systems. User Modeling and User-Adapted Interaction (2015)
16. Colombo-Mendoza, L.O., Valencia-García, R., Rodríguez-González, A., Alor-Hernández, G., Samper-Zapater, J.J.: RecomMetz: A context-aware knowledge-based mobile recommender system for movie showtimes. Expert Systems with Applications 42(3), 1202–1222 (Feb 2015)
17. De Pessemier, T., Courtois, C., Vanhecke, K., Van Damme, K., Martens, L., De Marez, L.: A user-centric evaluation of context-aware recommendations for a mobile news service. Multimedia Tools and Applications (2015)
18. Deng, J.J., Leung, C.H.C., Milani, A., Chen, L.I.: Emotional States Associated with Music : Classification , Prediction of Changes , and Consideration in Recommendation 5(1) (2015)
19. Han, J., Schmidtke, H.R., Xie, X., Woo, W.: Adaptive content recommendation for mobile users: Ordering recommendations using a hierarchical context model with granularity. Pervasive and Mobile Computing 13, 85–98 (2014)
20. Harvey, M., Ludwig, B., Elsweiler, D.: You are what you eat : learning user tastes for rating prediction pp. 1–12
21. Hawalah, A., Fasli, M.: Utilizing contextual ontological user profiles for personalized recommendations. Expert Systems with Applications 41(10), 4777–4797 (2014)
22. Heckmann, D., Schwartz, T., Brandherm, B.: GUMO the General User Model Ontology. User modeling ... (2005)
23. Heckmann, D.: Ubiquitous User Modeling, vol. 297 (2005)
24. Hussein, T., Linder, T., Gaulke, W., Ziegler, J.: Hybreed: A software framework for developing context-aware hybrid recommender systems. User Modeling and User-Adapted Interaction 24, 121–174 (2014)
25. Jawaheer, G., Weller, P., Kostkova, P.: Modeling User Preferences in Recommender Systems. ACM Transactions on Interactive Intelligent Systems 4(2), 1–26 (2014)
26. Kaminskas, M., Ricci, F.: Contextual music information retrieval and recommendation: State of the art and challenges. Computer Science Review 6(2-3), 89–119 (2012)
27. Kim, H.N., Ha, I., Lee, K.S., Jo, G.S., El-Saddik, A.: Collaborative user modeling for enhanced content filtering in recommender systems. Decision Support Systems 51(4), 772–781 (2011)
28. Kim, J., Lee, D., Chung, K.Y.: Item recommendation based on context-aware model for personalized u-healthcare service. Multimedia Tools and Applications 71(2), 855–872 (2014)
29. Kitchenham, B., Pearl Brereton, O., Budgen, D., Turner, M., Bailey, J., Linkman, S.: Systematic literature reviews in software engineering - A systematic literature review. Information and Software Technology 51(1), 7–15 (2009)
30. Lakiotaki, K., Matsatsinis, N.F., Tsoukiàs, A.: Multicriteria user modeling in recommender systems. IEEE Intelligent Systems 26, 64–76 (2011)
31. Lee, W.P., Lee, K.H.: Making smartphone service recommendations by predicting users' intentions: A context-aware approach. Information Sciences 277, 21–35 (2014)

32. Li, L., Zheng, L., Yang, F., Li, T.: Modeling and broadening temporal user interest in personalized news recommendation. Expert Systems with Applications 41(7), 3168–3177 (2014)
33. Maes, P., Others: Agents that reduce work and information overload. Communications of the ACM 37(7), 30–40 (1994)
34. Mulvenna, M.D., Anand, S.S., Büchner, A.G.: Personalization on the Net using Web mining: introduction. Communications of the ACM 43(8), 122–125 (2000)
35. Otebolaku, A.M., Andrade, M.T.: Context-aware media recommendations. Proceedings - 2014 IEEE 28th International Conference on Advanced Information Networking and Applications Workshops, IEEE WAINA 2014 1, 191–196 (2014)
36. Otebolaku, A.M., Andrade, M.T.: Context-aware media recommendations for smart devices. Journal of Ambient Intelligence and Humanized Computing 6(1), 13–36 (2014)
37. Ricci, F., Rokach, L., Shapira, B., Kantor, P.B.: Recommender Systems Handbook. Springer US, Boston, MA (2011)
38. Schedl, M.: Ameliorating Music Recommendation: Integrating Music Content, Music Context, and User Context for Improved Music Retrieval and Recommendation. Proceedings of International Conference on Advances in Mobile Computing & Multimedia pp. 3:3—-3:9 (2013)
39. Schreck, J.: Security and Privacy in User Modeling. No. September (2003)
40. Siolas, G., Caridakis, G., Mylonas, P., Kollias, S., Stafylopatis, A.: Context-Aware User Modeling and Semantic Interoperability in Smart Home Environments. 2013 8th International Workshop on Semantic and Social Media Adaptation and Personalization pp. 27–32 (Dec 2013)
41. Skillen, K.L., Chen, L., Nugent, C.D., Donnelly, M.P., Burns, W., Solheim, I.: Ontological user profile modeling for context-aware application personalization. In: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). vol. 7656 LNCS, pp. 261–268 (2012)
42. Verbert, K., Manouselis, N.: Context-aware recommender systems for learning: a survey and future challenges. Learning . . . 5(4), 318–335 (2012)
43. Yin, H., Cui, B.I.N., Chen, L., Hu, Z., Zhou, X.: Dynamic User Modeling in Social Media Systems 33(3) (2015)

A telematic based approach towards the normalization of clinical praxis

Víctor M. Alonso Rorís[1], Juan M. Santos Gago[1], Luis Álvarez Sabucedo[1], Mateo Ramos Merino[1], Javier Sanz Valero[2]

[1] Telematic Engineering Department, University of Vigo, 36310 Vigo, Spain
{valonso, jsgago, lsabucedo, mateo.ramos}@gist.uvigo.es
[2] Public Health & History of Science, University Miguel Hernandez, 03550 Alicante, Spain
jsanz@umh.es

Abstract. The provision of comprehensive support for traceability and control is a raising demand in some environments such as the eHealth domain where processes can be of critical importance. This paper provides a detailed and thoughtful description of a holistic platform for the characterization and control of processes in the frame of the HACCP context. Traceability features are fully integrated in the model along with support for services concerned with information for the platform users. These features are provided using already tested technologies (RESTful models, QR Codes) and low cost devices (regular smartphones).

Keywords: traceability, eHealth, software platform, mobile environments

1 Introduction

The healthcare environment is an area in which the quality and safety of clinical procedures and practices is particularly relevant. The arise of situations and risks not properly tackled may put at stake the life of patients [1]. For example, in case a patient requires to be provided with intravenous nutrition, it is especially critical to ensure the quality of the nutrient mixture supplied and the attention given [2].

Due to the sensitivity of the area, it is common the definition, by experts in the domain, of clinical practice guide and policy recommendations [3]. Upon its implementation, the control and verification of adherence to the procedures defined therein must be enforced.

In this line, one of the control methodologies with greater acceptance in environments where health hazards can arise is the HACCP (Hazard Analysis and Critical Control Points) [4]. HACCP is a system aimed to establish a preventive, systematic and organized control of risks. The core of this system is the identification of moments or places where monitoring specific variables within procedures in order to control potential hazards. HACCP is applied mainly in the field of nutrition. However, it is becoming more common its use in the pharmaceutical and healthcare environment [5], 6].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_62

The recording of events facilitates the assembling of evidences of the actions carried out and the results obtained. These records enable the application traceability mechanisms. This feature, traceability, must be understood as the ability to track the history, actual usage and current status of entities [7]. Traceability allows health authorities to respond quickly and appropriately to the eventual detection of risks for quality and safety. Therefore, in environments of risk for health, traceability is often enforced at the legislative level (e.g., in EU [8]). Nevertheless, it is common that health practitioners initially record data on paper and then they transfer it to information technology based systems [9]. In addition, these information systems are often ad-hoc telematics solutions, designed to cover only specific tasks (e.g., prescription and adherence to treatment). Thus, monitoring management tends to be error prone and expensive. Furthermore, many existing systems are not open and interoperable and its architecture is too rigid and monolithic.

Based on this lack, the authors of this work, a group of researchers from different institutions and experts with extensive experience in the healthcare and technology field, have collaborated under the support of projects mentioned in the acknowledgments to address a solution to this problem. Finally, a telematic based solution to support the standardization of control and traceability procedures in any health field was developed. The objective was to create a tool to carry out the implementation of controls (in systems such as HACCP) and to record the values obtained efficiently and in a cost-effective manner. To do this, the system must provide with tools to control the entire life cycle of procedures and entities (e.g., medication). Furthermore, it should allow to check and automatically analysis the recorded information in real time.

The applicability of the proposed system is verified in the field of parenteral nutrition (PN). This scenario was chosen due to the previous experience of the authors [10]. The PN is considered as a "high alert medication" and should be controlled throughout its life cycle [11]. Therefore, this is an ideal context that illustrates the application and associated outcomes of our system.

This document provides with a detailed description of the proposed model in its context and a deployment guideline. Therefore, the following section provides a high-level description of the context and characteristics of the system. Then, in Section 3, it is presented an overview of the architecture and functionality of the system. Later on, on section 4, the application of the proposal in the frame of PN is exemplified. Finally, in Section 5, a set of conclusions is laid.

2 General Description of the System

This proposal, as already mentioned, is based on the HACCP model. Under this model, moments or places where it is necessary to monitor one or more variables must be identified. These monitoring moments or places are known as Control Points (CPs) [12]. In our system, CPs are intended to record the monitored variables and elements under control into traceable records, hereinafter, traces.

In some cases, CP can be carried out without human intervention by automated agents (e.g., an embedded system that periodically records an operating temperature).

However, interaction with human users is usually required to monitor complex variables and the collaboration of a number of agents is required. This includes actors such as patients themselves and their families.

The proper implementation of the proposed system should allow to meet different objectives: monitoring adherence to procedures, risk control, traceability of entities and even behavioral analysis for continuous optimization and decision making procedures. To achieve these goals, it is required to monitor all types of entities involved. Actually, the solution must include mechanisms for the management of physical entities or conceptual ones (e.g., a treatment, a particular event, etc.).

One of the key requirements for traceability is the unique identification of entities [13]. Actually, this identification is usually done using labels on the entity itself or, in the case of logical entities, labeling a related area (e.g., the table where it is performed the control). Our system supports several types of labels, including wireless labels (such as NFC tags) and optical ones (such as 2D QR and DataMatrix codes). In this paper, we encode information using QR tags [14]. These tags can be easily read using devices such as smartphones with cameras, quite common nowadays to access to Web pages and services. In our proposal, labels are encoded as an HTTP URI. This URI will be generated by the system and will uniquely identify one single entity.

Users can retrieve from the Web, at runtime, the information and the operations associated with an entity simply by reading its label. These operations can be of two types, control or information. Control operations can carry out a particular CP. Specifically, a control operation defines variables that the user (automated agent or human) must monitor. Conversely, information operations are intended to retrieve relevant resources for the human user associated with the entity (e.g., video tutorials, manuals, brochures, etc.), a paramount feature nowadays [15].

The in-depth analysis of such contexts leads us to point out a number of characteristics that drive the modeling of the system and its behavior. The main conditions are:

- **Non intrusive**: platform should not collide with the established procedures.
- **Universal use**: no especial technological skills should be required.
- **Suitable devices for the context**: devices in use must allow features such as mobility and others required by the practitioners.
- **Security constraints:** the system must ensure that this information will not be accessed without proper authorization.
- **Robustness:** the platform must ensure its proper working and the traces collection even in adverse contexts (i.e., little or no connectivity).

3 System Architecture

The system fits on a client-server model. Actually, main features implemented are offered using REST APIs [16]. These APIs enable customers: to recover data stored about different elements of the domain under different formats (e.g., HTML or RDF); to retrieve the list of custom operations or the description of each operation; to invoke an operation with particular values; or to manage the historical of traces. The client software will be able to access the server functions via secure connections (i.e.,

HTTPS protocol). Agents are provided with a graphic layer for user interaction. In addition, the device on which it runs must support the required functional capabilities, such as reading labels, Internet access, and so on. Current mobile devices (e.g., tablets and smartphones) cover these needs. Indeed, there are a number of past experiences that proves their application in this environment (e.g., [17]).

In our system, two types of client agents were developed: a Web client and an Android application. The Web client allows access to the basic features of control through a common Web browser. Meanwhile, the Android application is a generic client agent capable of providing a functional service to any user in any application scenario. Among its main features is the ability to dynamically generate user interfaces based on the responses from the server. It is also provided with caching mechanisms that allow the system to continue operating even when the server is temporarily not available.

Regarding the control process procedures, the general scheme of interaction between the client and the server follows the steps shown on Fig. 1. This scheme starts when a label is read. Based on the URI contained on that label, the client queries the server agent about the accessible operations referenced by that address. The server parses the query and gathers (and returns) the available operations. These operations are shown to the user in a list. Depending on the user's choice, the client agent requires the system description of the operation. These operations are represented as resources in the REST server interface. In line with this, WADL [18] is used for the description of the operations. This language allows a comprehensive description of interfaces based on HTTP (e.g., input and output parameters, invocation mechanisms, response formats, etc.). The client agent processes this description to dynamically adapt to the appropriate invocation needs. In the case of a control operation, the monitor variables (represented as input parameters) that can not automatically be inferred (e.g., the product status) are requested to the user by means of forms. These forms are generated at runtime. Once the user enters the values, the client software uses the description information from the WADL file to invoke the method on the interface associated with the operation.

Finally, in the system, an auditable record of the monitoring process carried out is generated. For the formal modeling of this information, semantic-based technologies have been used. Semantic technologies enable to model and characterize the behavior of entire framework in a machine interpretable fashion. Thus, these technologies allow the application of advanced mechanisms for analysis and automatic extraction of new knowledge from the existing records (e.g., using inference engines). They also allow implementing mechanisms based on SPARQL query language to conduct complex and structured searches.

In the presented system, a data model for the abstract characterization of the application context was designed (check Fig. 2). In this model, concepts (e.g., users, CP, etc.), properties (e.g., name, description, etc.) and relationships (e.g., between a CP and the parameters to be monitored) are included. As far as possible, during the modeling phase, widely recognized semantic vocabularies (e.g., FOAF or Dublin Core) were used. Of course, it is possible to explicit concepts and characteristics of individuals in narrower environments.

These technologies allow the development of high-level functionality. The aim is to facilitate the efficient management of knowledge generated each context. In this

sense, the system enables the generation of audit reports and real-time filtering of historical traces. It also allows the generation of human-friendly reports (e.g., graphics) with the extracted information. Based on this, managers can perform better analysis and, thus, optimize effort and resources.

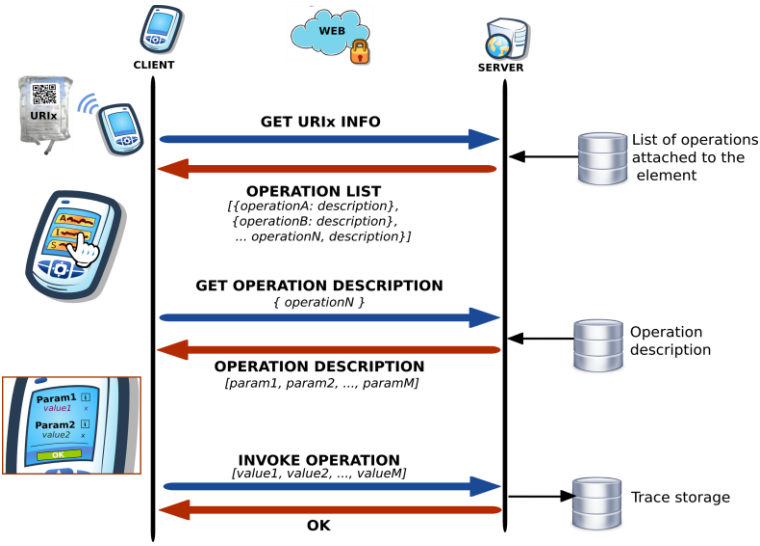


Fig. 1. Client-server interaction for the invocation of a control operation.

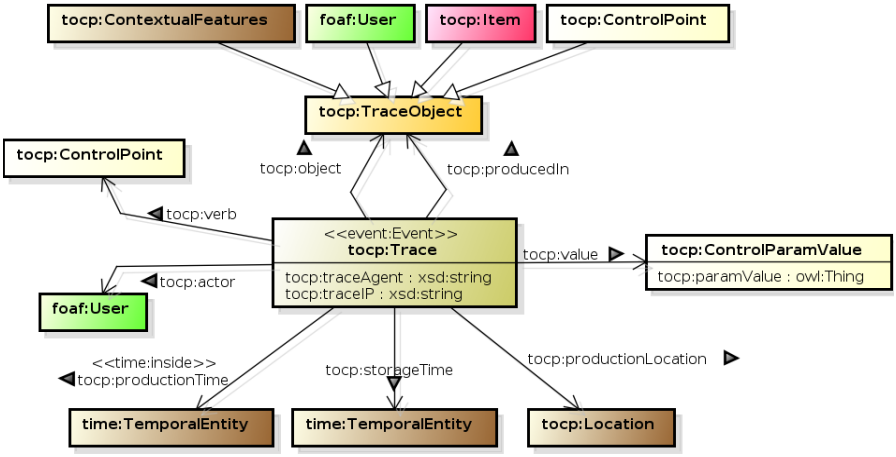


Fig. 2. Semantic model focused on the characterization of traces.

In order to achieve greater effectiveness in this type of analysis, the more comprehensive and the more detailed the information, the better. In this case, the use

of semantic technologies facilitates the implementation of enriching techniques for population of data using external information shared publicly on the Web (e.g., adding information about a drug component using data extracted from Wikipedia/DBPedia). Interested readers can check the performance of these techniques in previous works of authors [19].

4 Validation

PN mixtures are intended to provide basic nutrients intravenously, mainly, for patients whose gastrointestinal tract is not functioning. The PN mixtures can contain more than 50 components with a high potential for chemical and physical-chemical interactions.

All these conditions lead us to think that this is an ideal environment for setting up a control and traceability plan. In order to achieve this goal, the standardized procedures throughout the life cycle of PNs are used as the starting point. As a general rule, in due course of this normalization process, a set of documentation is generated, including textual descriptions of the various actions and behavioral recommendations. This documentation is known as Standard Operating Procedures (SOP) [20]. SOPs often introduced flow diagrams in order to facilitate the understanding of certain parts of the procedures.

Afterwards, a panel of experts discuss possible risks that may arise in the addressed processes. Finally, CPs are identified along identified processes and certain variables are targeted for monitoring. Regretfully, the implementation of a CP is often a costly procedure. Therefore, the HACCP system advocates only for implementing CP that are critical, also referred to as CCP (Critical Control Points). However, the application of the proposed platform reduces the cost per CP. Thus, it is possible to increase the number of CP and enhance the information available for control and traceability.

As an example scenario, in Fig. 3 it is shown a flowchart showing a standardized procedure excerpt. In particular, it is shown the immediately following events after the elaboration of a PN mixture, i.e., the bag labeling, quality control and storage.

Applying the HACCP model, on the diagram four CPs have identified for monitoring: CP1) the results of controls applied to the PN; CP2) identification of discarded PN; CP3) the type of protocol applied to each PN mixture for conservation; and CP4) the temperature of the refrigerator in which each PN is stored. The enactment of the first two CPs is the responsibility of the pharmacist; the nurse in charge of the third one; and the fourth one is on an electrical device provided with a temperature sensor.

In this scenario, human users will be provided with a smartphone with camera and Internet connection. In such devices, it has been installed the client application agent of our platform. In addition, entities of interest in the scene have been uniquely identified using labels with QR codes beforehand. These entities of interest include: each PN bag, the required tools to perform checks on the mixing, storage coolers, the waste container, CPs themselves, etc.

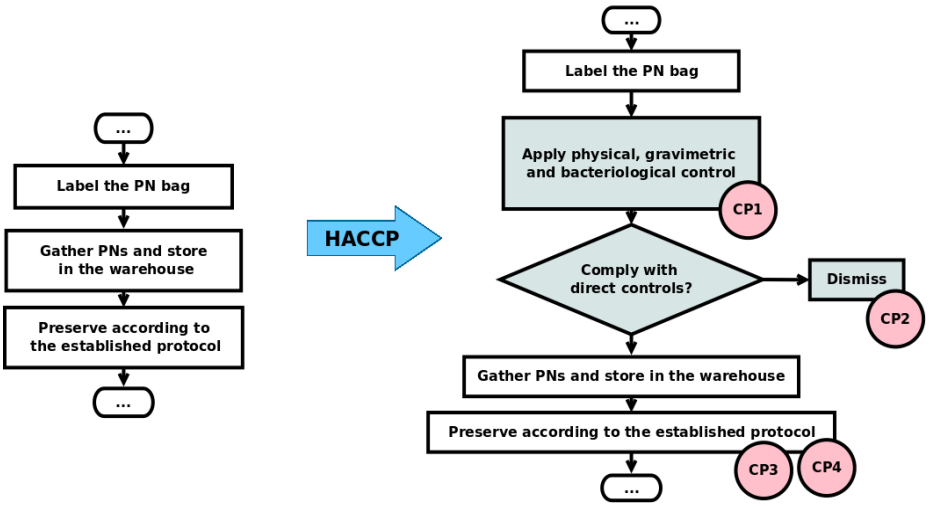


Fig. 3. Flowchart of a standardized treatment for PN and the result.

Using the proposed setup, it turns out feasible and convenient to implement the proposed technological system. Specifically, the common usage of the system takes place when users responsible for carrying out the procedure meet a CP. At that point, the user through the mobile client can use the agent to retrieve and invoke the associated operations.

Given the scenario above presented, the CP1 will be described in the frame of the application. In this CP, the pharmacist must check the quality of the mixture made according to its physical and biological properties (e.g., color changes, visible particles, weight, etc.). In this case, the pharmacist will use the application to read the label on the bag of the PN. In this way, he/she will receive a list of available operations on the mobile (check Fig. 4a). These operations will be conditioned by the status of pharmacist and the mixture PN itself. In case the label would be read by a nurse (or any other user), the list of retrieved operations would be different.

The pharmacist will be able to navigate among the different operations to select the desired one, i.e., the one designed to control the physical properties of the PN. Afterwards, on the screen of the device a form is generated (check Fig. 4b). In this form, it is requested to introduce mandatory data and optional information regarding the corresponding operation. These variables include: select from a list, the color of the mixing; mark whether or not precipitates can be seen with the naked eye; actual weight of the PN; read the label of the measuring equipment used (e.g., scales.); personal comments; etc. In addition, each requested field in the form has a description to guide the user. Once the appropriate values are introduced, the user submits the form for validation and registration.

According to this usage model, users can record the control actions performed. These traces can be checked online by the staff in charge in real time by means of a Web client. Using this tool, a paginated list of traces can be accessed. Moreover, this list can be filtered according to different criteria: the absence or presence of particular values in the parameters, the date and location where the trace were generated, the

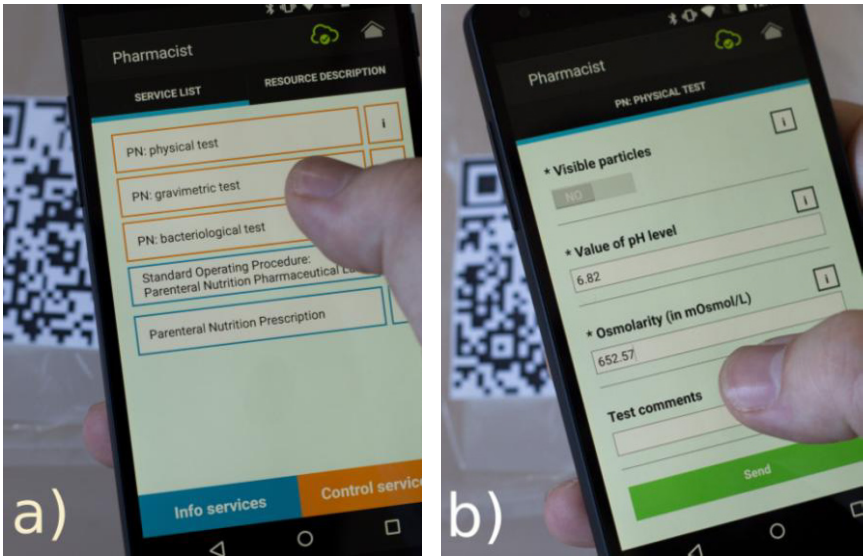


Fig. 4. Android client interfaces for: a) choosing a operation after reading a label; b) the form of a control operation with parameters to be monitored.

user responsible, the operation involved, the label read to invoke the operation, etc. These features allow managers to search in a agile and convenient fashion through all traces within the system and to get timely information to act with diligence as required. For example, if it is detected that the scales used in the CP1 is unbalanced, it would be feasible to identify immediately the PN mixtures involved and their last known location (check Fig. 5a).

Additionally, the log of traces also provides detailed information on any procedure. This information can be used to get a better understand of the operations and their context to optimize procedures. In this sense, the Web client provides access to statistics and plots about different features: number of traces by user, operation, or day; number of times each operation is invoked by each user; weekly and monthly average of traces (check Figure 5b) averages; etc. Also, the platform can export the gathered information as traces on standardized XES [21] formats to carried out further analysis. Therefore, it is possible to take full advantage of process mining tools as ProM[1].

5 Conclusions

A telematic-based platform to offer support for the implementation of plans for control and traceability in a health domain is presented. Its application has been

[1] http://www.processmining.org/prom/start

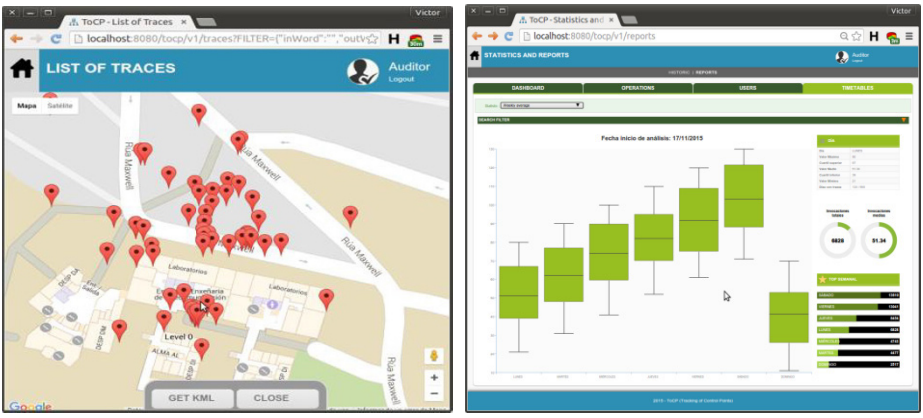


Fig. 5. Screenshots of the Web client for: a) trace location on a map; b) graph for the average generation of traces per week.

described and tested as a use case in the context of PN mixtures. Nevertheless, the selected scenario and the advantages of the platform identified can be easily applied to any other health care environment.

The system allows a simple and quick evaluation and analysis of trace generated during its application. This allows users to reduce their efforts in both, the implementation of quality policies, and the execution of actions in the event of a health risks.

The proposed platform is based on control systems widely tested and broadly adopted in the community. The CPs application allows to minimize deviations in the standard processes. Additionally, the use of regular mobile devices guarantees the availability and familiarity of use for human users on client agents. This way, and using the proposed scheme, the recovery services for dynamic interaction can be achieved in a straightforward manner taking into account each user at each moment and context in which he/she is located.

In addition to this, the system also provides a flexible mean to access relevant information according to the specific needs of each user. This feature may strengthen the knowledge of professionals involved. At the same time, it offers patients and their relatives support to get information about their background and situation.

Acknowledgement. This work has been partially funded by the European Regional Development Fund (ERDF), the Government of Spain and the Regional Government of Galicia under the TACTICA and GRC2013-006 projects and by the Instituto de Salud Carlos III by PI13/00464 project, also cofunded by ERDF.

References

1. Vincent, C., Taylor-Adams, S., Stanhope, N.: Framework for analysing risk and safety in clinical medicine. BMJ: British Medical Journal 316(7138), 1154 (1998)
2. Sacks, G.S.: Safety surrounding parenteral nutrition systems. Journal of Parenteral and Enteral Nutrition 36(2 suppl), 20S–22S (2012)
3. Woolf, S.H., Grol, R., Hutchinson, A., Eccles, M., Grimshaw, J.: Clinical guide- lines: potential benefits, limitations, and harms of clinical guidelines. BMJ: British Medical Journal 318(7182), 527 (1999)
4. Pierson, M.D.: HACCP: principles and applications. Springer Science & Business Media (2012)
5. Griffith, C., Obee, P., Cooper, R.: The clinical application of hazard analysis critical control points (HACCP). American Journal of Infection Control 33(5), e39 (2005)
6. Dahiya, S., Khar, R.K., Chhikara, A.: Opportunities, challenges and benefits of using HACCP as a quality risk management tool in the pharmaceutical industry. The Quality Assurance Journal 12(2), 95–104 (2009)
7. ISO, E.: 8402: 1995. Quality Management and Quality Assurance-Vocabulary (1995)
8. Directive, C.: 98/79/EC of the european parliament and of the council of 27 october 1998 on in vitro diagnostic medical devices. Official Journal of the European Union L 331, 1998 (1998)
9. Yen, P.Y., Gorman, P.N.: Usability testing of a digital pen and paper system in nursing documentation. In: AMIA Annual Symposium Proceedings. vol. 2005, p. 844. American Medical Informatics Association (2005)
10. Sanz-Valero, J., Alvarez-Sabucedo, L., Wanden-Berghe, C., Alonso-Rorís, V. M., Santos-Gago, J. M.: SUN-PP236: Deployment of a Tag-Based System to Ensure Traceability Management of Parenteral Nutrient Mixtures. Clinical Nutrition 34, S111. (2015).
11. Boullata, J.I.: Overview of the parenteral nutrition use process. Journal of Parenteral and Enteral Nutrition 36(2 suppl), 10S–13S (2012)
12. Laguna, M., Marklund, J.: Business process modeling, simulation and design. CRC Press (2013)
13. Moe, T.: Perspectives on traceability in food manufacture. Trends in Food Science & Technology 9(5), 211–214 (1998)
14. Sanz-Valero, J., Álvarez-Sabucedo, L., Wanden-Berghe, C., Martinez de Victoria, E.: QR-codes in food labeling: outlook for food science and nutrition. In Annals of Nutrition and Metabolism 63, 366-367 (2013).
15. Durán, P.A., Jiménez, R.M.R., Compes, C.C., Álvarez, M.C., Lesmes, I.B., a e de Lorenzo Pinto, A., Bravo, S.B., Soriano, L.F., Peris, P.G., Sáez, M.S.: Nutrición a o parenteral domiciliaria: satisfacción de los pacientes y sus cuidadores con la unidad o de nutrición clínica y el servicio de farmacia. Nutrición Hospitalaria 29(n05), 1123– o 1131 (2014)
16. Fielding, R.T.: Architectural styles and the design of network-based software architectures. Ph.D. thesis, University of California, Irvine (2000)
17. Nasi, G., Cucciniello, M., Guerrazzi, C.: The role of mobile technologies in health care processes: The case of cancer supportive care. Journal of medical Internet research 17(2) (2015)
18. Hadley, M.J.: Web Application Description Language (WADL) (2006)
19. Alonso-Rorís, V. M., Santos Gago, J. M., Pérez Rodríguez, R., Rivas Costa, C., Gómez Carballa, M. A., & Anido Rifón, L.: Information extraction in semantic, highly-structured, and semi-structured web sources. Polibits 49, 69-75. (2014).
20. Sajdak, R., Trembath, L., Thomas, K.S.: The importance of Standard Operating Procedures in clinical trials. Journal of nuclear medicine technology 41(3), 231–233 (2013)
21. Günther, C.W., Verbeek, H.: XES-standard definition (2014).

Part III
Software and Systems Modeling

An Implementation on MATLAB Software for Stability Analysis of Proportional Controllers in Linear Time Invariant Control Systems

Hau H. Vo[1], Pavel Brandstetter[2], Chau S. T. Dong[1], Tri Q. Thieu[1] and Duy H. Vo[1]

[1] Faculty of Electrical and Electronics Engineering, Ton Duc Thang University, Vietnam
[2] Faculty of Electrical Engineering and Computer Science, VSB-Technical University of Ostrava, Czech Republic
[1] {vohuuhau, dongsithienchau, thieuquangtri, vohoangduy}@tdt.edu.vn
[2] pavel.brandstetter@vsb.cz

Abstract. Stability range of proportional (P) controllers can be obtained using Routh-Hurwitz criterion for continuous linear time invariant (LTI) control systems or Bistritz criterion, Jury criterion for discrete LTI systems. Conditions from these criterions bring out inequalities. In case of high-order plants, these inequalities are very difficult to solve directly. In the paper, an algorithm is developed on MATLAB software to solve polynomial inequalites. With the support of this algorithm, stability criterions are implemented to find stability range of P controllers.

Keywords: Routh-Hurwitz criterion, Bistritz criterion, Jury criterion, critical gain, transfer functions, characteristic polynomials, characteristic equations, proportional (P) controllers, linear time invariant (LTI) control systems.

1 Introduction

Proportional controllers play an important role in continuous or discrete LTI control systems. Critical gain of P controllers is one of parameters which are used to obtain transfer functions of proportional-integral (PI) controllers and proportional-integral-derivative (PID) controllers as in [7]. Dynamics of continuous/discrete LTI control systems can be expressed as linear differential/difference equations. The Laplace transformation or the z transformation transforms these equations into transfer functions in *s* variable or in *z* variable. Methods for testing stability of LTI control systems use characteristic polynomials which are denominators of transfer functions as inputs.

Continuous LTI control systems are stable if all roots of characteristic equations have negative real parts or lie in the left half of the *s*-plane. The Routh-Hurwitz

[1] Please note that the LNCS Editorial assumes that all authors have used the western naming convention, with given names preceding surnames. This determines the structure of the names in the running heads and the author index.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_63

criterion is a mathematical tool that is used for testing stability. System is stable if and only if all coefficients of Routh array's first column or all determinants of Hurwitz matrix's principal minors are positive. Two methods are equivalent but Routh's procedure is easier to compute than Hurwitz's one is. In this paper, both are implemented.

Discrete LTI control systems are stable if all roots of characteristic equations are inside the unit circle in the *z*-plane or have moduli smaller than number one. The Routh-Hurwitz criterion can be expanded for testing stability through a bilinear transformation which is used to transform discrete LTI control system into continuous LTI control system and vice versa. This is because the stability of a linear discrete-time system expressed in the *z*-domain can also be determined using the *s*-plane methods developed for continuous systems (e.g., Routh–Hurwitz) [4]. Three stability tests are Schur–Cohn criterion, Jury criterion and Bistritz criterion. Bistritz criterion is simpler than two remainders. It has been also recognized to be more efficient than previously available stability tests for discrete systems like the Schur–Cohn and the Jury test [1]. Since the coefficients of the characteristic equations corresponding to physically realizable systems are always real, the Jury test is preferred to the Schur-Cohn test [2]. In this paper, Bistritz criterion and Jury criterion are implemented.

2 Stability Range of Feedback Continuous LTI Control Systems

Consider feedback continuous LTI control system with a single input single output (SISO) plant, whose transfer function is $G(s)$ and a compensator, whose transfer function is $G_C(s)$ in Fig. 1.

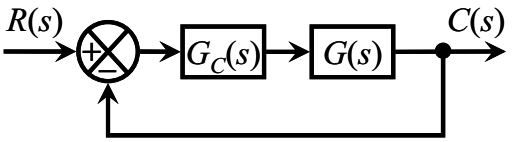


Fig. 1. Block diagram of feedback continuous LTI control system.

In practice, transfer function of the plant is given by

$$G(s) = \frac{b_0 s^n + b_1 s^{n-1} + \ldots + b_{n-1} s + b_n}{a_0 s^n + a_1 s^{n-1} + \ldots + a_{n-1} s + a_n}$$

where: a_i, b_i for $i = 0,1,\ldots,n$ are real coefficients and $a_0 \neq 0$. (**1**)

The following problem is proposed: determine the set of values of $k \in \mathrm{R}$, such that the feedback system in Fig. 1, with $G_C(s) = k$, is stable, using the Routh-Hurwitz criterion [6]. Characteristic equation of system is

$$1 + G_C(s)G(s) = 0 \ . \quad (\mathbf{2})$$

Characteristic polynomial $P(s,k)$ is derived from equation (2):

$$P(s,k) = (b_0k + a_0)s^n + (b_1k + a_1)s^{n-1} + ... + (b_{n-1}k + a_{n-1})s + (b_nk + a_n) \ . \quad (3)$$

Formula (3) shows that coefficients of $P(s,k)$ that are binomials on k. Hence, characteristic polynomial can be declared as two-column matrix on MATLAB software.

$$P = [b_0 \quad a_0; b_1 \quad a_1; \ldots; b_{n-1} \quad a_{n-1}; b_n \quad a_n] \ . \quad (4)$$

2.1 Routh Criterion

Routh array is a (n+1)-row table. In two first rows, numerators of elements are coefficients of $P(s, k)$ and their denominators are equal to one.

$$\begin{aligned} &N_{11}(k) = b_0k + a_0, N_{12}(k) = b_2k + a_2, N_{13}(k) = b_4k + a_4, \ldots, D_1(k) = 1 \\ &N_{21}(k) = b_1k + a_1, N_{22}(k) = b_3k + a_3, N_{23}(k) = b_5k + a_5, \ldots, D_2(k) = 1 \end{aligned} \ . \quad (5)$$

Table 1. Routh array.

row 1	s^n	$R_{11}(k) = \frac{N_{11}(k)}{D_1(k)}$	$R_{12}(k) = \frac{N_{12}(k)}{D_1(k)}$	$R_{13}(k) = \frac{N_{13}(k)}{D_1(k)}$	…
row 2	s^{n-1}	$R_{21}(k) = \frac{N_{21}(k)}{D_2(k)}$	$R_{22}(k) = \frac{N_{22}(k)}{D_2(k)}$	$R_{23}(k) = \frac{N_{23}(k)}{D_2(k)}$	…
⋮	⋮	⋮	⋮		
row (n–1)	s^2	$R_{(n-1)1}(k) = \frac{N_{(n-1)1}(k)}{D_{(n-1)}(k)}$	$R_{(n-1)2}(k) = \frac{N_{(n-1)2}(k)}{D_{(n-1)}(k)}$		
row n	s^1	$R_{n1}(k) = \frac{N_{n1}(k)}{D_n(k)}$			
row (n+1)	s^0	$R_{(n+1)1}(k) = \frac{N_{(n+1)1}(k)}{D_{(n+1)}(k)}$			

Element at the row i column j, for i = 3,…,n,n+1 and j = 1,2,… is given by

$$\begin{aligned} R_{ij}(k) &= \frac{R_{(i-2)(j+1)}(k)R_{(i-1)1}(k) - R_{(i-1)(j+1)}(k)R_{(i-2)1}(k)}{R_{(i-1)1}(k)} \\ &= \frac{N_{(i-2)(j+1)}(k)N_{(i-1)1}(k) - N_{(i-1)(j+1)}(k)N_{(i-2)1}(k)}{N_{(i-1)1}(k)D_{(i-2)}(k)} \end{aligned} \ . \quad (6)$$

Equation (6) shows that nonzero elements $R_{ij}(k)$, for i =1,2,…,n,n+1 and j = 1,2,… are ratios of two polynomials on k and can be described by two vectors in MATLAB. According to the Routh criterion, system in Fig.1 is stable if all elements of first column of Table 1 have the same negative or positive sign.

2.2 Hurwitz Criterion

Hurwitz matrix is an n-row square matrix which is constructed directly from coefficients of $P(s, k)$.

$$H = \begin{bmatrix} b_1k + a_1 & b_3k + a_3 & \dots & 0 \\ b_0k + a_0 & b_2k + a_2 & \dots & 0 \\ \vdots & \vdots & \ddots & \vdots \\ 0 & \dots & b_{n-2}k + a_{n-2} & b_nk + a_n \end{bmatrix}. \tag{7}$$

Assume that $(b_0k + a_0) > 0$, the necessary and sufficient condition that all roots of the characteristic equation lie in the left half of the s-plane is that the following Hurwitz determinants must all be positive [3].

$$D_1 = \det(H_1), D_2 = \det(H_2), \dots, D_n = \det(H_n) \ .$$

where: H_i, for i =1,2, …,n are i^{th} principal minors, which are matrices obtained by eliminating the last (n-i) rows and columns of Hurwitz matrix. (**8**)

3 Stability Range of Feedback Discrete LTI Control Systems

Consider feedback discrete LTI control system with SISO plant $G(s)$, Zero-Order Hold (ZOH), compensator $G_C(z)$, and sampler δ_T in Fig. 2.

Transfer function of the SISO plant $G(s)$ is equation (1) and transfer function of ZOH is given by

$$G_{ZOH}(s) = \frac{1 - e^{-Ts}}{s} = \frac{1 - z^{-1}}{s}$$

where: T is sampling period and $z = e^{Ts}$. (**9**)

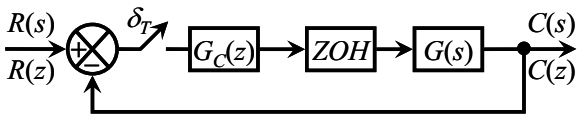


Fig. 2. Block diagram of feedback discrete LTI control system.

A similar problem is also proposed for the system in Fig. 2: determine the set of values of k, such that, with $G_C(z) = k$, is stable, using Bistritz criterion or Jury criterion . Characteristic equation of system is

$$1 + G_C(z)G(z) = 0 \ .$$

where: $G(z) = Z\{G_{ZOH}(s)G(s)\} = \dfrac{d_0 z^n + d_1 z^{n-1} + ... + d_{n-1} z + d_n}{c_0 z^n + c_1 z^{n-1} + ... + c_{n-1} z + c_n}$ (**10**)

Generally, characteristic polynomial $Q(z,k)$ is derived from equation (10):

$$\begin{aligned} Q(z,k) &= (d_0 k + c_0) z^n + (d_1 k + c_1) z^{n-1} + ... + (d_{n-1} k + c_{n-1}) z + (d_n k + c_n) \\ &= A_0 z^n + A_1 z^{n-1} + ... + A_{n-1} z + A_n \end{aligned} \ .$$

where: $A_i = d_i k + c_i$, for $i = 0,1,\ldots,n$ (**11**)

3.1 Routh-Hurwitz Criterion for Discrete LTI Control System

At first, characteristic polynomial of discrete system $Q(z,k)$ is transformed into characteristic polynomial of continuous system $F(w,k)$ by the bilinear transformation

$$\begin{aligned} F(w,k) = A_0 (w+1)^n + A_1 (w-1)(w+1)^{n-1} + \ldots \\ + A_{n-1} (w-1)^{n-1} (w+1) + A_n (w-1)^{n-1} \end{aligned} \ .$$

where: $w = (z+1)/(z-1) \Leftrightarrow z = (w+1)/(w-1)$ is bilinear transformation (**12**)

Next, collect polynomial $F(w,k)$ and apply Routh-Hurwitz criterion in section 2 to this polynomial with counting w variable as s variable.

3.2 Bistritz Criterion

Define reciprocal polynomial of $Q(z,k)$

$$Q^{\#}(z,k) = z^n Q(1/z,k) = A_0 + A_1 z + ... + A_{n-1} z^{n-1} + A_n z^n \ . \quad (\mathbf{13})$$

Do the initial step of recursive procedure

$$T_n(z,k) = Q(z,k) + Q^{\#}(z,k), T_{n-1}(z,k) = \frac{Q(z,k) - Q^{\#}(z,k)}{z-1} \ . \quad (\mathbf{14})$$

For $i = n-1,\ldots,1$, do following steps

$$\delta_{i+1}(k) = \frac{T_{i+1}(0,k)}{T_i(0,k)}, T_{i-1}(z,k) = \frac{(1+z)\delta_{i+1}(k) T_i(z,k) - T_{i+1}(z,k)}{z} \ . \quad (\mathbf{15})$$

Necessary conditions for stability are $T_i(0,k) \neq 0$, for $i = n,n-1,\ldots,1,0$. If these conditions are satisfied then system is stable if and only if terms $T_i(1,k)$, for $i = n,n-1,\ldots,1,0$, have the same sign.

3.3 Jury Criterion

Assume that the first coefficient A_0 is positive. The Jury table is given in Table 2

Table 2. Jury table.

Row	z^0	z^1	z^2	…	z^{n-2}	z^{n-1}	z^n
1	A_n	A_{n-1}	A_{n-2}	…	A_2	A_1	A_0
2	A_0	A_1	A_2	…	A_{n-2}	A_{n-1}	A_n
3	B_{n-1}	B_{n-2}	B_{n-3}	…	B_1	B_0	
4	B_0	B_1	B_2	…	B_{n-2}	B_{n-1}	
5	C_{n-2}	C_{n-3}	C_{n-4}	…	C_0		
6	C_0	C_1	C_2	…	C_{n-2}		
⋮							
$2n-5$	U_3	U_2	U_1	U_0			
$2n-4$	U_0	U_1	U_2	U_3			
$2n-3$	V_2	V_1	V_0				

The elements of rows from 3 to $2n-3$ are calculated from two previous rows

$$\begin{aligned} B_k &= \begin{vmatrix} A_n & A_{n-k-1} \\ A_0 & A_{k+1} \end{vmatrix}, && k = 0,1,2,\ldots,n-1 \\ C_k &= \begin{vmatrix} B_{n-1} & B_{n-k-2} \\ B_0 & B_{k+1} \end{vmatrix}, && k = 0,1,2,\ldots,n-2 \\ &\vdots \\ V_k &= \begin{vmatrix} U_3 & U_{2-k} \\ U_0 & U_{k+1} \end{vmatrix}, && k = 0,1,2 \end{aligned} \quad \textbf{(16)}$$

The coefficients in the second row have been obtained by reversing those in the first row [5]. Notice that the elements in any even-numbered row are simply the reverse of the immediately preceding odd-numbered row [2]. The system is stable if the all following conditions are satisfied

$$\begin{aligned} &A_0 > |A_n|, Q(1,k) > 0, Q(-1,k) \begin{cases} > 0 \text{ for } n \text{ even} \\ > 0 \text{ for } n \text{ odd} \end{cases} \\ &|B_{n-1}| > |B_0|, |C_{n-2}| > |C_0|, \ldots, |U_3| > |U_0|, |V_2| > |V_0| \end{aligned} \quad \textbf{(17)}$$

4 Solve Polynomial Inequalities on MATLAB Software

Consider one-unknown real-coefficient n-order polynomial inequality

$$P(k) = a_0 k^n + a_1 k^{n-1} + \ldots + a_1 k + a_n > 0 \ .$$

where: a_i are real coefficients, $a_0 \neq 0$, and k is unknown . **(18)**

Problem is proposed: determine the set S of values of $k \in R$ satisfies (18). Note that $P(k)$ has n roots which can be real numbers or pairs of conjugate complex numbers. Pairs of conjugate complex roots $a \pm bj$ don't affect the sign of $P(k)$ because ($k^2 - 2ak + a^2 + b^2$) is positive with every k. In case of a real root α of multiplicity h of $P(k)$, if h is even then $(k-\alpha)^h$ is positive with $k \neq \alpha$. If h is odd then $(k-\alpha)^h$ has the same sign with $(k-\alpha)$. With set of roots of $P(k)$, ignore all complex roots, real roots of even multiplicity h, and for real roots of odd multiplicity h, if h is greater than one then only retain single root.

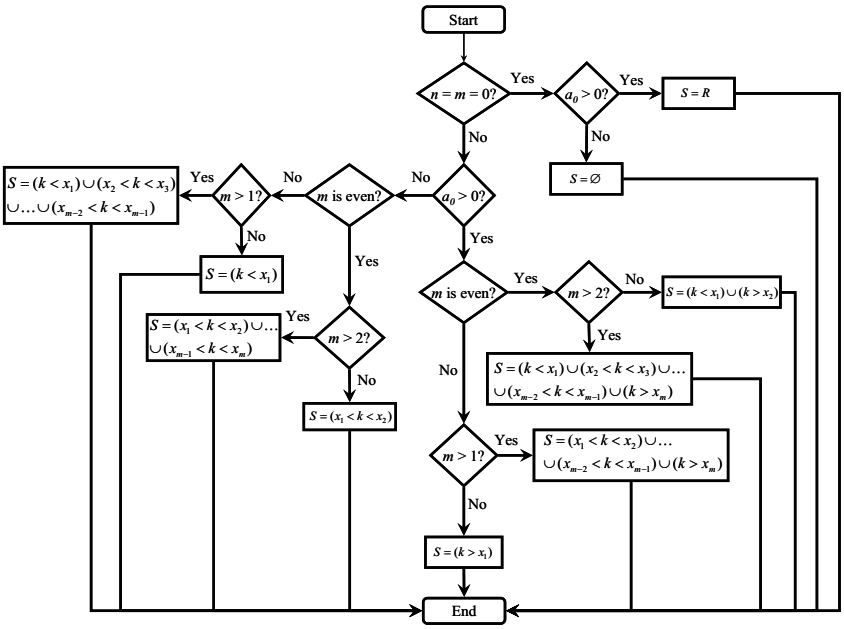


Fig. 3. Block diagram of proposed algorithm.

Generally, assume that $P(k)$ has m distinct real roots x_i, for i=1,2,…,m, which are sorted in ascending order $x_1 < x_2 < \ldots < x_m$. Note that, two adjacent roots are considered distinct only if $|x_i - x_{i+1}| > \varepsilon$, where $\varepsilon = 10^{-6}$ is a tolerance margin and the user can change this tolerance [6]. In [3], symbolic computation method on MAPLE software was used to solve (18). This method can be implemented by choosing symbolic engine (symengine) and evaluating MuPAD expressions (feval) in Symbolic Math Toolbox of MATLAB software. In [6], the test-point method was implemented on MATLAB software to solve (18). However, if m is large, both

become very time-consuming. Another algorithm with short calculating time is proposed in Fig. 3. Sets of k are described in MATLAB as Table 3. Intersection or union of two sets of k are done according to rules of set theory.

Table 3. Description of sets of k in MATLAB.

S	Description in MATLAB
$\varnothing$	S = [inf inf 0]
R	S = [inf inf 1]
$k < \alpha$	S = [α α 2]
$k > \alpha$	S = [α α 3]
$\alpha < k < \beta$	S = [α β 4]
$k \neq \alpha$	S = [α α 5]

5 Implementation on MATLAB

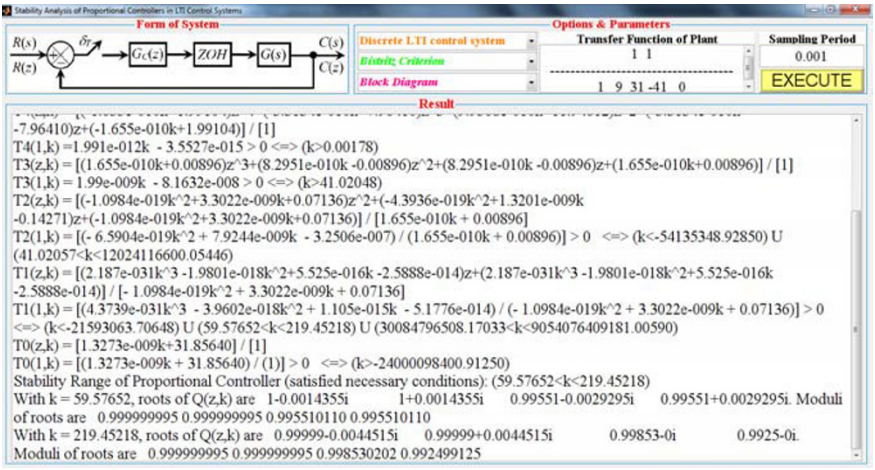


Fig. 4. GUI for Stability Analysis.

A Graphic User Interface (GUI) is built on MATLAB software, version 7.8.0.347 (R2009a) as Fig. 4 . This GUI has three panels. The first one has only one axes object for displaying form of system. The second one has three pop-up menus, one push button, two static texts and two edit texts. Three pop-up menus are used for selecting options: continuous/discrete system, Routh/Hurwitz criterion for continuous system or Routh/Hurwitz/Bistritz/Jury criterion for discrete system, and block diagram/characteristic polynomial. Two edit texts is used for inputting the transfer function of plant $G(s)$ or characteristic polynomial and sampling period T (only for discrete system). The last panel has one edit text for visualizing process and result of procedures. For verification accuracy of method, transfer function of plant $G(s)$ has

the same value as transfer function of plant in [6]: $G(s) = (s + 1)/(s^4 + 9s^3 + 31s^2 - 41s)$.

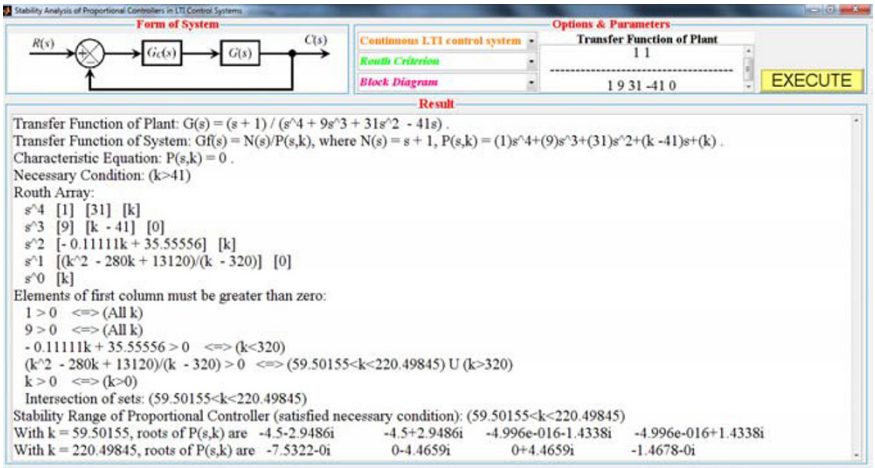


Fig. 5. Stability analysis of continuous LTI control systems.

For continuous system, stability range of proportional controller displayed in Fig. 5 is ($59.50155 < k < 220.49845$), equal to stability range in [6], and with critical gains (two borders of stability range), two roots of characteristic polynomial have negative real parts and two remainders lie on imaginary axis (zero real parts) of the s-plane. For discrete system, with sampling period $T = 0.1$ seconds, stability range is ($70.47080 < k < 142.56960$). Table 4 shows that the smaller sampling period is, the stability range of discrete system is closer to that of continuous system. Solutions obtained from procedures, are slightly different, solutions of Bistritz procedure gives the smallest accuracy as shown in table 5. However, when sampling period approaches zero, solutions of all procedures are completely inaccurate because components d_i of coefficients A_i in characteristic polynomial $Q(z,k)$ are approximately equal to zero.

Table 4. Stability range of discrete LTI control systems with different values of sampling period.

T	Routh-Hurwitz criterion	Bistritz criterion	Jury criterion
0.1	$70.47080 < k < 142.56960$	$70.47080 < k < 142.56960$	$70.47080 < k < 142.56960$
0.01	$60.27775 < k < 210.41076$	$60.27775 < k < 210.41076$	$60.27775 < k < 210.41076$
0.005	$59.88423 < k < 215.35087$	$59.88423 < k < 215.35087$	$59.88423 < k < 215.35087$
0.002	$59.65337 < k < 218.41334$	$59.65336 < k < 218.41335$	$59.65237 < k < 218.41435$
0.001	$59.57612 < k < 219.45258$	$59.57652 < k < 219.45218$	$59.56471 < k < 219.46399$

Table 5. Difference between moduli of two poles lies nearest to the unit circle and number one with k are critical gains

T	Routh-Hurwitz criterion	Bistritz criterion	Jury criterion
0.005	$0, 0$	$0, 0$	$0, 0$
0.002	$10^{-9}, 0$	$10^{-9}, -10^{-9}$	$2\times10^{-8}, 10^{-8}$
0.001	$7\times10^{-9}, -6\times10^{-9}$	$-5\times10^{-9}, -5\times10^{-9}$	$1.05\times10^{-7}, 0.61\times10^{-7}$

5 Conclusions

An algorithm was developed to solve one-unknown real-coefficient polynomial inequalities on MATLAB software. This algorithm was used to find stability range of feedback continuous or discrete LTI control systems. Results showed that solutions with different procedures were almost the same. For continuous system, Routh and Hurwitz criterions' solutions were identical but Hurwitz procedure requires more complicated computation for obtaining determinants of minor principals. For discrete system, all procedures gave slightly different results and Bistritz procedure was the simplest and most accurate one, because Routh-Hurwitz procedure required bilinear transformation and Jury procedure included more steps. Critical gain obtained from procedure can be used to design PI and PID controllers.

References

1. K. Premaratne and E.I. Jury, On the Bistritz tabular form and its relationship with the Schur-Cohn minors and inner determinants, Journal of the Franklin Institute, Volume 330, Issue 1, pp. 165-182, January 1993.
2. K. Ogata, Discrete-Time Control Systems, 2nd ed., Ed. EngleWood Cliffs, New Jersey: Prentice-Hall, pp. 182-192, 1995.
3. R. Wang, Symbolic Computation of Hurwitz Criterion, Proceedings of ISCACSD, Anchorage, Alaska, USA, pp. 112-116, 2000.
4. J. Aweya, M. Ouellette, and D. Y. Montuno, Design and Stability Analysis of a Rate Control Algorithm Using the Routh–Hurwitz Stability Criterion, IEEE Transactions on Networking, vol. 12, no. 4, pp. 719-732, August 2004.
5. K. M. Moudgalya, Digital Control, 2nd ed., Ed. Chichester, West Sussex: John Wiley & Sons, pp. 87-89, 2007.
6. Marcelo C. M. Teixeira, Edvaldo Assunção, and Márcio Roberto Covacic, Proportional Controllers: Direct Method for Stability Analysis and MATLAB Implementation, IEEE Transactions on Education, vol. 50, no. 1, pp. 74-78, February 2007.
7. Aidan O'Dwyer, Handbook of PI and PID Controller Tunning Rules, 3rd ed., Imperial College Press, Covent Garden, London, 2009.

Software for Simulation of Vehicle-Road Interaction

Francisco Duarte[1], Adelino Ferreira[2] and Paulo Fael[3]

[1] Pavement Mechanics Laboratory, CITTA, Department of Civil Engineering, University of Coimbra, Portugal, francisco.duarte@uc.pt
[2] Pavement Mechanics Laboratory, CITTA, Department of Civil Engineering, University of Coimbra, Portugal, adelino@dec.uc.pt
[3] Department of Electromechanical Engineering, University of Beira Interior, Covilhã, Portugal, pfael@ubi.pt

Abstract. This paper deals with the development of a software to simulate and study the vehicle-road interaction. This allows to quantify the forces induced and energy released from vehicles to the road pavement, in different vehicle motion scenarios, and the energy absorbed by the road surface, speed reducer, or a specific energy harvester surface. It enables the user to quantify the energetic efficiency of the process. A practical study is presented in order to show the effectiveness of the software, as well as its potential applications.

Keywords: Simulation software; Vehicle-road interaction; Energetic analysis.

1 Introduction

A road vehicle consumes energy to actuate its engine, and releases energy in different ways, through different components. Part of the released energy goes into the road pavement, and this increases when there is a breaking action. 15% to 21% of the energy is transferred to the vehicle's wheels, of which 7% to 10% is dissipated by wind resistance, 4% to 6% in rolling resistance and 4% to 5% in braking actions [1, 2].

However, road vehicles can have different motion situations and, in each of them, they have different distribution of forces and moments, which will lead to different values of released energy. To perform a credible energy transfer analysis, it is important to have a quantification of both the static forces and dynamic forces that vehicle induces on the road pavement, this last component resulting from the vehicle's oscillations. The element which contributes most to these oscillations is the road surface, which can have different profiles and be made of different materials. This is more relevant in the case of speed reducers, which induce higher oscillations in the vehicle.

In the present research work, it is intended to develop a software that allows to study the vehicle-road interaction, with an energetic perspective, in order to quantify the amount of energy released by the vehicle to the road in the different motion conditions (free-rolling, braking and accelerating). The software should enable the user to simulate this interaction according to the selected conditions and obtain both numerical and graphic results. The results will be useful first and foremost to understand this interaction and they will also help with the development of speed reducers and energy

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_64

harvesting devices, providing precision quantification of the energy that can be harvested, and the most favorable conditions in which to harvest it.

There are some commercially available software tools for simulating motions of multi-body mechanical systems, such as vehicles. ADAMS® software is a product of MSC Software and it is one of the most widely used multi-body dynamics programs worldwide [3]. This software was developed in the late 1970s and it has been demonstrated and verified in a wide range of engineering areas [4]. It is an appropriate software tool to study the dynamics of the vehicle components, when subjected to real environment conditions. However, Sayers [5] indicates that ADAMS® and other multi-body simulation software are not suited for real-time simulations, as they employ non-linear differential-algebraic equations, which require iterative solution methods.

Sayers [6] used symbolic computation to develop the AUTOSIM® software, which is a symbolic mathematics language to Automatically (AUTO) generate Simulation (SIM) codes, developed by Sayers and commercialized by the Mechanical Simulation Corporation [7]. Sayers [5] described how this software can be used to generate comprehensive vehicle dynamics models for Real-Time Simulation (RTS) applications, demonstrating the good adequacy of the generated code for RTS applications and how the same model can run using SIMULINK®. All of the math model solver programs in BikeSim®, CarSim® and TruckSIM®, software developed by the Mechanical Simulation Corporation, have been produced using AUTOSIM®.

All AUTOSIM® software has a very intuitive GUI (Graphical User Interface) and an extensive database with all the required vehicle parameters to perform accurate simulations due to the long experience working with vehicle manufacturers. The results are presented graphically, and it is possible to obtain the vehicle components positions (displacements), speeds, accelerations, angles and forces. It allows the user to select the route of the vehicle, the driver actions (such as acceleration, braking or steering), and it allows users to integrate the simulation with SIMULINK®, without affecting the simulation performance.

These software tools (ADAMS® and all AUTOSIM® sub programs) are used both by the automotive industry and research laboratories [8, 9, 10, 11] to perform studies regarding the vehicle components optimization (tires, suspension, chassis, etc.), road design, road safety, among other applications.

However, this software does not allow users to introduce the desired speed reducers, with the desired surface profiles and materials, nor, more specifically, does it allow the user to introduce energy harvest devices on the road pavement with movable surfaces, which have their own motion equations, and affect the vehicle motion equations. Due to this fact, none of the presented software is suited for studying the vehicle-road interaction from an energetic perspective, from the energy released by the vehicle and the energy absorbed by the road surface/energy harvest device, pre-defining the road/harvester surface profile, geometry, displacement, material, stiffness, among other features.

So, the main goal of the present research consists in the development of a software tool that allows users to integrate all the vehicle dynamics theory, with the speed reducers/ energy harvest devices integrated on the road pavement, in order to perform not only a load analysis, but more specifically, an energetic analysis of the interaction.

2 Software

2.1 Introduction

Previously to the development of the software, an extensive study was performed of vehicle dynamics and vehicle road interaction based on the main references in this area [12, 13, 14, 15, 16, 17]. From these, the main formulations regarding the vehicle models, motion equations, tire force determinations and contact patch pressure distribution, among others things, were defined.

Based on this study, a software tool was developed in MATLAB® environment, in order to study the vehicle-road interaction from an energetic perspective. The purpose of this software is to study this interaction in great detail, with the possibility of fully characterizing the vehicle under study, by defining its class, weight, axles, wheels, geometry, speed, acceleration, suspensions and tires, defining all the mechanical parameters (such as damping and stiffness for each suspension and tire); as well as fully characterizing the pavement or harvester surface, by defining its material, shape, geometry, and for a surface with displacement, its maximum displacement, mass, stiffness and damping properties. It also allows the user to select the model (quarter car or bicycle car model) and if the analysis is performed considering the contact patch or not.

Applying the vehicle dynamics and vehicle road interaction formulas, the software calculates all the displacements, both for the vehicle and the pavement/harvester surface, the applied and received forces, and the power and energy transferred (released from vehicle and received on the pavement/harvester surface), presenting the results both graphically and numerically.

To develop this software some assumptions were made in order to restrict the possibilities for parameter selection and to simplify the models, considering the goals and focus of this research work (ADAMS® and CARSIM® doesn't consider the same assumptions because they have different goals). The main assumptions are as follows:

- Motion only in a straight line, without turning. So, roll and yaw of the vehicle were not considered;
- For light vehicles, only two axles were considered, and two wheels per axle. For heavy vehicles, only three axles were considered, with the possibility of four wheels per axle;
- For light vehicles, front wheel traction was considered;
- For the vehicle weight field, it was considered that the driver and passengers weight were included;
- On the tire modulation, a "flat tread pattern" without "holes" on the pattern was considered;
- On the road modulation, dry conditions were considered;
- The road transversal inclination angle was considered to be equal to zero;
- Wind speed was neglected.

2.2 Software Inputs

To select the inputs, a Graphical User Interface (GUI) platform was developed (Figure 1).

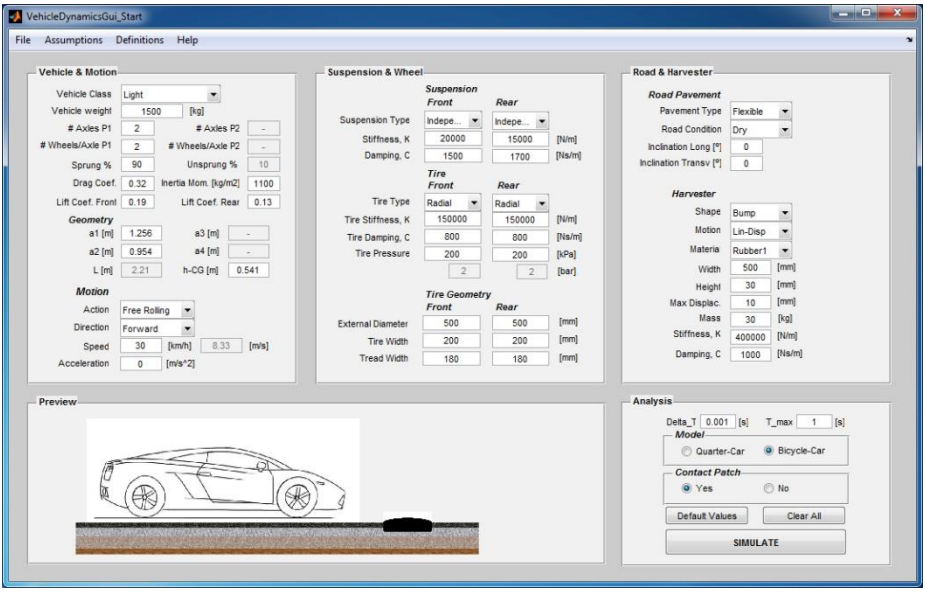


Fig. 1. Graphical user interface to select the inputs of the software.

This GUI has 5 distinct panels, with three for parameter selection, one for the preview of the selected features, regarding the vehicle, the pavement and the harvester surface, and other for the selection of analysis features.

The first panel allows the user to select the vehicle and motion properties. In terms of the vehicle, it allows the vehicle class, weight, number of axles, wheels per axle, percentage of sprung and unsprung mass, drag and lift coefficients, and inertia moment of the vehicle to be selected. It also allows users to define the vehicle geometry in terms of distances from each axle to the center of gravity, as well as the height of the center of gravity. In terms of vehicle motion, it allows to the selection of the action (free rolling, accelerating, braking, or stopped), the motion direction, the vehicle speed and acceleration (when the action is accelerating or braking).

The second panel allows the user to select the suspension and wheel properties. In terms of suspension, it allows users to select the suspension type and to define the suspension stiffness and damping values, for both the front and rear suspension. In terms of tire, it allows the user to select the tire type and to define the tire stiffness, damping and pressure, for both the front and rear tire. The tire geometry in terms of external diameter, tire width and tread width can also be defined, for both front and rear tires.

The third panel allows the road and harvester properties to be selected. In terms of road pavement, the user can select the pavement type, the road condition, the

longitudinal and transversal inclination of the pavement. For the harvester surface, users can select the shape (plane, bump, ramp, hump, triangle, S profile, Scale-Up or crest), the motion type, the material of the surface, the width and height and, when the user selects a surface motion, the maximum displacement, the mass of the surface, its stiffness and damping can be defined.

The fourth panel presents a summary of the selection, showing an image of the selected vehicle, an image of the selected pavement and an image of the harvester surface, by shape. With this information, the user can confirm selection visually.

The fifth panel allows the user to define the simulation time and each iteration interval, the car model to be simulated and contact patch, selecting "Yes" for a "Contact Patch Analysis", or "No" for a "Single Point Analysis". In this panel, the user can clean all the fields to select new values, and can press the "Simulate" button to start the simulation.

2.3 Formulations

When the simulation starts, the software defines all the "static" variables, i.e., those that do not depend on the vehicle dynamics, such as the front and rear unsprung masses, the sprung mass, drag and lift forces, forces per axle, both vertical and horizontal, the contact patch geometry for each wheel, and the initial kinetic energy of the vehicle.

Eight models were developed using the SIMULINK® tool to perform the dynamic analysis depending on the selected inputs:

1) No harvester displacement, quarter-car model, no contact patch analysis;
2) Harvester displacement, quarter-car model, no contact patch analysis;
3) No harvester displacement, bicycle-car model, no contact patch analysis;
4) Harvester displacement, bicycle-car model, no contact patch analysis;
5) No harvester displacement, quarter-car model, contact patch analysis;
6) Harvester displacement, quarter-car model, contact patch analysis;
7) No harvester displacement, bicycle-car model, contact patch analysis;
8) Harvester displacement, bicycle-car model, contact patch analysis.

Models 1 to 4 do not consider the contact patch. So, they perform "Single Point Analysis". Models 5 to 8 perform "Contact Patch Analysis".

In the models without harvester displacement, standard formulations presented in references [15, 16, 17] were used to determine the dynamic forces of the vehicle. In the models that include surface/harvester displacement, some adaptations were made in these formulas to determine the dynamic forces of the vehicle for the quarter car model and bicycle car model.

To determine the energy released by the vehicle and received by the pavement/harvester surface, the following equations were considered:

$$\partial K = \frac{1}{2} m_i \times (\partial v^2) = \frac{1}{2} m_i \left(v_f^2 - v_i^2\right) \quad (1)$$

$$E = F_z \times x_h \quad (2)$$

Where K represents the kinetic energy of the vehicle (Joules), m_i the vehicle mass (kg), v the vehicle longitudinal velocity (m/s), E the energy associated to the surface motion (Joules), F_z the load delivered by the vehicle tire to the surface (Newton), and x_h the surface displacement (m). The efficiency of the process was calculated dividing E per K.

2.4 Software Outputs

To present the software outputs graphically, a GUI platform was developed (Figure 2).

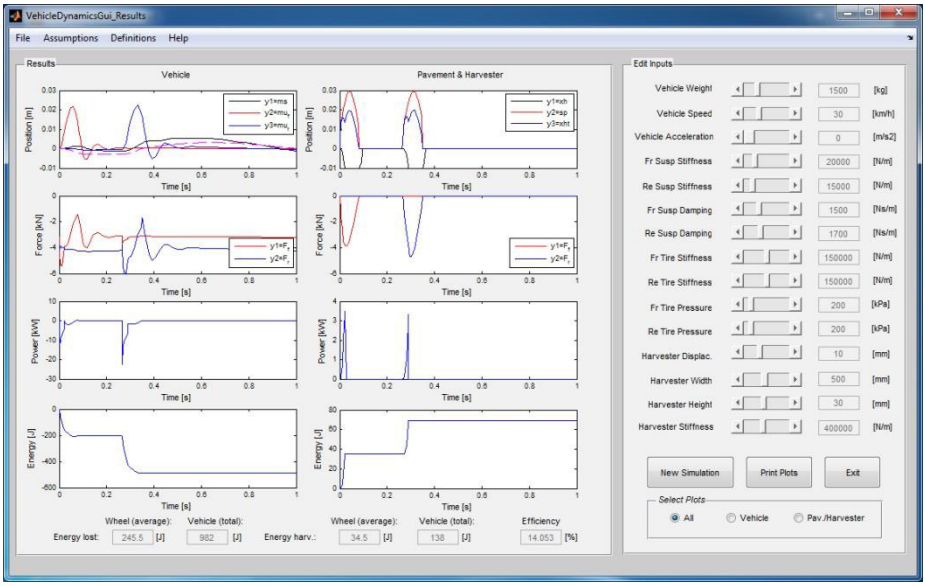


Fig. 2. Graphical user interface to present the outputs of the software.

This GUI has 2 distinct panels, with one for outputs presentation, and other for the selection of new values for the main variables of the system, as well as to choose an action: new simulation, print plots or exit.

The first panel presents graphically and numerically the outputs of the system with eight graphics and five values. On the left hand side results are presented for the vehicle outputs, starting with the vehicle mass displacements, then presenting the forces induced by the front and rear tires on the pavement, and finally, the power and energy lost by the vehicle in the interaction with the pavement obstacle. On the right hand side results are presented for the pavement outputs, starting with the position of the surface, the forces received by the surface, from each wheel of the vehicle, and finally, the power and energy received by the surface. The GUI also presents the values of the energy lost by each wheel of the vehicle and by the entire vehicle; the energy harvested

by each wheel actuation and by the actuation of the entire vehicle; and the efficiency of the energy transfer process.

The second panel allows users to define new values for the main variables of the simulation in order to re-simulate the model with some different changes, without having to leave the results GUI and start the process from the first GUI. The variables that can be changed are the vehicle weight, vehicle speed, vehicle acceleration, front and rear suspension stiffness and damping, front and rear tire stiffness and pressure, the harvester displacement, width, height and stiffness. The values are selected using a slider bar, with the user simply having to press the "New Simulation" button to start a new simulation. The graphics are updated after the new simulation is completed. This panel also offers users the possibility to print the plots, allowing them to select the desired plots to be printed and pressing the "Print Plots" button. Finally, it contains an "Exit" button to close the results GUI and return to the initial GUI.

3 Case Study

Considering all the variables of the software, one can easily conclude that it allows a user to perform thousands of different simulations. A case study considering a light vehicle moving on a speed reducer, or an energy harvest device, inserted on the pavement with possible vertical movement is presented. Three different surface displacements are considered (5, 10 and 20 mm), for seven different surface profiles. The variable values for the vehicle are presented in Table 1.

Table 1. Fixed values for the simulation variables of the vehicle.

	Variable name	**Value**	**Unit**
Vehicle & Motion	Vehicle class	Light	
	Vehicle weight	1,500	kg
	No. axles | Axles/wheel	2 | 2	
	Sprung - unsprung mass %	90% - 10%	
	Drag coefficient	0.32	
	Inertia moment	1,100	kg/m^2
	Lift coefficients (F | R)	0.19 | 0.13	
	Motion | Direction	Free rolling | Forward	
	Speed | Acceleration	30 | 0	km/h | m/s^2
Suspension & Wheel	Suspension type (F | R)	Independent | Independent	
	Suspension stiffness (F | R)	20,000 | 15,000	N/m
	Suspension damping (F | R)	1,500 | 1,700	Ns/m
	Tire type (F | R)	Radial | Radial	
	Tire stiffness (F | R)	150,000 | 150,000	N/m
	Tire damping (F | R)	800 | 800	Ns/m
	Tire pressure (F | R)	200 | 200	kPa
	Tire ext. diameter (F | R)	500 | 500	mm
	Tire width (F | R)	200 | 200	mm
	Tire tread width (F | R)	180 | 180	mm

The variable values for the road and surface properties are presented in Table 2. The results achieved by the simulations are presented in Table 3. Note that the value of the total energy released by the vehicle, considering a bicycle car model, is achieved by multiplying the calculated vehicle released energy by two, which is the number of vehicle sides.

Table 2. Fixed values for the simulation variables of the road surface.

	Variable name	Value	Unit
Road & Harvester	Pavement type | R. condition	Flexible | Dry	
	Inclination long. | Transversal	0 | 0	º
	Motion	Linear displacement	
	Harvester material	Rubber	
	Harvester width | Height	500 | 30	mm
	Harvester mass	30	kg
	Harvester stiffness	400,000	N/m
	Harvester damping	1,000	Ns/m

Table 3. Simulation results.

Surface	Surface displacement (mm)	Maximum force (N)	Vehicle released energy (J)	Pavement/har. received energy (J)	Efficiency (%)
Bump	5	5,309.84	1,044.00	62.00	5.94
	10	4,681.17	982.00	138.00	14.05
	20	4,772.08	804.00	268.00	33.33
Ramp	5	5,342.75	704.00	46.00	6.53
	10	5,551.22	672.00	106.00	15.77
	20	5,775.85	666.00	184.00	27.63
Hump	5	5,141.66	1,998.00	72.00	3.60
	10	4,549.69	2,076.00	165.00	7.51
	20	4,981.44	2,080.00	356.00	17.12
Triangle	5	6,187.79	922.00	52.00	5.64
	10	5,337.60	694.00	122.00	17.58
	20	5,287.91	588.00	224.00	38.10
S profile	5	6,912.24	868.00	42.00	4.84
	10	6,863.45	696.00	96.00	13.80
	20	6,927.68	548.00	250.00	45.62
Scale up	5	4,909.97	248.00	40.00	16.13
	10	4,992.78	250.00	94.00	37.60
	20	5,452.81	352.00	168.00	47.73
Crest	5	5,066.86	914.00	56.00	6.13
	10	4,603.69	1,110.00	128.00	11.53
	20	5,404.23	760.00	252.00	33.16

From the results presented in Table 3, it is possible to compare the differences between the surface profile and the forces induced by the vehicle on the surface, the released energy from the vehicle and the harvested energy on the surface, as well as the efficiency of the process. It can be concluded that, for the same displacement, the surface profile has a huge influence on the energy released by the vehicle and harvested by the surface. It can vary from only 248.00 J of energy lost (for the "Scale up" surface with 5 mm of surface displacement) to 1,998.00 J (for the "Hump" surface with the same displacement), leading to completely different values of energy harvested and conversion efficiency. From the results presented in Table 3 it is also possible to compare the influence of the surface maximum displacement on the energy lost by the vehicle and harvested by the surface. This is a very important feature of an energy harvesting device, as it allows the harvested energy and conversion efficiency to be maximized. However, the maximum value for the surface displacement should be limited and controlled, regarding the energy lost by the vehicle and the oscillations induced on it, which should be as low as possible.

4 Conclusions

The main goal of the present research work consisted of the development of a software that allowed users to study the forces induced by a vehicle in motion into the road pavement, a speed bump or an energy harvest device, as well as the energy lost by the vehicle, associated to the contact with the referred surface, and the energy received by that surface.

The software was developed in MATLAB® environment, including a GUI where the user can select and define all the variables associated to the simulation, and another GUI where the results are presented. The software has an extensive database of considered variables, allowing a huge amount of different combinations of values to be simulated, leading to the possibility of performing a great number of studies. The outputs of the system are focused on the forces and energy released by the vehicle and received by the pavement or by an energy harvest surface, but the computational model allows users to define new outputs and study other variables.

From the performed simulations, it was possible to conclude that the software corresponds to the goals of the project. It allows users to obtain the necessary outputs and easily permits the comparison of scenarios, regarding energy lost by a vehicle and harvested by the pavement or by an energy harvester surface, as well as the process efficiency.

The existing software tools, mainly ADAMS® and AUTOSIM®, already allow users to select all the vehicle characteristics and motion conditions, but the main differences of the developed software are evident: it allows us to obtain energetic outputs, select the pavement/energy harvester characteristics, dimensions and material, in a way that none of the other software tool do, and to compare the output, regarding both the vehicle and the pavement, together or separately.

The developed software can have multiple applications, from the study of vehicle suspensions and tires, regarding their interaction with speed reducers, to the design of speed reducers themselves, but one of the main applications should be the design of

energy harvest devices to implement on road pavements, which make use of vehicles' released energy to convert it into electrical energy. This initial version, not yet publicly available, is optimized for light vehicles. Further developments are being done to optimize it to heavy vehicles, with and without trailers.

Acknowledgments. The present research work has been carried out in the framework of project PAVENERGY – Pavement Energy Harvest Solutions (PTDC/ECM-TRA/3423/2014). The author Francisco Duarte is also grateful to the Portuguese Foundation of Science and Technology for the financial support provided to this study through Grant SFRH/BD/95018/2013.

References

1. IEA: Technology Roadmap: Fuel economy of road vehicles. International Energy Agency, Paris, France (2012).
2. Hendrowati W., Guntur H. and Sutantra I.: Design, modelling and analysis of implementing a multilayer piezoelectric vibration energy harvesting mechanism in the vehicle suspension. Engineering, 4 (11), 728-738 (2012).
3. MSC.Software: http://www.mscsoftware.com/product/adams. Accessed on 09/10/2015.
4. Prem H., Ramsay E., De Pont J., Mclean J., and Woodrooffe J.: Comparison of Modelling Systems for Performance-Based Assessment of Heavy Vehicles - Performance Based Standards: Nrtc/Austroads Project A3 and A4 (2001).
5. Sayers M.: Vehicle Models for RTS Applications. Vehicle System Dynamics, 32, 421-438 (1999).
6. Sayers M.: Symbolic Computer Methods to Automatically Formulate Vehicle Simulation Codes. PhD Thesis, University of Michigan (1990).
7. Mechanical Simulation Corporation: https://www.carsim.com/. Accessed 09/10/2015.
8. Sharp R., Evangelou S. and Limebeer D.: Multibody aspects of motorcycle modelling with special reference to Autosim. In Advances in computational multibody systems, 45-68 (2005).
9. Kinjawadekar T., Dixit N., Heydinger G., Guenther D. and Salaani M.: Vehicle dynamics modeling and validation of the 2003 ford expedition with esc using carsim, No. 2009-01-0452), SAE Technical Paper (2009).
10. Wei-qun R., Yun-qing Z. and Guo-dong J.: A new application of multi-body system dynamics in vehicle-road interaction simulation. Wuhan University Journal of Natural Sciences, 8 (2), 379-382 (2003).
11. Rao S.: Development of a Heavy Truck Vehicle Dynamics Model using TruckSim and Model Based Design of ABS and ESC Controllers in Simulink, Doctoral dissertation, The Ohio State University (2013).
12. Gillespie T.: Fundamentals of vehicle dynamics, Society of Automotive Engineers, Volume 114, (1992).
13. Wong J.: Theory of Ground Vehicles, Wiley-Interscience, Third Edition (2001).
14. Pacejka H.: Tire and vehicle dynamics. Elsevier (2005).
15. Jazar R.: Vehicle dynamics: theory and application. Springer Science & Business Media (2008).
16. Popp K. and Schiehlen W.: Ground vehicle dynamics. Springer Berlin Heidelberg (2010).
17. Rajamani R.: Vehicle dynamics and control. Springer Science & Business Media (2011).

Implementation of techniques, standards and safety recommendations to prevent XSS and SQL injection attacks in Java EE RESTful applications

Daniel Guamán[1,1], Franco Guamán[1], Danilo Jaramillo[1], and Roddy Correa[1]

[1] Departamento de Ciencias de la Computación y Electrónica, San Cayetano Alto, 1101608, Universidad Tecnica Particular de Loja, Ecuador
daguaman, foguaman, drjaramillo, racorrea@utpl.edu.ec

Abstract. There are recommendations and tools, given by OWASP that suggest basic techniques of prevention and protection of computer attacks over web applications where the common types of attacks are XSS and SQL Injection; for that reasons, we apply recommendations and good practice to minimize this kind of attacks; used some tools to validate automatically attacks and built some expressions to validate manually the intrusions in web applications. Therefore, this study was based on the development of a prototype under REST, design pattern Facade, Java EE and Glassfish [13].With the development of the prototype it was found that by the use of standards and norms recommend by OWASP the security in terms of overall design and source code in web applications can be greatly improved.

Keywords: OWASP, REST, SQL Injection, XSS.

1 Introduction

Software systems are a fundamental part within companies since they are usually built under important aspects of software development such as: architecture, methodologies, languages programming, physical infrastructure, functional and non-functional requirements and quality attributes. As part of the software systems we can mention the web applications that use the WWW[2] for making operations such as data consuming, data and information transactions, among others; in some cases, the access facility causes unexpected results when the aspects of software development are not taking into account and it's the main problem when some teams software build web applications, many people with different skills in programming, low use of coding standards and a little knowledge about the security when designing or implementing an application.

[2] World Wide Web

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_65

People, who demand this type of web applications usually make a request and wait for an answer, but many of them have not asked themselves whether behind the applications there are aspects related with security, reliability, performance, functionality, portability, among others. For example, when talking about security, if a person makes use of an application, functionality or service exposed on the web, which is easily vulnerable to attacks, data security or information involved in the process of request and answer will be compromised. To answer these questions, software engineers focus on making a proper analysis and design of web applications; however, in some cases, security aspects that can be implemented in terms of design, coding and implementation are not considered.

The security aspects that should be considered when developing a web application, at the level of design, coding and deployment are presented in this research work. To do so, the standards and recommendations of the OWASP[3] project were considered as reference to increase the security in this type of applications. With this purpose, the SQL Injection and Cross-site Scripting (XSS), listed as the first and third most common attacks in the OWASP Top Ten for this type of application were selected.

The purpose of this research is to reduce the vulnerabilities, and make the web applications secure from the standpoint of design, coding and deployment, by using Java EE[4], a REST[5] architectural style, a design pattern facade and tools that allow testing and validation processes. First, this research summarizes the issues addressed in the prototype, then the methodology used for the design and coding prototype is deeply described, and finally, the results and conclusions are presented.

2 State of the Art

2.1. Software Architecture

Software architecture allows early documentation of high-level software design solutions, providing a comprehensive and structural software view. It belongs to the post stage of lifting requirements. According to [1], thanks to the architectural specifications, software engineers are better supported to deal with the increasing complexity of software systems today. Therefore, this is one of the most important activities within software development. [2]

2.2. Architectural Style

The architectural styles determine a set of design rules that identify types of components and connectors that can be used to build a system or software subsystem with local and global constraints of its composition [27]. Other authors such as [3], [4] explain that an architectural style is not a software architecture, but a methodology that is a part of the solution of concrete problems.

[3] Open Web Application Security Project
[4] Java Platform Enterprise Edition
[5] Representational State Transfer

2.3. Rest

REST is an architectural style that considers a set of principles, actions and techniques to define an interaction between components with the use of a transport protocol [27], [12]; its operation is based on resources referenced through identifiers [31]. REST promotes the exposure of resources through a structured data format: JSON [6] or XML, that allow an easy language for humans and machines. These systems based on this architectural style are called RESTful[6]. Their activity uses the WWW standards, mainly HTTP [9], [22] and URI [3]. Regarding security, REST has some standards; one of the most common security forms is based on the use of HTTPS as a transport protocol [21].

2.4. Design Patterns

Design Patterns [16] and [26] are simple, documented, and established solutions to solve specific software problems [4]. In his book, Christopher Alexander [14] provides a description of necessary qualities of design patterns such as: a)Encapsulation and abstraction, b) Extent and variability, c) Generativity and composition and d) Balance.

Indeed, design patterns propose architects, developers, analysts and experts in software solutions, aspects for good decision making and a comprehensive vocabulary, which allows the software teams to have an effective communication and more simplicity for the development of software systems. The design patterns are classified into three groups: 1. Creating Patterns, 2. Structural Patterns, 3. Behavior Patterns. In [10], the different types of design patterns as well as their classification are discussed.

2.5. Software Security

Security provides a high degree of criticality; therefore, from the software development point of view, the data are a fundamental key at an organizational level, which must be ensured from all the aspects [24] and [18]. Additionally, they are considered as a set of resources aimed at making the assets of an organization confidential, complete, consistent and available to the users, authenticated by access control mechanisms and subject to audit. There are three aspects that should be taken into account for information assurance: 1. Confidentiality: Ensures that information may not be available, or discovered by third parties. 2. Availability: Ensures information security, hardware and software to be accessed at any time. 3. Integrity: Condition security that certifies that the information has been inserted, updated and deleted by authorized users.

According to [29], as a result of the lack of standardization and use of safety regulations during the process of software development, there are significant implications within an organization. For [29], today, assurance should not be planned,

[6] https://docs.oracle.com/javaee/6/tutorial/doc/gijqy.html

but it must be executed at the moment of finalizing software implementation details. During this study, technical and regulatory software assurance techniques will be analyzed; we will particularly focus on three levels: architectural design, source code and database.

- **Architectural Design:** in this first level, two methodologies that will allow the assurance of the software application were identified. Methods of authentication and data encryption of hypertext were applied; to do so, JAAS [30] and HTTPS [23] were studied and used respectively.
- **Source code and database:** This level was based on the study of the techniques identified by OWASP [31]; in this step, store procedures and implementation of parameterized queries were applied. These techniques potentially contribute to the shielding of the weaknesses related to SQL Injection [28]. The stored procedures calls belong to the data extraction way of the DB[7] ; these are small programs with their own logic, which directly interact with the DB engine, while the parameterized queries contribute to the separation of the SQL query string of the specification parameter.

2.5. Owasp

It is an open source project dedicated to study and combat security vulnerabilities in web software [2]. OWASP manages several security projects; among the most important, OWASP Top 10 [31]; which contains the 10 most influential types of attack toward the applications' security. The main objective of this project is to provide basic of prevention and protection techniques of computer attacks, in terms of software development. OWASP use parameterized queries as a good programming practice, this practice forces the developer to define the SQL query and then define the parameters to be sent and so distinguish between the query and parameter. A sample implementation in the present prototype using JAVA EE parameterized queries, shown below:

```
String SP = "CALL listPerson(?)";
Query q = getEntityManager().createNamedQuery(SP);
q.setParameter(1, cedula);
```

This method allows calling a stored procedure and sends a parameter using the technique applied. The difference between good and bad practice in programming shown below in the Table1.

[7] Database

Table1. Good and bad practices in programming

	Java Coding	***Result***
Good practice	String SP = "CALL listPerson(?)"; Query q = getEntityManager().createNamedQuery(SP); q.setParameter(1, cedula);	Error 500
Bad practice	String SQL = "SELECT * FROM person WHERE cedula =' "+ cedula + " ' "; *Query q = getEntityManager().createNamedQuery(SQL);*	Information of all people
Vulnerability String attack	SQL Injection ' or '1' = '1	

Where, the bad practices return a fragment SQL how valid result: *SELECT * FROM person WHERE cedula = '' OR '1' = '1'*; the same becomes understandable string for the database engine and as a result returns all data stored in the database in the table persons; while the combination of parameterized queries and stored procedures throws an error because the chain of attack is unknown, this happens because the parameterized queries distinguish the query parameter; namely, making the attack vector " 'or '1' = '1 " as a single string and produces an accurate error that the parameter does not belong to a valid query string; therefore, in the prototype stored procedures and parameterized querys are used.

Another Owasp recommendation is use cleaning method of special characters; this method is used in order to have a special characters filter. Both XSS and SQL Injection are similar vulnerabilities that allow an attacker to inject malicious code with the intent to obtain information or assurances logical break Web applications. Therefore, this method is responsible for cleaning the parameter entered by the user prior to passing a parameter query and clean up the special characters and replacing them with reference codes. Some of the strings recommended by Owasp that were applied to validate the prototype in order not to allow such attacks and XSS SqlInjection are shown in the Table 2.

Table 2. String used to validate prototype and description of use

String located at URI	Description of use
http://localhost:8080/pft/ws/persona/' and 1=convert(int, @@version)--	Gets the version of the database. When used Stored Procedures and configure https as protocol, the string sql injections were not executed; but with http protocol, SQL injections were executed.
http://localhost:8080/pft/ws/persona/' and 1=convert(int, @@version)	Gets the version of the database on wich database objects are executed.
http://localhost:8080/pft/ws/persona/' and 1=convert(int, @@servername)	Gets the name of the server where the application resides.
http://localhost:8080/pft/ws/persona/ null union all select 1,2,3,4,table_name,6,7,8,9,10,11,12,13,1	Obtain information such as table name from database.

4,15 from information_schema.tables http://localhost:8080/pft/ws/persona/ valor‘ ; DROP TABLE nombretabla;	Delete a table in the database.
http://localhost:8080/pft/ws/persona/<script> alert(‘exploit XSS | Hacked’)</script>	One JS alert is generated in the browser. It is the most basic test of XSS vulnerability. Without a method of cleaning special characters, the vulnerability alert was executed; after implementation of the method it not detected vulnerabilities.

2.6. Deployment Resources

In order to obtain and quantify the results of this study, the tests were based on three factors: architecture, quality of the source code and security evaluation of web services. In order to obtain those results, we focused on the use of four specialized tools in the analysis of the factors to be evaluated: Architecture, Code source quality and Security assessment of web services.

- **Architecture:** *Structural Analysis for JAVA*, [19] Some characteristics of the selected tool were used to validate the architectural solution, which deeply scans the compiled file (.jar) of the application. It specifically evaluates the software architecture, its coding and stability. *Sonargraph Architect* is a static analysis tool that lets you define the software architecture model, it can be verified and executed automosly or with IDE Eclipse or IntelliJ plugins, it also gives the user the ability to understand the structure of the developed system, and shows the interaction between components, classes, and other programming artifacts that are part of software development.
- **Code Source quality**: *SonarQube*, is an open source platform used by the development teams to monitor the code quality [20]. It mainly covers seven areas of software quality, among which we can find the architecture and software design. The quality validation is based on an analysis where the SQALE method is used [15].
- **Security assessment of web services:** *SoapUI* [17], [8] is an specialized tool that analyses the SOAP and REST security services. Its operation involves the explotation of different vulnerabilities using input parameters to the WS[8].

3 Methodology

To carry out this research, a RESTful WS was built in order to apply the security related concepts that were previously analyzed and recommended by OWASP. To do so, the first step was to define a software architecture that allows exposing sensitive information through specific WS. Next, a data model and identifiers that represent the resources to be exposed were defined. The implementation of the WS was limited to the HTTP GET verb, which specifies a consultation action as well as specific Java EE

[8] Web Service

implementations [11]. For the pattern design implementation sections, logic control assurance and vulnerability, the following steps were selected:

- **Architectural Design Pattern:** *Facade*, provides a simple logic, which means that software programing is structured and that it allows the abstraction of a layer, so that if one of them requires changes, it is not necessary to modify the others, thus, the maintainability and modifiability criteria are applied [32], [25].
- **Logical security control:** *Authentication*, where the characteristics of HTTP and HTTPS will be used. Web services are exposed on the Internet to be consumed from any mobile device or web app, therefore, through this control, a safe data access wants to be guaranteed. Using https helps mitigate issues of logical security controls; however, the configuration of secure http response headers must not forget as: X-XSS-protection, X-Frame-Options: deny; http-only: true.

Sections of solution design, coding, deployment and architecture are presented below.

3.1. Solution Design

Architecture: As shown in Fig. 1, the architecture proposed by JAX-RS [11][5] is considered as a reference in the application component. At the architectural level, one of the security methodologies selected was specified: the JAAS Authentication. Additionally, components such as the client and database can be observed. The architectural flow provided by the proposed design is similar to a client-server architecture where the client initiates a request and the server determines a response.

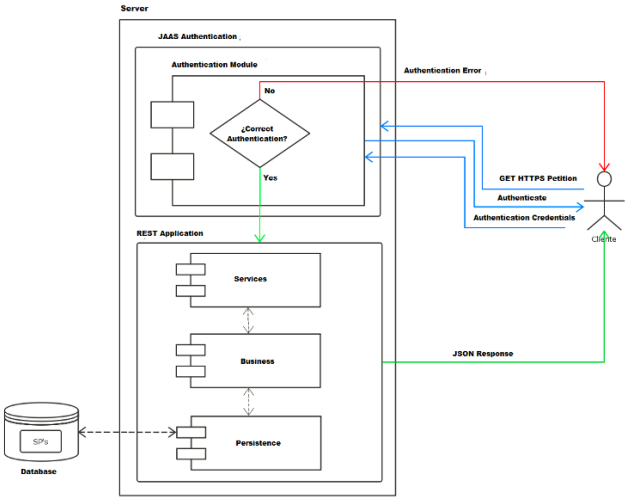


Fig. 1. Architectural Design Representation

WS RESTful Identifiers: In table 3, the URI[9] designed to represent data resources are shown.

[9] Uniform Resource Identifier

Table 3. Web Services Identifiers

URI	Parameter	Resource
https://www.utpl.edu.ec/pft/ws/persona	Empty	Information of all people.
https://www.utpl.edu.ec/pft/ws/persona/{cedula}	Identification number (ID number)	Filters the information of a specific person, using the ID number as a parameter.
https://www.utpl.edu.ec/pft/ws/persona/{cedula}/proyecto	Identification number (ID number)	Shows the project assigned to a specific person, using the ID number as a parameter.

3.2. Coding

For this stage, the resources needed for building the RESTful WS were taken into account. In the Table 4, the resources are presented. It is important to mention that the perspective of solution was focused on the use of license-free tools.

Table 4. Technological Resources

Resources	Selection
Programing language	JAVA
API coding	JAX-RS
API persistence	JPA 2.1
Application Server	Glassfish 4.1
Database	MYSQL

The construction of the WS involved the implementation of the security techniques studied, building methods with the capacity of providing the required logic to the REST application in order to solve the customer requests and needs. To do so, the coding process applied the programming paradigm OOP (Object – oriented programming) and the use of the structural design pattern Facade [25], [7] with the purpose of separating programming into communicational interfaces that enable the application modifiability. In the Fig. 2, the security techniques applied at this level can be observed. The portion of source code corresponds to the class where the logic for extracting data from the database was determined; this is simultaneously one of the design pattern interfaces that were implemented.

```
35      public List<T> listarModalidades() {
36          Query q = getEntityManager().createNamedQuery("Modalidad.ListarModalidades");
37          return q.getResultList();
38      }
39
40      public List<T> listarNivelAcademico() {
41          Query q = getEntityManager().createNamedQuery("NivelAcademico.ListarNivelAcademico");
42          return q.getResultList();
43      }
44
45      public List<T> listarPersonaProyectoPorCedula(Object cedula) {
46          String parametro = u.limpiarXSS(cedula.toString());
47          Query q = getEntityManager().createNamedQuery("Persona.ListarPersonaProyectoPorCedula");
48          q.setParameter(PARAMUNO, parametro);
49          return q.getResultList();
50      }
```

Fig. 2. Source code written in Java

3.3. Deployment

Prior to the deployment and security implementation, the safety logic control was designed. This step involved the specification of roles and users with access to the Web services. Next, the setup files that belonged to the application assurance at the server- level were encoded in order to obtain a link between the software and server.

In this process, the communication protocol HTTPS, the JAAS authentication and the HTTP secure response headers were configured [31]. In the web.xml file, the following properties are designed:

- **HTTP Only:** to protect the application from attackers who read and write scripts; in other words to avoid accessibility through the script code. This is shown in Fig. 3.

```
<session-config>
        <cookie-config>
            <http-only>true</http-only>
        </cookie-config>
 </session-config>
```

Fig. 3. HTTP coding in XML

- **Clickjack:** It was applied as a measure of strength to prevent ClickJacking attacks; this type of attack usually intends to steal the identity of a user in order to take over his computer, by clicking on a web page. Its chain setup corresponds to a safety filter implemented in the ClickjackFilter Class within the driver package, where its logic denies this type of attack. A section of this application is shown in Fig. 4.

```
<filter>
       <filter-name>ClickjackFilterDeny</filter-name>
        <filter-class>
            rest.controladores.ClickjackFilter
        </filter-class>
    <init-param>
        <param-name>mode</param-name>
        <param-value>DENY</param-value>
    </init-param>
</filter>
<filter>
    <filter-name>ClickjackFilterSameOrigin</filter-name>
    <filter-class>
        rest.controladores.ClickjackFilter
    </filter-class>
    <init-param>
        <param-name>mode</param-name>
        <param-value>SAMEORIGIN</param-value>
    </init-param>
</filter>
```

Fig. 4. Clickjack Coding

- **HTTPS and Authentication:** the secure transport protocol HTTP was configured in order to encrypt connections and to prevent them from being intercepted by third parties; besides the authentication logic. As a result of those configurations, a secure transport protocol was implemented to encrypt HTTPS connections, as well as its logical control security, limiting access to those users that not allowed.

4 Testing and Results

Based on the study and implementation executed for building the RESTful WS, the necessary validations were carried out in three stages: architecture, coding and WS security.

```
<security-constraint>
    <display-name>Constraint1</display-name>
    <web-resource-collection>
        <web-resource-name>ssl</web-resource-name>
        <description/>
        <url-pattern>/*</url-pattern>
        <http-method>GET</http-method>
    </web-resource-collection>
    <auth-constraint>
        <description/>
        <role-name>admin</role-name>
    </auth-constraint>
    <user-data-constraint>
        <description/>
        <transport-guarantee>CONFIDENTIAL</transport-guarantee>
    </user-data-constraint>
</security-constraint>
<login-config>
```

Fig. 5. HTTPS Configurations

4.1. Software Architecture

The analyzes carried out in this first stage were based on the results issued by the tools described in paragraph 2.5; where a 100% of similarity between the application developed and the proposed architecture was obtained. Moreover, the analysis of the results issued by the tools showed that according to the standards of this tool, the developed software had a 91% of stability. The systems that represent more than 90% of stability are reliable and show the quality expected for software applications.

In the Fig. 6, the implementation of the Facade pattern and the construction of the necessary components for the REST implementation are shown. In order to visualize the solution diagram, the .jar file was loaded in the tool; in this way, the following diagram was obtained.

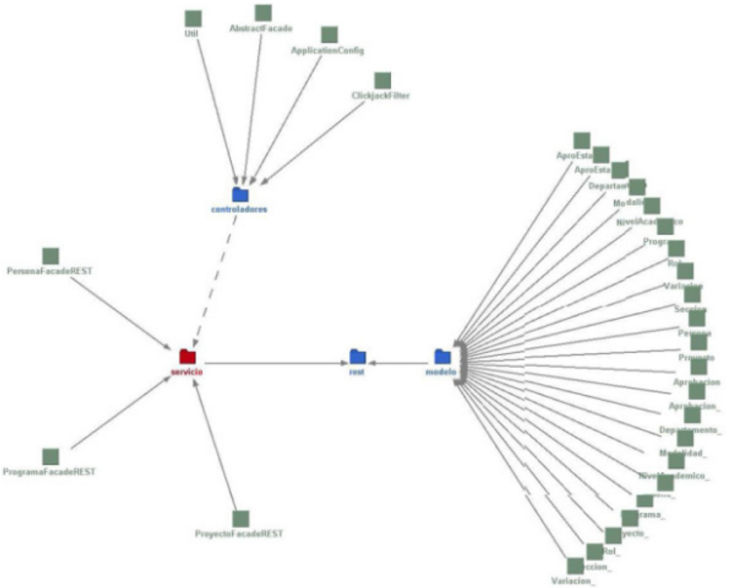


Fig. 6. Architecture Design: Structural Analysis for Java

In Fig. 7, we can observe the packet structure, the components, the classes and their relationships. The classes belonging to the services directly interact with the external methods and with the class that belongs to the invoked service. As a result, we analyzed the PersonaFacadeREST class where it can be seen that it directly interacts with the AbstractFacade and Person Classes. The AbstractFacade is the design pattern of the selected facade and Person is the class that gets data from the persistence since the Person table from the database is mapped along with its relationships here. Moreover, it responds to the EntityManager methods that correspond to the data persistence and the GET method, which expresses the consultation action of the web services.

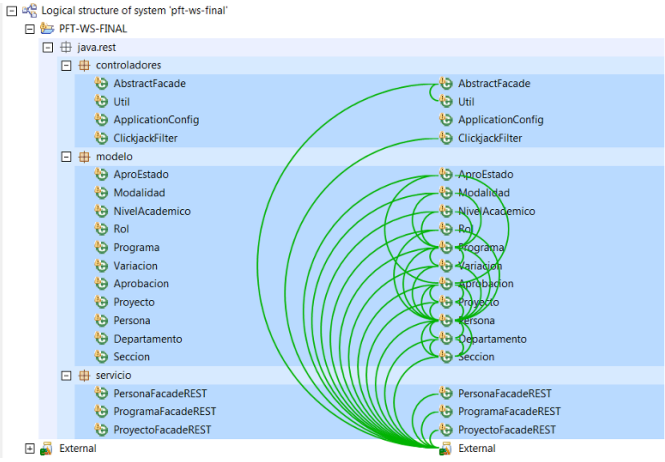


Fig. 7. Architecture Design: SonarGraph

4.2. Source Code

For this second stage of testing, the quality of the written source code was evaluated by using the SonarQube tool. Four iterations of code evaluation were executed, which made it possible to achieve the desired quality. Most of the problems encountered during the verifications were the result of the lack of programming standards, which were resolved in each iteration. The results obtained from the tool are shown in Table 4. The main programming errors were not used standard according programming language, misuse of collections and generics in Java, commented code, error in writing of entities, call failed parameterized statements, among others.

Table 4. Number of problems related with the source code quality

Iteration Number	Number of problems encountered
1	1038
2	240
3	102
4	3

Fig. 8 shows the progress in the solution of the source code quality problems that were found, which resulted in a positive curve because in each iteration the following problems were minimized: duplicate code blocks, method parameters, uncaught exceptions, constant names without a naming convention, among others.

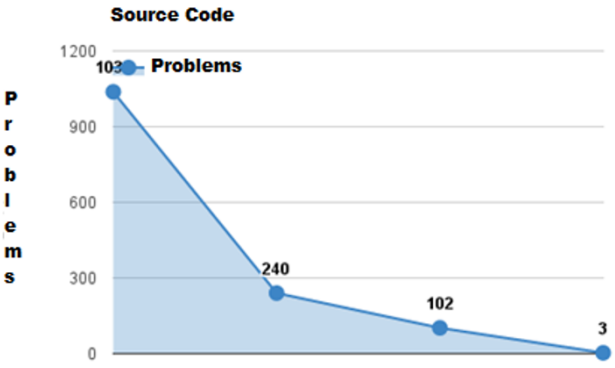


Fig. 8. Troubleshooting curve of source code quality

Finally, based on the results obtained it was possible to improve the source code quality as well as to achieve the desired security due to the use of the standards and safety parameters suggested by the OWASP and SonarQube tools. It is important to mention that based on the SQALE metrics applied by SonarQube in its analysis, we got a grade of "A" and a technical debt of 0%, which justify the quality of the software written.

4.3. Security

In this last stage, the security software prototype was evaluated through the study of the two vulnerabilities exposed before. For the software security validation, the following tools were used: Vega Subgraph, Owasp Zap and SoapUI. The results shown in Fig. 9. correspond to the alerts generated by SoapUI.

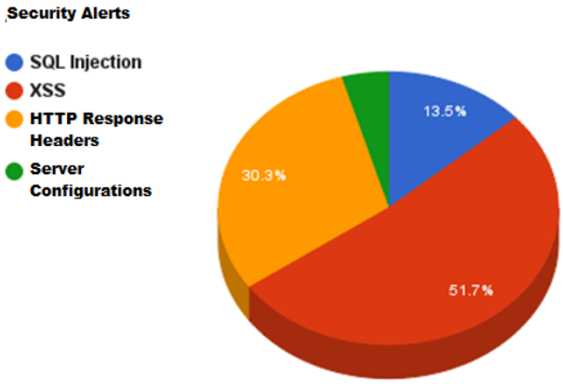


Fig. 9. Software security alerts

Alerts generated by the tool determined greatest weakness in WS toward XSS attacks because of the lack of a secure HTTP response headers configuration, which if absent, generate a greater weakness impact toward XXS. As for SQL Injection, the problems are mainly caused due to the lack of safe programming standards. It is important to emphasize that the application of external security mechanisms at the server level and the communication of software architecture primary components (Client-Server), contributes to the reduction of software weaknesses; which means that the encryption connection using HTTPS standards reduces the impact of weakness.

For justifying the results, the aspects mentioned above were evaluated considering the weaknesses of the study, the communication protocol and the data extraction procedure. Fig.10. shows a potential peak of alerts when an HTTP communication protocol shared by both methodologies of data mining is used.

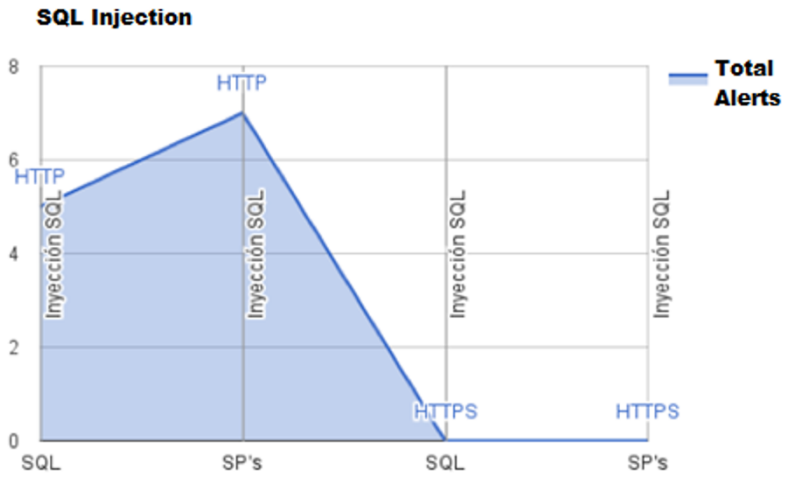


Fig. 10. Security alerts for SQL Injection

On the other hand, the results obtained for XSS are shown in Fig. 11, where the highest number of weaknesses occurs in using SQL statements and HTTP transport protocol.

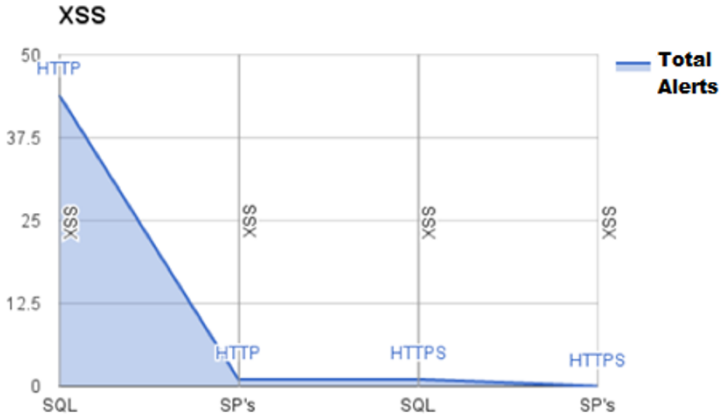


Fig. 11. XSS security alerts

5 Conclusions

The development of RESTful web services certifies full independency of technologies and programming languages. Its JSON response language is universal and it allows intercommunication between different software technologies. Additionally, it manages lighter contents that benefit performance of web applications.

In terms of writing code, the Facade design pattern contributes to the structuring of the source code and software security, as it remains isolated communication interfaces, allowing in this way that the programming logic is not exposed to potential attackers. In the same way, the use of OWASP standards as a reference for web applications assurance greatly mitigates the lack of safety standards established for REST.

The implementation of stored procedures as recommended by OWASP guarantees information assurance and mainly prevents from SQL injection type attacks. Furthermore, this technique improves performance in relation to the request and response of the RESTful web services.

As part of the prototype design and coding, it was found that the main way of preventing XSS attacks consists on cleaning up the parameters entered by the end-user in the resource identifiers (URI), prior to the execution and resolution of the HTTP request. Additionally, the use of secure communication channels such as HTTPS is essential because it encrypts the connections, thus helping to prevent the theft of information as well as the violation of logical access.

The validation process using iterations allowed the adjustment of the source code to the standards recommended by the SonarQube tool, which uses SQALE based metrics and quality standards. This process also allowed the validation of the use of parameters as part of the URI, which represents a good practice for the design of RESTful identifiers since it benefits the concealment of specification variables to potential attackers.

Finally, in any type of software development it is necessary to use data persistence, since it allows managing communication with any database engine and ensuring compliance of software quality attributes such as: portability and compatibility.

6 Future Works

Due to the increasing adoption of REST, safety security and software development standards should be established in order to guarantee its integrity. To do so, efforts should be doubled at early software development stages, allowing the setting of basic safety measures during its life cycle. Therefore, the next step is to focus the study on other HTTP verbs with REST and architectural styles such as SOA, and 3 Layers in order to validate different actions on data exposed through web services.

References

1. Aleti, A. et al.: Software Architecture Optimization Methods: A Systematic Literature Review. Softw. Eng. IEEE Trans. 39, 5, 658–683 (2013).
2. Bass, L. et al.: Software Architecture in Practice. Architecture. 2nd, JANUARY 2003, 528 (2003).
3. Berners-Lee, T. et al.: Uniform Resource Identifiers (URI): Generic Syntax. Rfc. 2396, 40 (1998).

4. Bieman, J.M. et al.: OO design patterns, design structure, and program changes: An industrial case study. IEEE Int. Conf. Softw. Maintenance, ICSM. 580–591 (2001).
5. Coward, D.: Java TM API for WebSocket. In: Java TM API for WebSocket. p. 43 (2013).
6. Crockford, D.: The application json media type for javascript object notation. 1–10 (2006).
7. Dale, M.R., Izurieta, C.: Impacts of Design Pattern Decay on System Quality. (2014).
8. Fertig, T., Braun, P.: Model-driven Testing of RESTful APIs. 1497–1502 (2015).
9. Fielding, R. et al.: RFC 2616: Hypertext transfer protocol–HTTP/1.1, June 1999. Status Stand. Track. 1, 11, 1829–1841 (1999).
10. Gamma, E. (2006).: Patrones de diseño: elementos de software orientado a objetos reutilizables. (2006).
11. Hadley, M., Sandoz, P.: JAX-RS: Java™ API for RESTful Web Services. Oracle Corp. 96 (2008).
12. Haupt, F. et al.: A model-driven approach for REST compliant services. (2014).
13. Heffelfinger, D.R.: Java EE 5 Development Using GlassFish Application Server: The Complete Guide to Installing and Configuring the GlassFish Application Server and Developing Java EE 5 Applications to be Deployed to this Server. (2007).
14. Lea, D.: Christopher Alexander: an introduction for object-oriented designers. ACM SIGSOFT Softw. Eng. Notes. 19, 1, 39–46 (1994).
15. Letouzey, J.-L.: The SQALE method for evaluating Technical Debt. 2012 Third Int. Work. Manag. Tech. Debt. 31–36 (2012).
16. Li, H.: RESTful Web service frameworks in Java. 2011 IEEE Int. Conf. Signal Process. Commun. Comput. ICSPCC 2011. 1, (2011).
17. Lim, S.: Method of Application Driven QoS Service in Open Service Platform based on RESTful Web Services. 632–633 (2014).
18. McGraw, G.: Software Security. Secur. Privacy, IEEE. 2, 2, 80–83 (2004).
19. Munro, M.J.: Product metrics for automatic identification of “bad smell” design problems in Java source-code. Proc. - Int. Softw. Metrics Symp. 2005, Metrics, 125–133 (2005).
20. Pablo, J. et al.: Análisis de seguridad y calidad de aplicaciones (Sonarqube) Análisis de seguridad y calidad de aplicaciones (Sonarqube). (2015).
21. Pautasso, C. et al.: Restful web services vs. “big”web services: making the right architectural decision. Proceeding 17th Int. Conf. World Wide Web. 805–814 (2008).
22. Ramsdell, B.: SMIME version 3 message specification. 1–32 (1999).
23. Rescorla, E.: Http over TLS. 1–7 (2000).
24. Serme, G. et al.: Enabling message security for RESTful services. Proc. - 2012 IEEE 19th Int. Conf. Web Serv. ICWS 2012. 114–121 (2012).
25. Shuai, J., Huaxin, M.: Design Patterns in Object Oriented Analysis and Design. IEEExplore. 326–329 (2011).
26. Shuang, L., Peng, C.: Developing java EE applications based on utilizing design patterns. 2009 WASE Int. Conf. Inf. Eng. ICIE 2009. 2, 398–401 (2009).
27. Taylor, Richard N., Mark S. Ackerman, D.S.R.S.R.: Architectural styles and the design of network-based software architectures. (2000).
28. Wei, K., Muthuprasanna, M.: Preventing SQL injection attacks in stored procedures. Aust. Softw. Eng. Conf. 8 pp.–198 (2006).
29. Yag, M.: Integrando la Ingeniería de Seguridad en un Proceso de Ingeniería Software. September 2015, (2015).
30. Authorization Service (JAAS) Reference Guide, http://docs.oracle.com/javase/1.5.0/docs/guide/security/jaas/JAASRefGuide.html.
31. Owasp, https://www.owasp.org/index.php.
32. Patterns Design, http://msdn.microsoft.com/es-es/library/bb972240.aspx.

The difference operation between templates of binary cellular automata

Zorandir Soares[2], Maurício Verardo[2], and Pedro P. B. de Oliveira[1,2]

[1] Universidade Presbiteriana Mackenzie
Faculdade de Computação e Informática &
[2] Universidade Presbiteriana Mackenzie
Pós-Graduação em Engenharia Elétrica e Computação
Rua da Consolação 896, Consolação
01302-907 São Paulo, SP - Brazil
zorandir@gmail.com
mauricio.verardo@gmail.com
pedrob@mackenzie.br

Abstract. A cellular automata template is a generalisation of the state transition tables of cellular automata. Templates have recently been introduced to represent families of cellular automata that share a given property. This paper introduces the operation of difference between templates, used to find cellular automata that have a given property but lack another. We also introduce a process called *exception templates* that is required to this operation. Experimental results of both techniques are illustrated with examples in the space of elementary cellular automata.

Keywords: Cellular automata, rule space, templates, difference between templates, exception templates.

1 Introduction

Cellular automata (CAs) are dynamical systems typically discrete in time, space and state variables. CAs can produce behavior of great complexity even based on simple rules of local action [1]. The study of classical problems of cellular automata, like the parity problem [2] and the density classification problem [3] can help understand how this complex behavior emerges.

The most basic approach to find a suitable solution to classic problems consists in testing each of the rules of a particular family of CAs in order to check whether some rule is able to solve the problem. However, this approach shows to be inefficient or impractical for larger families of CAs, which is the most usual panorama in literature.

Evolutionary computing has been consistently used to deal with larger families. This type of algorithm has proven very effective to find solutions for density and parity classification [4].

Another strategy to find suitable rules is restricting the search space by rules that have a given property. In order to represent a subspace with a particular

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_66

property without the need of enumerate all of the rules in the space, one can use *templates*, as proposed by De Oliveira and Verardo [5, 6].

Up to the moment, two key operations have been defined to be applied to templates: *expansion* and *intersection* [5, 6]. Here we introduce two new operations, namely, the *difference between templates* and another that generates the *exception templates*. Moreover, application of these operations are presented with simple examples.

This paper is organised as follows. Next, Section 2 gives some basic concepts about cellular automata. Following, Section 3 presents more details about templates and its major operations. Section 4 introduces the operation of difference between templates and the one that generates the *exception templates*, as well as their applications. The paper concludes with Section 5 with closing remarks.

2 Cellular Automata

Cellular Automata are simple mathematical idealisations of natural systems [7]. They consist of a lattice of discrete cells, each of which can take on one of a finite set of discrete states in a given time step. The states of the cells evolve in discrete time steps usually according to deterministic rules that specify the state of each cell according to those of their neighbouring cells [7].

We assume that the cells have k possible states which are represented by integer values in the range of $[0, k-1]$. The state of a cell is changed by the local function of the automaton (its rule), formed by a state transition set, that applies to its current state and those of adjacent cells. In order to define the size of the neighbourhood of the cells, usually a radius r is defined encompassing the extent by which the neighbouring cells will be accounted for.

A family (or space) of cellular automata, is defined by the radius r and the number of states k. One-dimensional cellular automata with $r = 1$ e $k = 2$ constitute the so-called elementary cellular automata. In order to refer to the rules of a space, it is common to use the number obtained by the decimal representation of the outputs of the state transitions, sorting the neighbourhoods lexicographically from the largest to smallest state; for instance, in the elementary space, the number of the rules corresponds to the decimal sequence formed by the 8-bit output, arranged from neighbourhood 111 down to 000.

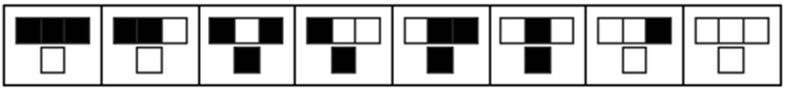


Fig. 1. Rule table of the elementary CA 60.

In other words, as neighbourhood are sets of adjacent cells that determine the state of the current cell in the next time step, all CA has a rule that relates

each possible neighbourhood with the state of the central cell in the next time step. This rule can then be represented by rule tables with n-tuples, $n = 2r + 1$ in the one-dimensional case. For example, the rule table of the elementary CA 60 is given by ((1,1,1),0), (1,1,0),0), (1,0,1),1), (1,0,0),1), (0,1,1),1), (0,1,0),1), (0,0,1),0), (0,0,0),0)), and illustrated in Figure 1 by its iconic representation table of the elementary CA 60.

Since the number of rules in a space is given by $k^{k^{2r+1}}$, any increase in the values of k and r generates families with an exponentially increase in the number of rules. An approach to handle this problem is to use static properties as a hint on how the CA will behave during its evolution. A static property is obtained directly from the CA's rule table. The use of static properties can highly restrict the initial search space. With templates we can represent a set of rules with a certain static property. For the sake of simplicity, whenever we refer to a CA template from now on, we mean one-dimensional and binary CA template.

In order to explain how templates work, it is important to understand the properties of number conservation, internal symmetry and colour blindness, that will be used in later examples.

2.1 Number Conservation, Internal Symmetry and Colour Blind Cellular Automata

Number conservation is a static property that determines that the sum of the states of a particular cellular automata should not change during the CA's evolution, regardless of the initial configuration.

According to Boccara and Fukś [8], a CA is conservative when its local function f, applied to every neighbourhood $(\alpha_0, \alpha_1, \ldots, \alpha_{n-1})$, considering $n = 2r + 1$, satisfies the conditions described in Eq. 1.

$$f(\alpha_0, \alpha_1, \ldots, \alpha_{n-1}) = \alpha_0 + (\sum_{i=0}^{n-2} f(0_0, 0_1, \ldots, 0_i, \alpha_1, \alpha_2, \ldots, \alpha_{n-1}) - f(0_0, 0_1, \ldots, 0_i, \alpha_0, \alpha_1, \ldots, \alpha_{n-i-1})) \quad (1)$$

Another interesting property is internal symmetry. But in order to grasp its meaning, first we need the concept of rule equivalence. The following explanations are valid for binary rules, although it is possible to generalise the notion to arbitrary k states.

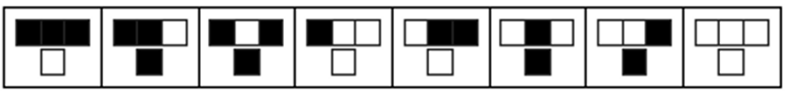


Fig. 2. Elementary CA 102, equivalent by reflection to elementary CA 60.

Given the rule table of a CA, there are three transformations that can be applied to it, such that the resulting rule table represents an equivalent rule to

the original CA: *reflection*, *conjugation* and *composition*. Reflection is the transformation obtained by mirroring the bits of the neighbourhoods in all neighbourhoods of the rule table, while preserving the same output. Conjugation is obtained by flipping all states of the cells of the rule table. Finally, by composition we mean the mathematical notion of composing conjugation and reflection, regardless of the order. Figure 2 illustrates the process; after applying the reflection transformation in elementary rule 60 we obtain the elementary CA 102.

The internal symmetry is defined by the number of state transitions that remains the same after a specific transformation has been applied. For example, the internal symmetry value by reflection of the elementary CA 60 is 4 because it shares the state transitions $((1,1,1),0)$, $((1,0,1),1)$, $((0,1,0),1)$ and $((0,0,0),0)$ with rule 102, its equivalent rule by reflection.

Finnaly, the colour blind property is directly related to transformation by conjugation, so that the colour blind rules are those with maximum internal symmetry by conjugation. Then, a CA is considered colour blind when it is invariant to the application of all state permutations in the states of transition table [9]. Naturally, there is generally $k!$ permutations, but only one in the binary case, which can be described as $\{0 \to 1,\ 1 \to 0\}$.

3 Templates

A template is a generalisation of the state transition tables of CAs by means of variables or functions. A template represents a set of CAs which share a given static property. Templates were created and implemented by De Oliveira and Verardo [5, 6] and are currently available in the open source library *CATemplates* [10] on GitHub.

Formally, a *template* is an n-tuple formed by k^{2r+1} items, wherein each item i represents a function $g_i(x_{k^{2r+1}-1}, x_{k^{2r+1}-2}, \ldots, x_1, x_0)$. By default, a template variable x_i can take on any state between 0 and $k-1$, but their values can be limited by the notation $x_i \in C$, in which C is a set representing the possible values of x_i.

As an example, the template of the elementary space $T_1 = (1, 1, 1, 1, 1 - x_1, x_2, x_1, 0)$ represents all rules that have state 0 at position 0 (always from right to left), state 1 at positions 4, 5, 6 and 7, any state in the interval $[0, k-1]$ at positions 1 and 2, and in position 3 the complementary state to the value of position 1. Therefore the template T_1 represents the set of elementary rules $\{248, 242, 252, 246\}$, that correspond in binary form, respectively to $\{(1,1,1,1,1,0,0,0), (1,1,1,1,1,0,0,1,0), (1,1,1,1,1,1,1,0,0), (1,1,1,1,1,0,1,1,0)\}$.

The process of finding all the rules represented by a template is called *expansion*. There are several generator algorithms of templates representing rules with certain property implemented in the library *CATemplates* [10].

The template $T_{comp} = (1 - x_0, 1 - x_4, 1 - x_2, x_4, 1 - x_1, x_2, x_1, x_0)$ of the elementary CAs, for example, when expanded generates only rules that have maximum internal symmetry by reflection and by conjugation. But the template

$T_{cb} = (1-x_0, 1-x_1, 1-x_2, 1-x_3, x_3, x_2, x_1, x_0)$ of the elementary CAs expands only to colour blind rules.

Besides the possibility of template expansion, De Oliveira and Verardo [5, 6] also developed an algorithm to generate templates that represent the intersection between two sub-spaces of rules represented by distinct templates. To illustrate, consider the search for a rule set composed by CAs that are both colour blind and have maximum internal symmetry by composition of reflection and conjugation. In order to find this rule set, two steps need to be performed: first one must match the two templates that represent the desired properties, thus forming an equation system defined by the template components. Them by solving the equation system, relationships are generated between the variables that, when applied to templates received as input, will result in the template representing the intersection.

For instance, consider the template T_{comp} representing rules with maximum symmetry by composition and the template T_{cb} representing colour blind rules. The first step towards the intersection between the two template is to equate them, which leads to the equation system represented by Eq. 2:

$$\begin{cases} 1-x_0 = 1-x_0 \\ 1-x_4 = 1-x_1 \\ 1-x_2 = 1-x_2 \\ \quad x_4 \quad = 1-x_3 \\ 1-x_1 = \quad x_3 \\ \quad x_2 \quad = \quad x_2 \\ \quad x_1 \quad = \quad x_1 \\ \quad x_0 \quad = \quad x_0 \end{cases} \tag{2}$$

Then, the system is solved yielding the solution set $S = \{x_3 = 1 - x1, x_4 = x_1\}$. This solution set is then applied as a set of replacements to the templates received as parameter. If the latter do not show variable constraints, the result of either replacements can be chosen, thus ending the process and resulting in the template $(1-x_0, 1-x_1, 1-x_2, x_1, 1-x_1, x_2, x_1, x_0)$; this template is the intersection of T_{comp} and T_{cb} and, therefore, represents all elementary rules that are colour blind and possess maximum symmetry by composition.

If at least one of the templates presents variables with restriction, a second step should be carried out. Therefore, the expressions that restrict the variables are extracted, generating a set that is then translated into a new equation system to be solved; the new solution set is then applied as a set of replacements in the templates passed as parameter.

Inspired by the intersection operation, here we introduce the operation of difference between templates.

4 Difference Between Templates and Exception Templates

The difference operation has two templates as input parameters, which we call $T_{minuend}$ and $T_{subtrahend}$. The operation's output results in a set of templates that represents all rules accounted for template $T_{minuend}$ but not by $T_{subtrahend}$.

The difference operation is a process with several steps. The first consists in the process of intersecting the two parameter templates, resulting in template T_{int}. If the intersection is null, the outcome of the difference is $T_{minuend}$ itself. Otherwise, it is matched to template $T_{minuend}$, thus generating logical combinations of equations. Then, the tautological equations, if any, are removed, and the remaining equations subjected to a negation operation, which in the binary case means the permutations $\rho = (0 \to 1, 1 \to 0)$. The existing occurrences of the logical operator $\wedge$ is then replaced by $\vee$ and the resulting system of equations solved, which results in a set of replacements in the variables of $T_{minuend}$. If the replacement set is empty or invalid (due to references to non existing rules in the space, as exemplified below), all rules pertaining to $T_{minuend}$ also belong to $T_{subtrahend}$ and, therefore, the process ends up with an empty set.

For a better appreciation of the process, consider the template that represents the colour blind rules $T_{cb} = (1 - x_0, 1 - x_1, 1 - x_2, 1 - x_3, x_3, x_2, x_1, x_0)$ and number conserving templates $T_{con} = (1, 1 + x_2 - x_3, 1 - x_2, 1 - x_1 - x_2, x_3, x_2, x_1, 0)$, both generated using the library *CATemplates*. The first step to find the difference from T_{cb} to T_{con} is to make the intersection between them, which results in $T_{int} = (1, 1 - x_1, 1 - x_2, 1 - x_1 - x_2, x_1 + x_2, x_2, x_1, 0)$. Since the intersection is not null, the next step is to equate T_{cb} with T_{int}, which generates the equation system represented by Eq. 3:

$$\begin{cases} 1 - x_0 = & 1 \\ 1 - x_1 = & 1 - x_1 \\ 1 - x_2 = & 1 - x_2 \\ 1 - x_3 = & 1 - x_1 - x_2 \\ x_3 = & x_1 + x_2 \\ x_2 = & x_2 \\ x_1 = & x_1 \\ x_0 = & 0 \end{cases} \tag{3}$$

However, this system must be represented by logical combinations of the equations, as shown in Eq. 4:

$$\begin{aligned} 1 - x_0 = 1 \wedge 1 - x_1 = 1 - x_1 \wedge 1 - x_2 = 1 - x_2 \wedge \\ 1 - x_3 = 1 - x_1 - x_2 \wedge x_3 = x_1 + x_2 \wedge x_2 = x_2 \wedge x_1 = x_1 \wedge x_0 = 0 \end{aligned} \tag{4}$$

All tautological equations are then eliminated, and the $\wedge$ symbol is replaced by $\vee$, resulting in the system shown in Eq. 5:

$$1 - x_0 = 1 \vee 1 - x_3 = 1 - x_1 - x_2 \vee x_3 = x_1 + x_2 \vee x_0 = 0 \tag{5}$$

The last step is to apply the negation operation to the equations; in the binary case, this means the swaps $0 \rightarrow 1$ and $1 \rightarrow 0$ or, equivalently, the application of function $f(x) = 1 - (x)$. Eq. 6 represents the logical combination of equations resulting from these operations.

$$1 - x_0 = 1 - 1 \vee 1 - x_3 = 1 - (1 - x_1 - x_2) \vee x_3 = 1 - (x_1 + x_2) \vee x_0 = 1 - 0 \tag{6}$$

The equations are solved, generating the solution set $S = \{\{x_0 \rightarrow 1\}, \{x_3 \rightarrow -x_1 - x_2 + 1\}\}$. As S has more than one item, both solutions must be used to make substitutions to the template $T_{cb} = (1 - x_0, 1 - x_1, 1 - x_2, 1 - x_3, x_3, x_2, x_1, x_0)$, finally yielding the set of templates $\{(0, 1 - x_1, 1 - x_2, 1 - x_3, x_3, x_2, x_1, 1), (1 - x_0, 1 - x_1, 1 - x_2, x_1 + x_2, 1 - x_1 - x_2, x_2, x_1, x_0)\}$

In many cases, only the steps described so far are sufficient to make the difference between both templates. But there are cases in which the template $T_{subtrahend}$, corresponding to T_{con} in the given example, has substitutions that lead to invalid rules. This situation occurs, for example, when expanding the template $(1, 1 - x_1, 1 - x_2, 1 - x_1 - x_2, x_1 + x_2, x_2, x_1, 0)$ by assigning the value 1 to the variables x_1 and x_2. This expansions yields 2 at position 3 (from right to left) of the template, which is outside of the range $[0, k - 1]$, corresponding therefore to a rule that is not part of the space at issue.

In order to circumvent this problem, it is necessary that, after the first steps of the difference operation, we also check for exception templates at the intersection of $T_{minuend}$ and $T_{subtrahend}$, that is, templates that represent substitutions that outside the range $[0, k - 1]$. For example, let us carry on with the difference operation between T_{cb} and T_{con}, and consider the template $T_{int} = (1, 1 - x_1, 1 - x_2, 1 - x_1 - x_2, x_1 + x_2, x_2, x_1, 0)$ the intersection between them, for $k = 2$.

The first step of the difference operation occurs normally and generates the templates:

$$\{(x_7, x_6, x_5, x_4, x_3, x_2, x_1, 1), (x_7, x_6, x_5, x_1 + x_2, x_3, x_2, x_1, x_0)\}$$

In this case, any expansion of T_{int} including the set of substitutions $\{x_1 = 1, x_2 = 1\}$ will cause the positions 3 and 4 of the template to display values that do not belong to the interval $[0, k - 1]$. Hence, all templates that have $\{x_1 = 1, x_2 = 1\}$ generate only rules not represented by the template T_{int}. So the difference operation will also generate the template $(x_7, x_6, x_5, x_4, x_3, 1, 1, x_0)$, which is the exception template of T_{int}.

Therefore every rule represented by the template $T_{minuend} - T_{cb}$ in the given example – and which is also represented by the exception template from the the intersection of $T_{minuend}$ and $T_{subtrahend} - T_{int}$ in this example – should be represented by at least one of the templates resulting from the difference operation. For this, the algorithm that finds the difference between templates considers all exception templates found, intersects them with $T_{minuend}$ and adds them to the set of templates obtained from the first steps of the difference operation. Thus, for the example discussed above, the resulting set of difference templates

is represented as:

$$\{(0, 1-x_1, 1-x_2, 1-x_3, x_3, x_2, x_1, 1),$$
$$(1-x_0, 1-x_1, 1-x_2, x_1+x_2, 1-x_1-x_2, x_2, x_1, x_0),$$
$$(1-x_0, 0, 0, 1-x_3, x_3, 1, 1, x_0)\}$$

One advantage of the difference operation between templates is that it allows for finding answers to various non-trivial questions, such as to determine which rules are number conserving but not colour blind, and at the same time, do not do not have maximum symmetry by composition. To answer the question it would suffice to take the template of conservative rules, and then subtract from it the intersection between the template of rules with maximum symmetry by composition and that of rules with colour blindness. In this particular case, the result is a set of templates that represent all the conservative rules except the identity rule.

It is worth noting that the set of templates returned may lead to a smaller search space than that embedded in template $T_{minuend}$, and that the operation is able to represent the difference between two templates without the need to perform the expansion. Subsequently the resulting templates can be used by other operations, and this is the main advantage of the operation. But all in all, it is also interesting to note that the whole process works as an automatic theorem proving capability concerning rule properties in a given CA space.

5 Final Remarks

By relying on the notion of templates of cellular automata as introduced by De Oliveira and Verardo [5, 6], here it was introduced the difference operation between templates as well as showed an approach to finding exception templates that provide a constraint on template expansion. Both operations are general enough to prove their value in many efforts towards finding CA rules in a large space, particularly in the classic problems of parity and density classification.

Also, we showed the possibility to obtain non-trivial answers to questions about searches for rules with certain static properties by means of templates, that prevents from relying on the use of search algorithms or enumerative methods.

It is noteworthy that the difference operation can generate a large number of templates, which may, in specific cases, not effectively reduce the search space. This is an issue we are currently addressing, by means of a technique for handling binary templates as Boolean algebraic expressions; initial experiments have clearly shown the effectiveness of the approach. Furthermore, since the difference operation is presently constrained for binary CAs, its generalisation to higher values of k is also under way.

Acknowledgements

The authors thank MackPesquisa, FAPESP and the federal agencies CAPES and CNPq, for different forms of support during the development of this work.

References

1. Wolfram, S.: A new kind of science. Volume 5. Wolfram media Champaign (2002)
2. Betel, H., De Oliveira, P.P.B., Flocchini, P.: Solving the parity problem in one-dimensional cellular automata. Natural Computing **12** (2013) 323–337
3. De Oliveira, P.P.B.: On density determination with cellular automata: Results, constructions and directions. Journal of Cellular Automata **9** (2014) 357–385
4. Wolz, D., De Oliveira, P.P.B.: Very effective evolutionary techniques for searching cellular automata rule spaces. J. Cellular Automata **3** (2008) 289–312
5. De Oliveira, P.P.B., Verardo, M.: Representing families of cellular automata rules. The Mathematica Journal **16** (2014)
6. De Oliveira, P.P.B., Verardo, M.: Template based representation of cellular automata rules. In Isokawa, T., Imai, K., Matsiu, N., Peper, F., Umeo, H., eds.: 20th International Workshop on Cellular Automata and Discrete Complex Systems, Himeji, Japão, Julho 7-9 (2014) 199–204
7. Wolfram, S.: Cellular automata and complexity: collected papers. Volume 1. Addison-Wesley Reading (1994)
8. Boccara, N., Fukś, H.: Number-conserving cellular automaton rules. Fundamenta Informaticae **52** (2002) 1–13
9. Salo, V., Törmä, I.: Color blind cellular automata. In: Cellular Automata and Discrete Complex Systems. Springer (2013) 139–154
10. Verardo, M., De Oliveira, P.P.B.: CATemplates. (2015) https://github.com/mverardo/CATemplates.

Design and Evaluation of a Personalized Cancer Treatment System using Human-Computer Interaction Techniques

Alexandra Martinez[1], Rodrigo Mora[2], Gustavo López[3], Constantino Bolaños[3], Daniel Alvarado,[3] Andrés Solano[3], Mariana López[3], Steve Quirós[2], and Andrés Báez[4]

[1] Escuela de Ciencias de la Computación e Informática, Universidad de Costa Rica, San José, Costa Rica
[2] Centro de Investigación en Enfermedades Tropicales, Facultad de Microbiologa, Universidad de Costa Rica, San José, Costa Rica
[3] Centro de Investigaciones en Tecnologías de la Información y Comunicación, Universidad de Costa Rica, San José, Costa Rica
[4] Hospital Rafael Ángel Calderón Guardia, San José, Costa Rica
{alexandra.martinez, rodrigo.morarodriguez, gustavo.lopez_h, constantino.bolaños, daniel.alvarado_g, andres.solanoportuguez, mariana.lopez, steve.quiros}@ucr.ac.cr, fabaeza@ccss.sa.cr

Abstract. This paper presents a case study where Human-Computer Interaction techniques were applied in the design and evaluation of a health system. The system consisted of a software platform that supports personalized cancer chemotherapy based on a tumor chemosensitivity assay. The essential background on personalized cancer treatment is provided. The system was designed using "contextual design," a user-centered technique that involves contextual inquiry, interpretation, work modeling, consolidation, visioning, storyboarding and paper prototyping. The most salient products from the design phase and details of the system implementation are shown. The system was assessed using the Heuristic Evaluation method, which is a usability inspection performed by experts. Results from this evaluation indicate that only one of ten heuristics was missing from the system, while five were partially covered and four were fully covered.

Keywords: Contextual design; heuristic evaluation; HCI techniques; personalized cancer treatment; ATP tumor chemosensitivity assay.

1 Introduction

Cancer is among the top causes of death in developed and many developing countries, including Costa Rica. Chemotherapy resistance (a phenomenon that results when cancer cells become tolerant to chemotherapy drugs) is the main barrier towards an effective cancer treatment because the choice of the 'right therapy' is hampered by cancer biological robustness and patient-to-patient variability.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_67

Therefore, we aim for personalized cancer treatment, whose goal is to overcome resistance by identifying the most effective chemotherapeutic drug for a patient's tumor, prior to treatment.

The Research Institute on Tropical Diseases at the University of Costa Rica decided to implement the clinical application of the ATP (adenosine triphosphate) Tumor Chemosensitivity Assay, an in vitro assay that chooses the best therapeutic option for a patient, thus giving birth to a cancer laboratory. This laboratory needed a software system to support the personalized cancer treatment process based on the ATP assay. It was anticipated that the system would be hard to model due to its complexity and the multiple tasks and interactions involved among its users. Hence, we resorted to Human-Computer Interaction (HCI) techniques to design of the system. To be consistent with a user-centered design technique, we evaluated the system with a usability inspection method.

This study presents the application of two HCI techniques, *contextual design* and *heuristic evaluation*, in the design and evaluation of a system that supports personalized cancer chemotherapy at our cancer laboratory. The system consists of a software platform with two main components: a mobile application for the cancer lab staff and a web application for the oncologists requesting the assays (one for each core user group). The system supports the entire process, from the assay request by the oncologist, passing through the different assay stages, to results report and patient follow-up of the the oncologist on the clinical response.

The rest of the paper is organized as follows. Section 2 presents background in personalized cancer treatment, user-centered design and usability evaluation methods. Section 3 describes the design, implementation and evaluation of the system. Section 4 states our conclusions.

2 Background

In this section we provide some background on personalized cancer treatment and the particular tumor chemosensitivity assay supported. We also offer some background on the Human-Computer Interaction techniques that were used for this case study: contextual design and heuristic evaluation.

2.1 Personalized Cancer Treatment

The therapeutics of most cancers includes the use of chemotherapeutic drugs, which are highly toxic and produce severe side effects. Chemotherapeutic drugs are applied in reduced doses to reduce collateral damage to the patient; however, reduced doses often leave residual cancer cells that may cause tumor relapse. Cancer therapeutics are therefore limited by the tumor's resistance to chemotherapy, which is the major obstacle for effective patient treatment [7]. In traditional clinical practice, resistance is detected during treatment (i.e., the patient is using the prescribed drugs and they are not working) [5]. The problem is that once a tumor is resistant to a chemotherapy, it very often becomes resistant to multiple chemotherapeutic agents. It is therefore important to start with

the chemotherapeutic drug that has the maximum probability to reduce tumor robustness. Prescribing suboptimal drugs to a cancer patient will lower her life quality and chances of survival (due to the induced multidrug resistance).

In addition, highly specific drugs have been developed for certain cancer molecules, with proven effectiveness only on a reduced group of people (not the whole population). Some of these drugs have reached clinical application and are being included in standard protocols. However, the cost of these protocols is higher than that of traditional treatments.

Therefore, availability of laboratory tests to identify patients' resistance is highly desirable as it enables recognition of patients who may benefit of each treatment, thus preventing ineffective drug therapy and its associated side effects. Furthermore, such laboratory tests could reduce the overall costs of chemotherapy by determining whom should be given the new and expensive protocols. Hence, this early diagnosis of resistance enables optimized and individualized therapy for cancer patients [7, 8]. Early diagnosis of resistance is achieved by combining clinical, pathological and molecular markers, and complementary in-vitro chemosensitivity tests.

2.2 The ATP Tumor Chemosensitivity Assay

The ATP Tumor Chemosensitivity Assay (ATP-TCA) is used to determine the efficacy of chemotherapeutic drugs in inhibiting tumor cell growth in vitro. To date, ATP-TCA is the only in vitro chemosensitivity assay for tumors, and has a predictive value of 93% for sensitivity (i.e., tumor's positive clinical response) and close to 100% for resistance (i.e., tumor's clinical nonresponse) [6]. In comparison, a bacterial antibiogram, which is routinely used in hospitals to predict bacteria's resistance to antibiotics, has a predictive value of 90% for sensitivity, but only 35% for resistance [2].

The ATP-based assay has been developed to overcome technical limitations exhibited by other techniques, such as low evaluability rates, low degree of standardization and reproducibility, low technical strength and poor methodological effectiveness. This assay has gained merits as a chemosensitivity test in tumors, having over 80 scientific publications that include 30 retrospective and prospective clinical trials on different cancer types. It has been reported to increase tumor response rates and prolong survival times [6], and is particularly useful when there are many alternative treatment protocols (as in breast cancer). It has also been used to screen for new chemotherapeutic regimens to treat breast, ovarian and melanoma cancers [6].

In summary, the ATP-TCA assay is a valuable tool for oncologists, who can choose what therapeutic options to test in vitro before medicating the patient. It may be considered the assay with best documented and validated technology. It also has various technical advantages over the rest, namely, it is highly reproducible, easy to manage as a kit, has low technical failure rates, and high sensitive and methodological effectiveness [6].

2.3 Human-Computer Interaction Techniques

Contextual Design Contextual design is a user-centered design approach for software systems and products [3]. The contextual design process guides the design team in understanding and redesigning customers' work, in order to define computer systems that support them [1]. Contextual design encompasses seven steps: contextual inquiry, interpretation sessions, work modeling, consolidation, visioning, storyboarding and paper prototyping [3]. *Contextual Inquiry* is a field data gathering technique that allows designers to observe how users work, communicate, and behave during their daily activities. *Interpretation Sessions* create a shared understanding within a cross-functional team, by analyzing data and capturing key issues from contextual interviews. *Work modeling* captures the structure of users' practice from different viewpoints that are relevant for the design. There are five types of work models: 1) *sequence model*, which shows the steps required to perform a task, in order; 2) *flow model*, which describes people's communication, coordination, roles and responsibilities within a work practice; 3) *cultural model*, which describes how the culture and policy influence users' work; 4) *physical model*, which depicts the layout of the environment in which the work is performed, and the limitations it imposes on design; and 5) *artifact model*, which represents physical or virtual things used to support a work practice. *Consolidation* unifies data from individual user interviews into an affinity diagram to reveal common patterns in the work structure and variations to it. *Visioning* helps the teams have a clear picture of how their solution will fit into the whole practice, and how the product or system will impact the users' work. *Storyboarding* specifies the details of the vision, showing what happens when people interact with the new system [3]. *Paper prototyping* are rough mock-ups of the system used to test the solution's design with the users. (Refining the design with users gives designers a customer-centered way to resolve disagreements.)

Heuristic Evaluation The heuristic evaluation is a usability inspection method based on a list of recognized usability principles (so called heuristics). A small group of evaluators inspect the system interface in an unstructured way, looking for usability problems (heuristic violations). The most common usability heuristics are the Nielsen's ten principles for interaction design [9]: 1) visibility of system status, 2) match between system and the real world, 3) user control and freedom, 4) consistency and standards, 5) error prevention, 6) recognition rather than recall, 7) flexibility and efficiency of use, 8) aesthetic and minimalist design, 9) help users recognize, diagnose and recover from errors, and 10) help and documentation. This method is valuable when time and resources are limited, since skilled experts can detect usability problems in short time with no need of end-users. Its weakness is that it tends to reveal only low-severity general interface problems, but no high-severity problems [10, 4]. Heuristic evaluation has been used to assess the usability of health systems [4].

3 System Design, Implementation and Evaluation

3.1 System Design

For designing the system that supports the personalized cancer treatment based on the ATP assay protocol, we used contextual design. Specifically, we followed the contextual inquiry, interpretation, work modeling, vision, and prototyping steps. In the work modeling phase, we decided to combine the sequence and flow models into a single model, and skip the cultural model since we did not deem it essential for the design. Our users were microbiologists from the cancer lab (second and eighth authors) and the hospital (ninth author). Due to space limitations, we present only the most relevant products from contextual design.

Fig. 1 shows the joint *sequence* and *flow model*. It represents the interaction, steps, roles, and responsibilities of the people involved in the assay and follow-up process. This is the main flow of the work practice. Other flows involving maintenance activities, users registration and authorization, and others, are excluded from Fig. 1, but were nonetheless considered when designing and implementating the system. The main roles in our flow model and their main responsabilities are the following:

Oncologist (O) Requests assays (comprising the selection of treatments to be tested), chooses the patients treatments, and performs patient follow-ups.
Microbiologist (M) Approves service requests from oncologists, assesses whether the specimen is adequate to perform the assay (after dissociation), supervises the entire assay process, verifies the correctness of assay results, analyzes and reports the results back to the oncologist.
Technician (T) Prepares specimens for assay, prepares and performs assays, and records data during the execution of the assays.
Pharmacist (H) Administers treatments to the patients.
Patient (P) Access her assay results and personal information.

The *physical model* of the cancer lab environment is shown in Fig. 2. Notably, lab staff needs to move around the lab space to perform different activities such as measuring, preparing, monitoring and analyzing.

Even though we did not make a graphical representation of the *artifact model*, artifacts were collected. The physical artifacts identified were the patient medical record (including pathology report and pharmacy information regarding treatments administered to patients), the specimen to perform the assay on, and the instruments and equipment needed for the ATP assay. Fig. 3 shows one of the stations where specimen is prepared for the assay, with associated equipment. We also identified two virtual artifacts (digital documents): the 'ATP Tumor Chemosensitivity Assay - Instructions for Use' and the 'Clinical Practice Guidelines for the Treatment of Breast Cancer'.

The *vision* was to develop a software platform that facilitated collection, storage, management, and communication of ATP-TCA assays data. We focused on two key user groups (customer population) that are core actors of the work practice, and thus, will benefit the most from a support platform: cancer lab

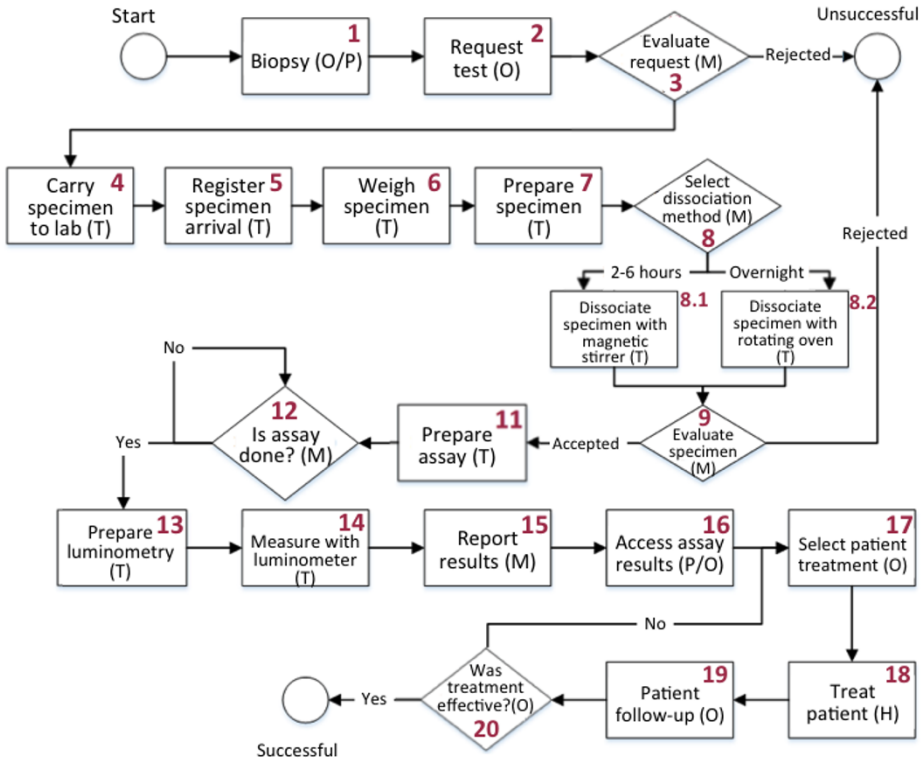


Fig. 1. Joint sequence and flow model.

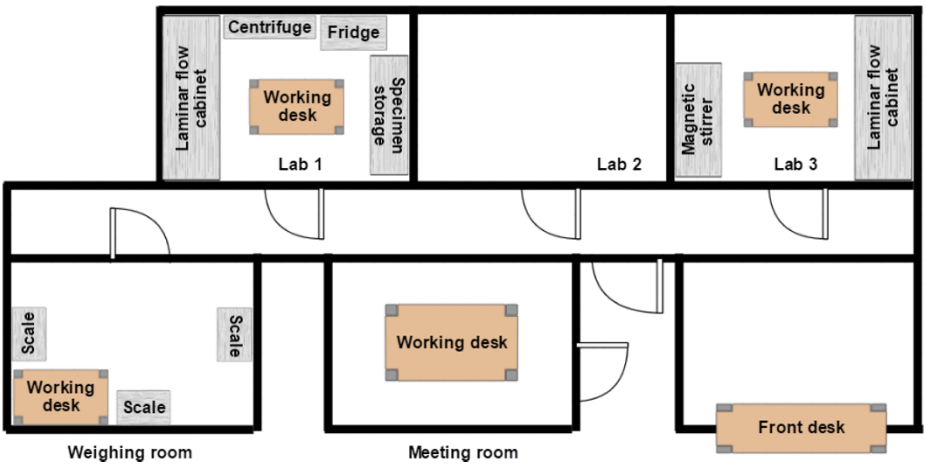


Fig. 2. Physical model.

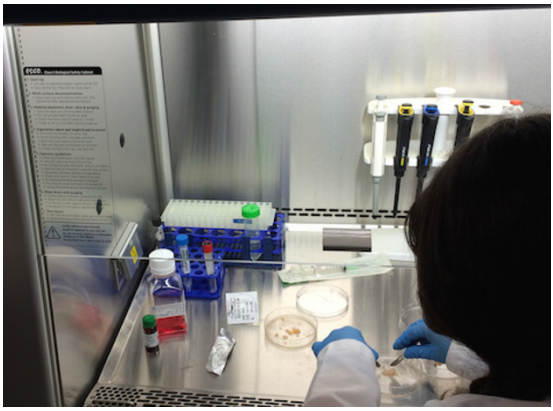


Fig. 3. Some artifacts used during specimen preparation at cancer lab.

staff and oncologists (or hospital personnel requesting the assays). Hence, the envisioned software platform consists of two main components:

1. A mobile application that enable cancer lab staff to easily manage and track patients' data, as well as to maintain operational information such as available drugs, tumor types, hospitals, etc. Here, cancer lab staff includes the microbiologist and technician roles specified in the flow model. Mobility of the solution is an important feature in this context due to the frequent displacement of the staff (see description of the physical model), hence the idea of developing an *app* for a tablet that lab staff can carry around.
2. A web application whereby oncologists can request assays for their patients, see assays results when they are ready, and report patients' clinical response to actual treatment (follow-ups). Key features of the solution are ease of use and agility, since oncologists are always busy and cannot afford much time on the system.

There were also the pharmacist's and patient's components, but we did not give them much relevance since they were not deemed core and we did not have access to representatives of those groups.

Paper prototyping was made with wireframes, developed by a user-experience design expert, who collaborated with the technical team (seventh author). Wireframes were created for the interfaces needed by cancer lab staff and oncologists. A sample wireframe is shown in Fig. 4 (the system language is Spanish as it is intenteded to be used in Costa Rica). Two iterations of wireframe design and validation (with users) were made before the system was implemented.

3.2 System Implementation

The system was implemented by a technical team (authors with affiliation 1 and 3) consisting of a lead, a database developer, front-end developers and programmers. It was developed in .NET and MySQL database. The software architecture

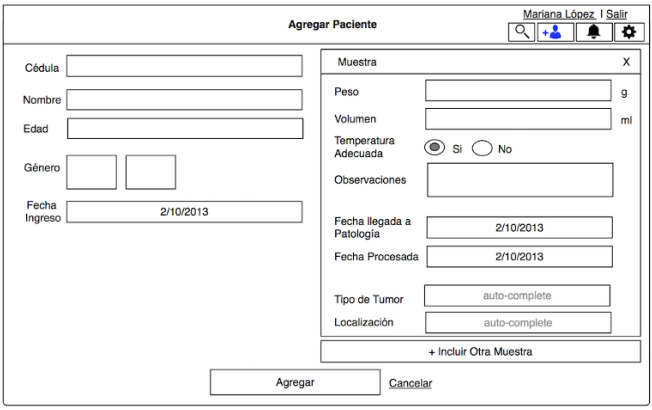


Fig. 4. Sample wireframe.

consisted of three layers: a front-end, a back-end, and a web services layer that allows communication between the other two. Web services were used to allow transparent changes in the back-end model. For the cancer lab component, we chose a web application rather than a native mobile app mainly for portability and flexibility reasons, since not all staff members used the same mobile devices. This web application was optimized for a 10″ tablet.

The implemented system supports the sequence and flow model at various points. It includes interfaces for all the roles described in the model. Fig. 5 shows the correspondence between the implemented interfaces and the joint sequence and flow model from Fig. 1. In particular, interface 2 allows oncologists to request assays (service provided by the cancer lab); interface 3 allows microbiologists to evaluate requests and mark them as approved or rejected; interface 5 allows microbiologists to search for patients with pending specimens and register the specimen arrival; interface 6 allows technicians to add information about the specimen (this corresponds to the wireframe in Fig. 4); interface 7 allows technicians to add information from specimen processing; interface 11 allows technicians to prepare and initiate the assay protocol (also called chemosensitivity); interface 15 allows microbiologists to load, analyze, and report assay results; interface 16 allows both oncologists and patients to access assay results; interface 18 allows pharmacists to add information regarding treatments given to patients; and interface 19 allows oncologists to add information related to patients follow-ups.

3.3 System Evaluation

The system was evaluated using the heuristic evaluation method. An HCI expert (third author) gave a rating for each of the Nielsen's usability heuristics [9], using a 3-point scale (pending, partial coverage, and total coverage) and wrote comments to justify his ratings. This expert was chosen from the HCI research

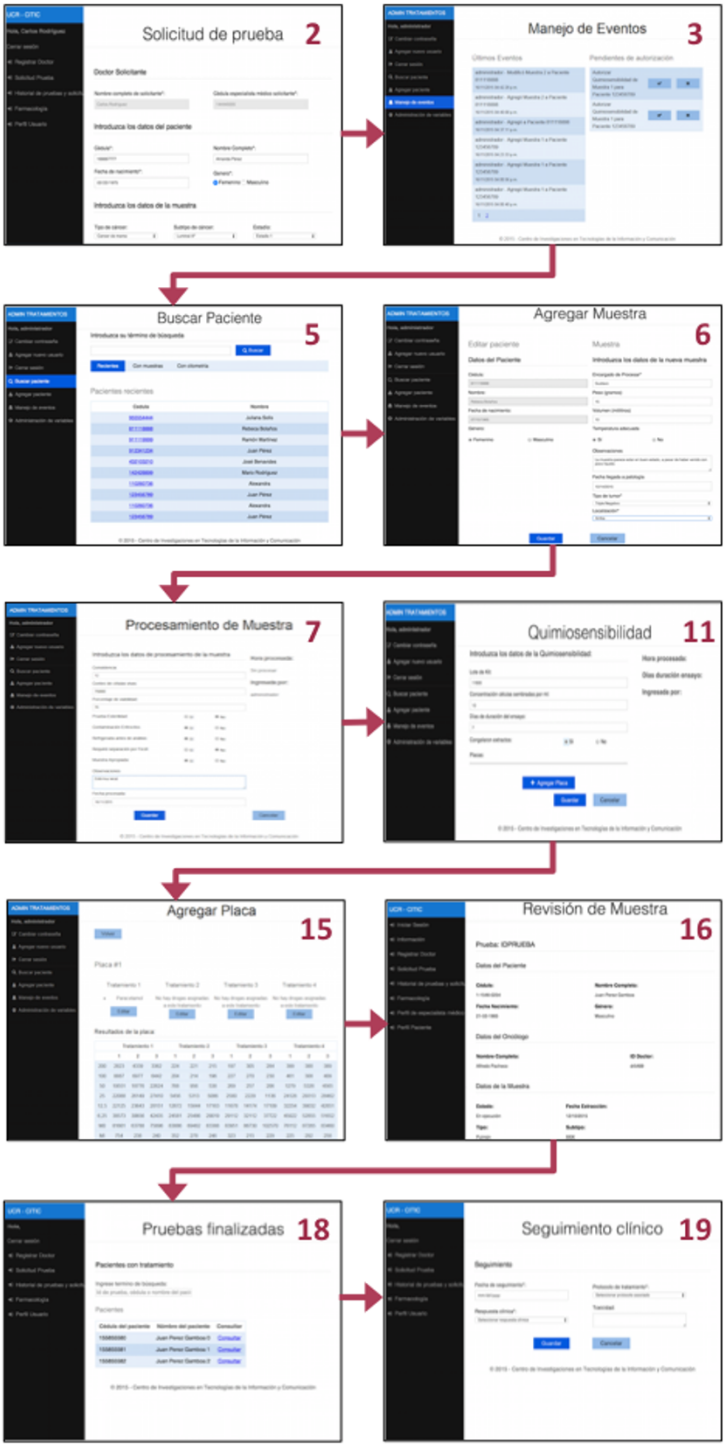


Fig. 5. Interfaces for the joint sequence and flow model.

group at our university, as he had worked on several HCI-related projects, performing similar evaluations. Table 1 shows the results of the heuristic evaluation. We observe from the table that four of the ten heuristics were totally covered by the implemented system, five were partially covered and only one was not covered at all. Expert's comments on the 'Help and documentation' heuristic (rated as pending') were that there were no tooltips explaining the different fields or actions, and there was no help documentation for the users. We believe it is possible to fix this usability problem in a future version of the system, as it does not affect the code logic. Regarding the heuristics rated as 'partial', one of them is easy to fix (an 'id' should match real world numbering), one cannot be fixed since it is actually a feature (users cannot undo certain actions, thus having limited control and flexibility), and the other two involve several small fixes that will require some effort (validating dates and other data, placing some buttons on a better place, making messages more visible and icons more consistent).

Table 1. Results from the heuristic evaluation.

Heuristic	Pending	Partial	Total
1. Visibility of system status			X
2. Match between system and the real world		X	
3. User control and freedom		X	
4. Consistency and standards		X	
5. Error prevention		X	
6. Recognition rather than recall			X
7. Flexibility and efficiency of use			X
8. Aesthetic and minimalist design			X
9. Help users recognize, diagnose, and recover from errors		X	
10. Help and documentation	X		

4 Conclusion

We examined the application of two Human-Computer Interaction techniques in the design and evaluation of a system in the health domain: contextual design and heuristic evaluation. The former drove the design process through the following steps: contextual inquiry, interpretation, work modeling, visioning, and paper prototyping. Then, the system was implemented using conventional techniques (3-layer web application). Finally, in a heuristic evaluation, an HCI expert rated each of the Nielsen's usability heuristics on a 3-point scale, indicating total, partial o no coverage.

The system from this case study was a software platform for the support of personalized cancer treatment. The platform comprised a mobile application for the cancer lab staff and a web application for the oncologists requesting assays.

The most salient products from the application of both HCI techniques were provided. In particular, we explained the joint sequence-and-flow model and its

the main roles: the oncologist, the microbiologist, the technician, the pharmacist, and the patient. The physical model was also illustrated, and the artifact model was described. The vision was explained, and an example of the paper prototyping was offered. On the other hand, results from the heuristic evaluation indicated that only one of the ten heuristics was missing from the system, while the other nine were either totally or partially covered.

We found that the contextual design technique largely contributed to have a shared understanding of the users' work practices across the team. During the design process, the designers, developers, and team leader learned the domain terminology, tasks, and key aspects. Arriving to the sequence and flow model was a hard process that required several iterations, but having a clear picture of the main flow was important so that everybody involved in the design or development of the system would understand how each part fits and interacts with each other. The physical model gave us clues about the importance of mobility for the cancer lab staff, hereby driving the idea of using tablets. Paper prototyping was very useful to test evolving solutions with the users, and gathering rapid feedback before implementation.

References

1. Beyer, H., Holtzblatt, K.: Contextual design. interactions 6(1), 32–42 (Jan 1999)
2. Doern, Gary V., .B.S.M.: The clinical predictive value (or lack thereof) of the results of in vitro antimicrobial susceptibility tests. Journal of Clinical Microbiology 49, S11–S14 (2011)
3. Jacko, J.A.: The Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, 3rd ed. CRC Press (2012)
4. Jaspers, M.W.M.: A comparison of usability methods for testing interactive health technologies: Methodological aspects and empirical evidence. International journal of medical informatics 78(5), 340–353 (2009)
5. Kitano, H.: Cancer as a robust system: implications for anticancer therapy. Nat Rev Cancer 4(3), 227–235 (03 2004)
6. Kurbacher, C.M., Cree, I.A.: Chemosensitivity testing using microplate adenosine triphosphate-based luminescence measurements. Methods Mol Med 110, 101–120 (2005)
7. Lippert, T.H., Ruoff, H.J., Volm, M.: Intrinsic and acquired drug resistance in malignant tumors. the main reason for therapeutic failure. Arzneimittelforschung 58(6), 261–264 (2008)
8. Lippert, T.H., Ruoff, H.J., Volm, M.: Intrinsic and acquired drug resistance in malignant tumors. the main reason for therapeutic failure. Arzneimittelforschung 58(6), 261–264 (2008)
9. Nielsen, J., Molich, R.: Heuristic evaluation of user interfaces. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems. pp. 249–256. CHI '90, ACM, New York, NY, USA (1990)
10. Yen, P.Y., Bakken, S.: A comparison of usability evaluation methods: Heuristic evaluation versus end-user think-aloud protocol –an example from a web-based communication tool for nurse scheduling. AMIA Annual Symposium Proceedings 2009, 714–718 (2009)

Part IV
Software Systems, Architectures, Applications and Tools

3D markerless motion capture: a low cost approach

Yves Rybarczyk[1,2]

[1] UNINOVA, DEE, FCT, Universidade NOVA de Lisboa,
Quinta da Torre, 2829-516 Monte de Caparica, Portugal
[2] MIST, Universidad Tecnológica Indoamérica,
Machala y Sabanilla, 170103 Quito, Ecuador
yr@uninova.pt

Abstract. A markerless motion capture technique is described for reconstructing three-dimensional biological motion. In the first stage of the process, an action is recorded with 2 CCD webcams. Then, the video is divided in frames. For each frame, the 2D coordinates of key locations (body joints) are extracted by the combination of manual identification (mouse pointing) and image processing (blobs matching). Finally, an algorithm computes the X-Y coordinates from each camera view to generate a file containing the 3D coordinates of every visible point in the display. This technique has many advantages over other methods. It does not require too specialized equipment. The computer programming uses open source software. The technology is based on an inexpensive portable device. Moreover, it can be used for different environments (indoor/outdoor) and living beings (human/animal). This system has already been tested in a wide range of applications, such as avatars modeling and psychophysical studies.

Keywords: Image processing, 3D reconstruction, biological motion.

1 Introduction

Motion capture is used in a wide range of areas, from the entertainment industry (e.g., tridimensional animation) [1, 2] to scientific studies, such as biological motion analysis [3, 4]. However, this is usually an expensive and complex technology, which is not affordable for all research groups. Moreover, the capture devices work only in very controlled conditions. In case of entertainment, a popular tool more and more used in gaming is the Kinect device from Microsoft [5]. Although this technology is relatively cheap, it does not provide high spatial and temporal resolutions, which limit its use for research purposes [13]. In addition, it is based on infrared rays and, consequently, it can only be used in indoor environments. Nowadays, a motion capture that enables a precise analysis of movements requires high cost professional tools, such as the Vicon system [6]. This kind of technology is based on markers positioned on the individual body, in order to increase the precision. In several cases the use of markers cannot be applied because of constraints regarding the subject (e.g., an animal) or the setting (e.g., recording the movement in a natural environment). The purpose of this article is to propose a technological alternative to

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_68

carry out a tridimensional capture from low-cost materials (2 CCD webcams) and without any marker. The technique is based on the combination of two motion capture methods: i) manual selection of key features in the image [7] and ii) 3D reconstruction of motion from two bidimensional planes [8]. The first part of the article describes the hardware configuration of the cameras. The second part explains the computational method applied. Finally, the last section shows the results obtained, which are discussed in the conclusion.

2 Hardware Configuration

The video capture is carried out by two CCD webcams that permit a stereoscopic reconstruction of the scene through two different viewpoints (Fig. 1). In this configuration, a common feature on the two camera views has different coordinates in the camera images. From this disparity, the tridimensional coordinates of the feature can be calculated following three stages:

- Feature extractions (e.g., the body joints);
- Matching of the similar points in the two images (= stereo-corresponding points);
- Calculation of the 3D coordinates of the points from the disparity obtained in the previous stage.

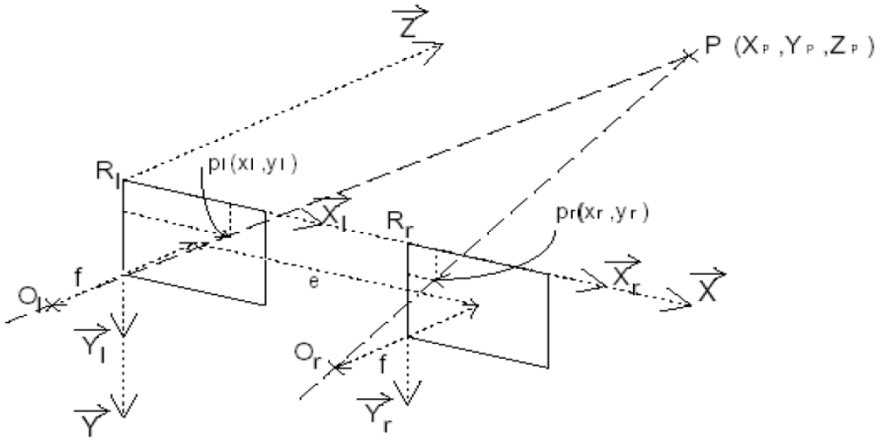


Fig. 1. Configuration of the two CCD webcams (R_l *and* R_r). This design is based on the study carried out by [9].

Here, the two camera device is designed in order to simplify the calculation of the 3D coordinates of the stereo-corresponding points, thanks to two properties:

- The optical camera axes are parallels;
- The junction line between the two optical camera axes is horizontal.

In this configuration, the disparity only exists following the horizontal axis of the camera images.

3 Computational Method

3.1 Video Capture and Frame-by-Frame Segmentation

The video capture is carried out at a frame rate of 30 frames per second. The image size is 640x480 px. The example demonstrated in the article is a "sit-down / stand-up" movement. Fig. 2 shows a decomposition of the action for five main steps of the movement, which are: stand-up, almost sit, sit, almost up, stand up again. This action was chosen because it is complex and identifiable enough to evaluate the reliability of the system. Once the video is recorded it is divided in several frames, which are processed in the next stage of the method.

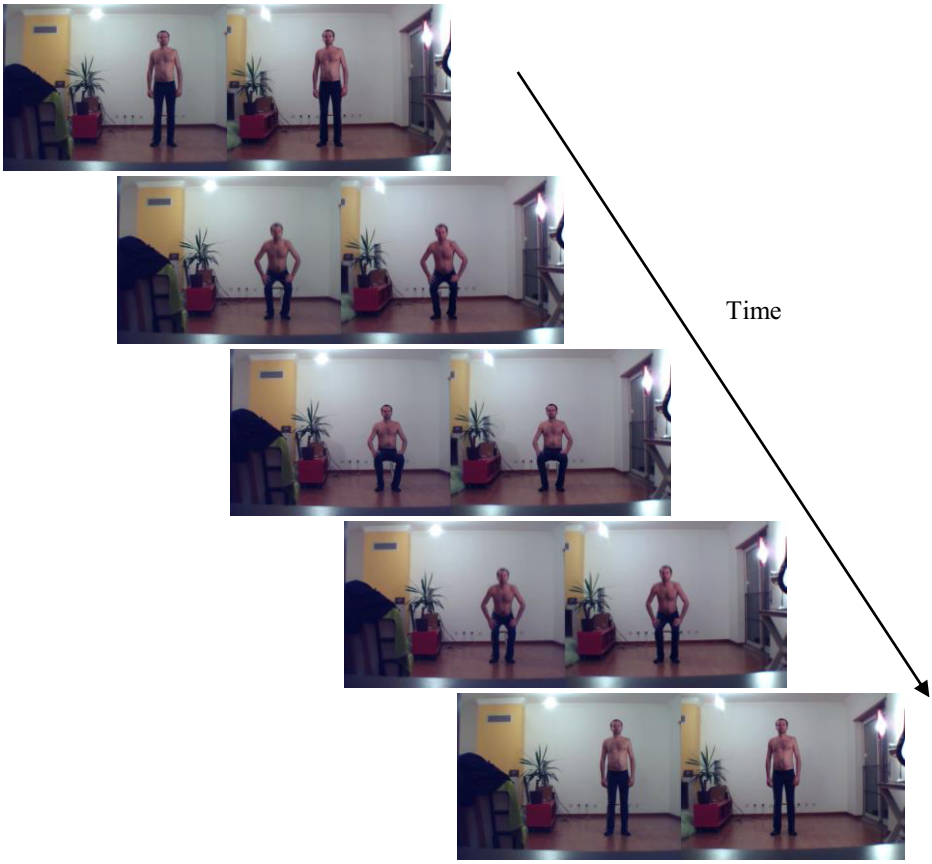


Fig. 2. Five of the main frames of the example movement used to test the system: "sit-down / stand-up" action. In each picture, the left part correspond to the image captured by the left camera (R_l) and the right part is captured by the right camera (R_r).

3.2 Background Subtraction

The first part of the processing consists in subtracting the complete image (individual + background) from the image of the background only, in order to isolate only the relevant features that have to be processed (Fig. 3). The background removal is carried out through the algorithm as follows [10]:

- Memorize the background image;
- Check every pixel in the frame. If it is different from the corresponding pixel in the background image, it is a foreground pixel. If not, it is a background pixel.

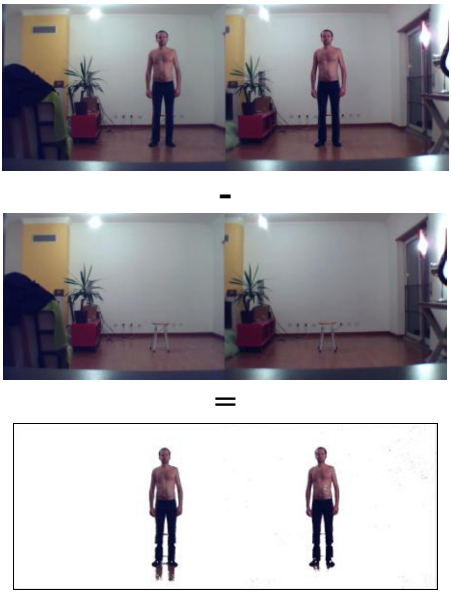


Fig. 3. Description of the principle of background removal. The image that includes the individual is subtracted from the background image. The result is a picture with the individual only.

3.3 Selection of Key Locations

Manual process: temporal tracking. To select a location, the user must click the mouse at each desired body joint in the left camera view. X-Y locations (in image coordinates) are recorded through a program in Java/Processing. The bidimensional coordinates of 13 (or 15) joints are listed into a file, in the following order: 1. head, 2. R shoulder, 3. R elbow, 4. R wrist, 5. R hip, 6. L shoulder, 7. L elbow, 8. L wrist, 9. L hip, 10. R knee, 11. R ankle, 12. L knee, 13. L ankle, 14. sternum, 15. navel. 40x40 px blobs (green squares in Fig. 4) are extracted around each click location to be used for the 2nd stage of the process.

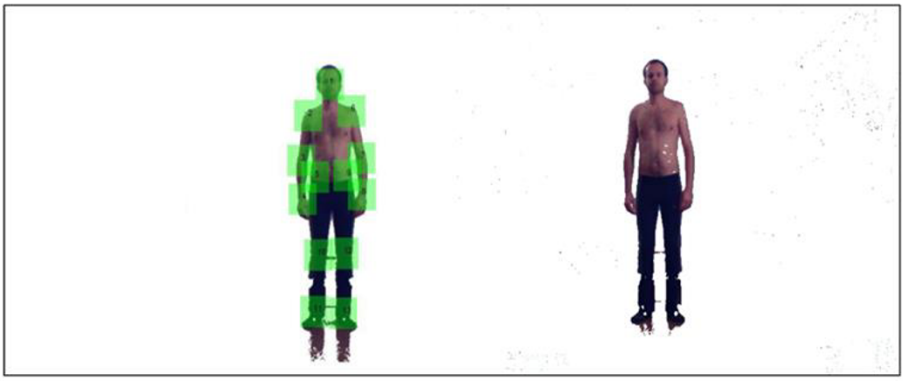


Fig. 4. In the first step of the image processing, the key features (here, the individual joints) from the left view are manually selected (green squares). Each joint is identified with a specific number.

Automatic process: spatial matching. Contrary to the previous stage, this one is based on an autonomous algorithm of image processing. A black and white filter is applied on each extracted blob to facilitate the blob matching. The program searches for the 40x40 px blob, in the right camera view, having the most identical pixel colors as the left side blob (Fig. 5). Since the two optical camera axes are horizontals, the blob to be matched is necessarily located on the same Y coordinate. The stereo-corresponding points are recorded into a right view coordinate file, following the same order as in the manual process. Then, the 2D coordinates of each viewpoint (right and left) are used for the 3rd step of the process.

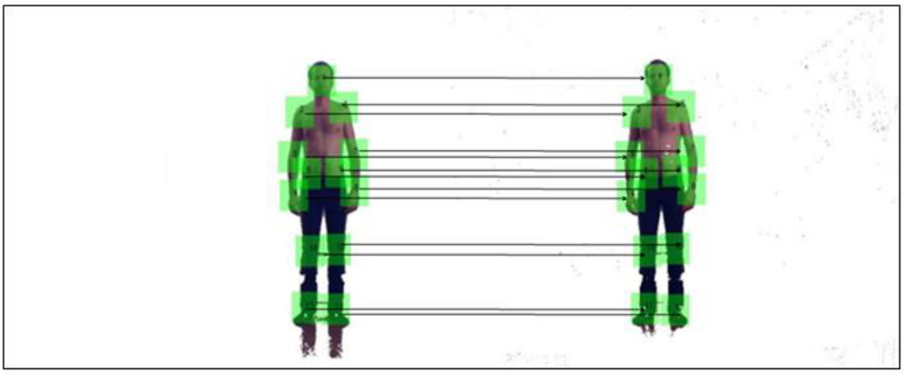


Fig. 5. In the second step, each joint from the left view is automatically matched with its pair on the right view. A same ID number, for right and left images, is applied for a determined joint (e.g., 1 for the head, 2 for the right shoulder…) in order to facilitate the calculation of the 3D coordinates from the two 2D coordinates.

3.4 3D Coordinates Calculation

The calculation of tridimensional coordinates of each key point in the image is carried out from the two 2D coordinates of a same joint in the bidimensional video frames. The equations used for the computation are as follows:

$$X_p = x_1.e / p_x.\delta \ . \quad (1)$$

$$Y_p = y_1.e / p_x.\delta \ . \quad (2)$$

$$Z_p = f.e / p_x.\delta \ . \quad (3)$$

Here is the description of each parameter of the equations presented above:

- (X_p, Y_p, Z_p) = coordinates of the P body point;
- (x_l, y_l) = coordinates of the left camera image of the P point;
- (x_r, y_r) = coordinates of the right camera image of the P point;
- e = distance between the 2 optical centers;
- p_x = horizontal pixel pitch of the CCD sensors;
- f = focal distance of the cameras;
- δ = horizontal disparity between the 2 stereo-corresponding points (x_l - x_r).

3.5 Data Processing

Normalization. The data normalization consists of moving the body's barycenter to the origin of the 3D axes. It permits a control of the effects applied to the avatar, such as a linear translation, Y-rotation…

Filtering. The data are filtered to make the movement smoother. The process consists of calculating the average of the coordinates of a same joint in two successive frames. A significant increase in the quality of the animation is obtained after these successive operations on the row data.

4 Results

The method used to select and match each identical feature between the two different viewpoints lead to a 100% of correct identifications. It means that the algorithm implemented enables us to match perfectly each joint in the two different camera views. After computation of the equations (1), (2) and (3) to calculate the tridimensional coordinates of each joint, a program was implemented to display the final result. Fig. 6 shows the outcome in the form of a stick-based representation of the "sit-down / stand-up" action.

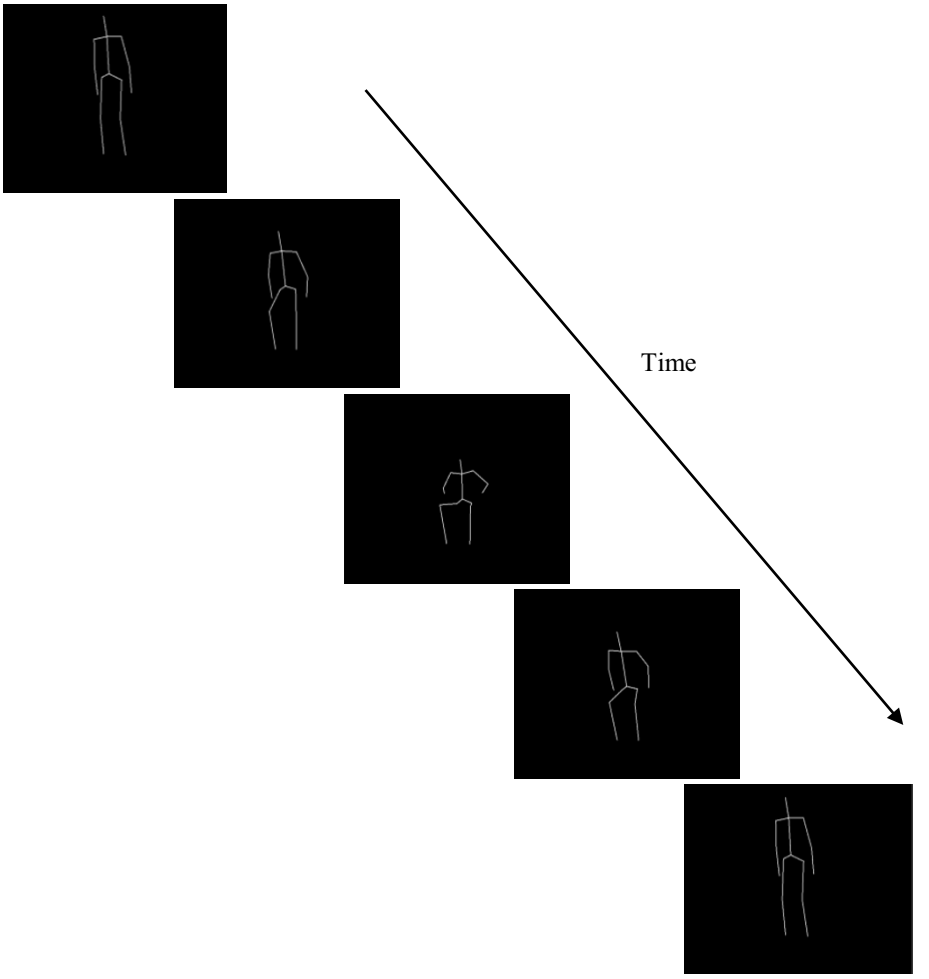


Fig. 6. Stick-based display of the video resulting from the 3D calculation of the individual joints for the "sit-down / stand-up" action. As it can be noticed the outcome is perfectly similar to the movement recorded with the two low-cost cameras.

5 Conclusions and Future Work

This project has shown that an affordable technology, based on computer vision, can be an alternative means of tridimensional motion reconstruction, when a commercial system (e.g., Vicon, Kinect…) cannot be applied, because the conditions prohibit the use of reflective markers and/or the action has to be recorded in an outdoor environment. For now, the manual selection process limits the precision of joint localization and requires a human operator. To ensure a complete automation of the joint selections, the future step will be to associate the image processing with a model

of the individual body to decrease the error risks and to achieve higher localization accuracy [11, 12, 14]. Nevertheless, the good results obtained with the current system show that it can be a useful tool for applications in several areas. In psychophysics, it can be applied to the modeling of biological motion in order to create avatars, such as point-light displays (e.g., point-light-walkers), which are used for visual perception studies or simply in animations. In health, it can allow a tridimensional analysis of the motion in a clinical context (e.g., comparison of movement smoothness before and after a cerebral surgery or medication in parkinsonic patients). Finally, in sport, it can be used to record the body movements in natural conditions (indoor/outdoor) to be observed and analyzed, in order to improve the athlete's posture and motor skills.

References

1. Heloir, A., Neff, M.: Exploiting Motion Capture for Virtual Human Animation: Data Collection and Annotation Visualization. In: Workshop on Multimodal Corpora - Advances in Capturing, Coding and Analyzing Multimodality. Valletta, Malta (2010)
2. Gameiro, J., Cardoso, T., Rybarczyk Y.: Kinect-Sign: Teaching Sign Language to Listeners through a Game. In: Rybarczyk, Y., Cardoso, T., Rosas, J., Camarinha-Matos, L. (eds.) Innovative and Creative Developments in Multimodal Interaction Systems, pp. 141--159. Springer, Heidelberg (2014)
3. Rybarczyk, Y., Santos, J.: Motion Integration in Direction Perception of Biological Motion. In: Fourth Asian Conference on Vision. Matsue, Japan (2006)
4. Dekeyser, M., Verfaillie, K., Vanrie, J.: Creating Stimuli for the Study of Biological Motion Perception. Behavior Research Methods, Instruments, & Computers 34(3), pp. 375--382 (2002)
5. Windows Dev Center, https://dev.windows.com/en-us/kinect
6. Vicon Motion Systems, http://www.vicon.com/
7. Shipley, T., Brumberg, J.: Markerless Motion Capture for Point-Light Displays. Technical report, available at http://astro.temple.edu/~tshipley/mocap.html
8. Zhang, Z., Troje, N. F.: 3D Periodic Human Motion Reconstruction from 2D Motion Sequences. Neural Computation 19, pp. 1400--1421 (2007)
9. Harmazi, M., Bensrhair, A., Bennouna, M., Miché, P., Mousset, S.: Implementation of a Real-Time 3D Vision Sensor for a Vehicle Driving Aid. In: TILT Conference. Lille, France (2003)
10. Shiffman, D.: Learning Processing: A Beginner's Guide to Programming Images, Animation and Interaction. Morgan Kaufmann, San Francisco (2008).
11. Caillette, F., Aphrodite G., Toby H.: Real-Time 3-D Human Body Tracking Using Learnt Models of Behaviour. Computer Vision and Image Understanding 109(2), pp. 112--125 (2008)
12. Canton-Ferrer, C., Casas, J.R., Pardàs, M.: Human Motion Capture Using Scalable Body Models. Computer Vision and Image Understanding 115(10), pp. 1363--1374 (2011)
13. Dutta, T.: Evaluation of the Kinect Sensor for 3-D Kinematic Measurement in the Workplace. Applied Ergonomics 43, pp. 645--649 (2012)
14. Chen, L., Wei, H., Ferryman, J.: A Survey of Human Motion Analysis Using Depth Imagery. Pattern Recognition Letters 34, pp. 1995--2006 (2013)

Energy implications of common operations in resource-intensive Java-based scientific applications

Cristian Mateos[1], Ana Rodriguez[1], Mathias Longo[1], and Alejandro Zunino[1]

ISISTAN Research Institute. UNICEN University. Campus Universitario, Tandil (B7001BBO), Buenos Aires, Argentina. Tel.: +54 (249) 4385682 ext. 35. Also Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET). E-mail: cristian.mateos@isistan.unicen.edu.ar

Abstract. Today's scientific applications usually take considerable time to run, and hence parallel computing environments, such as Grids and data centers/Clouds, have emerged. Indeed, traditionally, much research in high-performance computing has been conducted with the goal of executing such applications as fast as possible. However, energy has recently been recognized as another crucial goal to consider, because of its negative economic and ecological implications. Energy-driven solutions in these environments are mostly focused on the hardware and middleware layers, but little efforts target the application level. We revisit a catalog of primitives commonly used in object oriented-based scientific programming, or micro-benchmarks, to identify energy-friendly variants of the same primitive. Based on this, we refactor three existing scientific applications, resulting in energy improvements ranging from 2.58% to 96.74%.

Keywords: Energy, Scientific application, Java, Micro-benchmarks

1 Introduction

Current scientific applications are characterized by the need of parallel computing environments delivering large amounts of computational power. From a software perspective, such applications are often structured based on the master-worker paradigm: the master component splits the input data to process and creates many associated resource-intensive jobs (workers), which are then dispatched to run in parallel on multiple machines. After all jobs complete their execution, the master collects and joins individual results. This simple model is popular in diverse disciplines such as Bioinformatics [19], Earth Sciences [11] and Molecular Science [22].

In this line, a paradigm that has experienced a substantial growth is Cloud Computing [1], which favors building powerful parallel computing infrastructures along with easy of use. Although the use of Clouds finds its roots in IT environments, it has gradually entered scientific and academic ones [14]. Unlike other environments such as Grids, where computing resources are geographically dispersed, Clouds (a.k.a. data centers) are highly centralized and constitute a single administrative domain.

Regardless of the targeted environment, research in high-performance computing has traditionally focused on executing jobs as fast as possible. Tremendous research spanning the well-known three-layer stack comprising hardware (e.g., adding cores), platform (e.g., better middleware-level schedulers) and applications (e.g., parallel programming models)

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_69

has been done. However, this whole research is being rethought to add energy efficiency to the list of critical factors to consider, apart from performance [3]. Indeed, statistics about the impact of energy on economic costs in data centers are stunning. For example, energy consumption accounts for 15 percent of the total operational expenditures [10]. In 2007, the energy consumed in data centers in Western Europe was 56 TWh and will increase to over 100 TWh per year by 2020 [7]. Aside from these, inefficient energy management has negative ecological consequences due to CO2 emissions.

In response, there are many proposals to increase energy efficiency in data centers. At the hardware level, there are efforts to improve CPUs, storage/network elements, and mechanical-based cooling/heat controllers. For instance, the former line includes equipping processors with finer "C-states" and smarter DVFS (Dynamic Voltage Frequency Scaling) techniques, or considering ARM-based processors, which are used in mobile device manufacturing. At the middleware level, most efforts are devoted to trade-off obtained performance and used energy when scheduling jobs [4]. However, literature shows that there are little efforts focusing on energy efficiency at the application level.

All in all, this paper analyzes the energy consumed by different versions of micro-benchmarks representing common programming operations found in scientific applications, such as array copying and matrix traversal. The experiments performed show that, for the same operation, there are versions which are much more energy-efficient than others. Based on these results, we refactored three existing scientific applications using the energy-efficient versions, obtaining substantial energy savings. We scope our research to Java, a language which has proven to be useful for developing resource-intensive applications and platforms [20] because of its "write once, run anywhere" philosophy, which mitigates the inherent heterogeneity of parallel environments.

Section 2 explains the studied micro-benchmarks. Section 3 presents the experiments to quantify energy gains. Section 4 presents the conclusions and prospective future works.

2 Common operations in scientific applications

We chose eight groups of micro-benchmarks [5] because their recurrent use in Java-based scientific programming. These groups are array copying, matrix traversal, string handling, arithmetic operations, exception handling, object field access, object creation and use of primitive data types.

Over the years several libraries for scientific use were developed in diverse object-oriented (OO) languages such as C++ and Java [15]. Then, we decided to determine, particularly, energy improvement using such libraries to copy an array over implementing manually the same functionality. Additionally, matrices have many important mathematical uses. For instance, matrix-matrix multiplications are important kernels in linear algebra algorithms [13]. Regarding string manipulation, concatenation is the most important operation [6]. Concerning the fourth group, several studies have focused on optimizing arithmetic operations or involve large numbers of them [17]. Moreover, exceptions represent a widely used mechanism for elegant error handling. The next group, method invocation, was chosen since in OO programming methods must be called to use any subroutine associated with a class. Moreover, we chose object creation not only because objects are the focus of OO programming and object creation itself reduces the performance of the application, but also application performance indirectly declines because of costly memory management tasks –e.g., the garbage collector in Java or explicit object

disposal in C++– which clean memory from unused objects. Finally, the last group is the use of primitive data types versus (heavier) object-based data types.

2.1 Array copying

Most languages provide built-in libraries to expose common functionality for reuse, such as searching and sorting data structures, random number generation algorithms, etc. Using this support has significant advantages over using an ad-hoc implementation. Particularly, many of the Java built-in functionalities have been rewritten over the years resulting in dramatic performance improvements [5].

We specifically compare the use of `System.arraycopy` with a manual solution for the same functionality. Array structures are one of the most important structures in scientific codes. Programmers use arrays instead of multiple variable declarations. For instance, in mathematics arrays are used for representing polynomials.

2.2 Matrix traversal

Matrices are mathematical structures that have many different uses such as writing problems conveniently and compactly, helping to solve problems with linear and differential equations, and coordinating changes in some types of integrals. Additionally, in graph theory an adjacency matrix can be naturally associated to each graph where the position [i,j] indicates if vertex *i* is connected with vertex *j*. Therefore, we tested micro-benchmarks where *NxM* matrices are traversed by rows and columns.

2.3 String handling

Java applications use the `String` class to save/read data or display messages to the user, among other uses. Concatenating smaller strings is necessary to create bigger data chunks. Then, we work with the "+" operator versus using the `StringBuilder` class, which exploits buffering. Considering Strings in Java are immutable, i.e., their values cannot be changed after they are created, the use of the "+" operator might not be efficient for a large number of concatenations. The operator applied on *n* strings has a complexity of $O(n^2)$, and requires memory space to maintain intermediate concatenations. In consequence, we expect an energy improvement using `StringBuilder` .

2.4 Arithmetic operations

Arithmetic operations are one of the most usual primitives in scientific applications. Moreover, since addition is the commonest arithmetic operation CPUs solve, we measure energy consumption of adding different primitive data types, namely *int*, *long*, *float* and *double*. We expect integer operations to be more efficient than floating point operations due to the greater inherent computational complexity of these later.

2.5 Exception handling

Using exceptions is the ordinary way to manage any unexpected event like division by zero or null pointer access. When an object is in a condition it cannot handle, it creates and raises an exception that has to be captured by someone else higher in the call stack. The mechanism allows developers separating error-handling code from regular code, which improves code readability and modifiability.

However, the exception handling mechanism has a negative effect on application performance. Writing code inside a try-catch block prevents the Java Virtual Machine (JVM)

from performing some optimizations because exceptions and exception handling are exceptional situations, i.e., code that is rarely executed. This means that if this code is optimized, it will represent a small benefit to the performance. In addition, knowing where the flow of control "came from" is not easy or is almost impossible for the optimizer. Also, throwing an exception involves object creation. Therefore, this paper analyzes two methods to communicate error situations which are functionally equivalent, one using exceptions to respond to an specific situation and one without these. It is worth noting that we do not said that try-catch blocks should be avoided, but instead we aim at quantifying their energetic cost.

2.6 Object field access

Class comprise attributes/fields, and methods that implement their behavior. One of the practices recommended by the paradigm is information hiding, which tells that each class should provide special public methods called accessors (*getters* or *setters*), which could be referred by other classes to access fields in the declaring class. While this practice results in more flexible designs, invoking accessors –as any other kind of method– also has a negative impact on application performance and clearly consumes energy. For our purposes we compared obtaining an attribute value through a *getter*, versus performing this directly (without encapsulating the functionality in a method).

2.7 Object creation

OO bases on storing data in modular sets of information items (objects). Then, object creation is inherent to OO because different entities with different states coexist in memory at runtime, but this involves some computational –and hence energy– cost. Sometimes developers can avoid creating new objects by reusing objects of the same class but no longer used after resetting their attributes. We then analyze the impact that object creation has on energy consumption over reusing them.

As the possibilities to evaluate this aspect are diverse, we chose an object commonly used in programming: Lists, which are in turn constituting parts of many other data structures. We compare the energy consumption when creating a new list (specifically instances of `ArrayList`) object against reusing an existing list instance and methods to reset the list to its initial (empty) state.

2.8 Use of primitive data types

Past programming languages only had primitive data types (*integers*, *booleans* and *strings*) and procedures. Developers could define their own procedures and chain them to build larger programs. After, abstract types appeared. Java has classical primitive data types that are not classes *per se*, but in addition each of them has a corresponding object data type or wrapper (e.g., *int -> Integer*). Primitive data types use the bits needed to represent its content while storing the same information using objects requires more memory. We then evaluate the energy saving using primitive data types versus using wrapper classes.

3 Experiments

Next, we evaluate the impact of micro-benchmarks on energy consumption, and their effect on real scientific applications. Unlike traditional compiled languages, Java compiled code (bytecode) is platform-independent and interpreted on demand by the JVM. The JVM includes a dynamic compiler that performs an optimized bytecode-to-assembly translation of the parts of a program that are most frequently used [2], and a *garbage*

collector, a memory manager periodically launched to free unused memory. These features, however, introduce "noise" when profiling Java programs. Thus, we used Google's Caliper [9], a framework for running micro-benchmarks that deals with these problems.

To increase generality, Java 1.7 and 1.8 were considered. We first measured the energy consumption of each micro-benchmark version using either JVMs. After that, we applied the same process to three scientific applications considering two variants: original codes, and modified codes using the most energy-efficient micro-benchmark versions. To obtain measures, an external device called PowerMeter[1] was used, which measures the voltage, amperage, active power and apparent power several times per second with less than a 3% of error. We plugged a host computer to the device, a Samsung NP-N150 Netbook with an Atom N450 processor (@1660 MHz) and 1 GB DDR2 of RAM, running Ubuntu 14.04. Each test was run with the screen and the wireless off to avoid noise consumption, and without the battery. Sections 3.1 and 3.2 present the micro-benchmarks and applications results, respectively.

3.1 Micro-benchmarks results

As we can see, Table 1 depicts the average power consumption (in Joules) of each micro-benchmark. The next paragraphs discuss the results in more detail.

Array copying `System.arraycopy` , which provides a built-in method for copying arrays, was chosen because this functionality is commonplace in the scientific community. To evaluate the efficiency of this library a standard manual implementation of the same functionality was used. Results show that using the library improves energy consumption by a 37.36% with Java 1.7 and 37.90% with Java 1.8. As this paper is focused on just one library, we can not extend the results to other libraries, but for the case of array copying gains are important.

Matrix traversal One of the most common operations used in a matrix is exploring its elements to do some later processing. This paper uses *NxM* matrix structures and compares traverse by rows versus traverse by columns. Specifically, a matrix of 1024*x*1024 was used to run tests. One of the key advantages of these micro-benchmarks is the triviality of changing the traverse mode in an existing code. The results show an improvement of 99.95% and 99.80%, with Java 1.7 and 1.8 respectively, using the traverse by row version. In Java, a matrix is a two-dimensional array in which each cell of the first-level array has associated another array. Iterating by row means each internal array is held in the heap until it is fully traversed. Iterating by column means all internal arrays have to be loaded in the heap for all the iterations. Between iterations, the arrays could be erased by the garbage collector, and eventually loaded again, wasting resources.

String handling Table 1 shows that using the class `StringBuilder` instead of the "+" operator generates an improvement of 95.20% (Java 1.7) and of 93.90% (Java 1.8), over 1,000 string concatenations. The main reason for this variation is that string literals in Java programs, are implemented as instances of the `String` class. But, Strings are inmutables, so their values cannot be changed after created. Consequently, using "+" involves the creation of a temporal object that contains the final string. Instead of the "+" operator, the `StringBuilder` class maintains a mutable string of characters and provides methods to modify it without creating new objects.

[1] `http://power-meter.com.ar/products.html`

Micro-benchmark	Version	Consumption (J)		Saving (%)	
		Java 1.7	Java 1.8	Java 1.7	Java 1.8
Array copying	Manual array copy	162.4	102.8		
	System array copy	100.9	63.8	37.8	37.9
Matrix iteration	By-column iteration	130910.3	53776.8		
	By-row iteration	62.7	102.6	99.9	99.8
String handling	String concatenation (+)	6249.0	4456.1		
	String builder	295.0	271.7	95.2	93.9
Arithmetic operations	Add constant to *double*	6895.0	5152.5		
	Add constant to *float*	6023.5	5089.3	12.6	1.2
	Add constant to *long*	4112.3	3643.5	31.7	28.4
	Add constant to *int*	895.6	838.8	78.2	76.9
Exception handling	Use Exception	8814.0	14108.6		
	No Exception	37.0	28.1	99.5	99.8
Object field access	Getter-based access	10750.6	9190.0		
	Direct access	2101.6	1700.8	80.4	81.4
Object creation	On-demand creation	1081.1	813.1		
	Object reuse	462.2	461.6	57.2	43.2
Primitive data types	Use of object data types	3901.8	3082.3		
	Use of primitive data types	3055.7	2356.2	21.6	23.5

Table 1. Micro-benchmarks results

Arithmetic operations For brevity, this experiment involved adding a constant value to a numerical variable declared several times by varying its data type. Operations with float numbers are more costly than operations with integer numbers. Thus, the latter group uses less energy than the former group. Specifically, using the *int* data type and Java 1.7 has an improvement of 12.63%, 31.37% and 78.2% over relying on the *double*, *float* and *long* data types, respectively. In the case of Java 1.8, the results show an improvement of 1.22%, 28.40% and 76.90%, respectively.

Then, using the most specific data type results in a good practice to save energy when programming scientific codes. Additionally, the *double* and *long* data types consume more energy than the *float* and *int* data types, respectively, because the first data types provide greater accuracy than the second ones. Consequently, greater precision implies more consumption.

Exception handling The results in Table 1 support the analysis presented in Section 2.5. As expected, programmers can significantly save energy by not using exceptions. Table 1 shows an improvement of 99.58% for Java 1.7 and 99.80% for Java 1.8.

The creation of objects and the limited optimizations to the exception mechanism made by the JVM, produce higher energy consumption. To ensure minimum energy consumption, exceptions must be reserved only for error situations where cannot be dealt with other mechanism, like the example of division by zero explained in 2.5.

Object field access Obtaining a value from a frequently accessed field directly –not through a getter– yields an improvement of 80.45% using Java 1.7 and 81.49% using Java 1.8, Table 1. However, the programmer must not declare as public all variables of a class, or combine several methods of a class that are unrelated to avoid repetitive invocations. Loss of legibility and the high coupling of the resulting applications would outweigh the benefit. Then, developers must determine to what extent it is valuable to set aside OO design good practices (information hiding in this case) to decrease energy consumption. But, there are known cases, such as accessing class variables within methods of the same class, where direct access can be applied.

Object creation The hypothesis that object creation produces more energy consumption than reusing objects holds. We scope the analysis to reusing linear data structures. Improvements of 57.24% and 43.23% using Java 1.7 and Java 1.8, respectively, where obtained. Developers must be careful not to create objects that are not needed in the application. Thus, they can achieve significant savings in energy consumption. Programmers must also avoid reusing objects which are being used or may be used in future by the application for correctness reasons. Additionally, we must consider that improvements may vary depending on the object to be created; however, we tested with lists, an object type very popular to implement other data structures.

Use of primitive data types The use of primitive data types such as *int*, *float* and *boolean* allows an energy saving of up to 21.68% using Java 1.7 and 23.55% using Java 1.8. As mentioned in 2.8, if primitive data types are used, the creation of new objects is avoided. Indeed, in the previous micro-benchmark, it was shown that object creation leads to higher energy consumption. Although different objects were used here, this might explain why the use of primitive data types has a lower consumption compared to object types.

3.2 Test applications results

We then exploited the previous results to refactor three real scientific applications obtained from the Ibis/Satin project [21], namely Fast Fourier Transform (FFT), Matrix Multiplication (MMult) and the Knapsack problem (Knapsack), and thus measuring the energy impact of the micro-benchmarks on full-fledged applications. We evaluated original codes against refactored codes by using the most energy-efficient versions of micro-benchmarks. Table 2 shows the energy consumption.

FFT implements an algorithm for calculating the discrete Fourier transform (DFT), which has an impact on different areas such as image and signal processing. Being $x_0, x_1, ..., x_{n-1}$ complex numbers, DFT is defined as $f_j = \sum_{k=0}^{n-1} x_k e^{-\frac{2\pi i}{n} jk} \qquad j = 0, 1, ...n-1$. The original implementation of this application was in turn inspired in the well-known Radix-2 Cooley-Tukey algorithm.

The main change to the original application was the elimination of immutable classes, particularly an existing `Complex` class. In the refactored code, `Complex` class instances can change the values of their attributes without creating a large number of immutable instances. Also, arithmetic precision was decreased without altering the output of the application. Table 2 shows that improvement were 2.58% (Java 1.7) and 13.27% (Java 1.8).

Moreover, MMult takes two matrices (A_{mxn}, B_{nxp}) and returns a matrix (C_{mxp}) where

$C_{ij} = \sum_{k=1}^{n} a_{ik} * b_{kj}$, being i and j the row and column numbers. Matrix multiplication is

App.	Version	Consumption (J)		Saving (%)	
		Java 1.7	Java 1.8	Java 1.7	Java 1.8
FFT	Original	1181.56	2656.22		
	Refactored	1151.06	2303.72	2.58	13.27
MMult	Original	4149.50	3884.75		
	Refactored	1678.61	1652.11	59.54	57.47
Knapsack	Original	4244.85	4168.88		
	Refactored	143.63	135.64	96.61	96.74

Table 2. Test applications results

for instance useful for solving systems of equations and in the area of linear algebra. To produce C, the original application assumes square matrices and first divides each input *nxn* matrix into four quadrants. This is done recursively based on a depth parameter. We considered maximum depth (i.e., the recursion stops at the cell level). This decision allows us to show the impact of the micro-benchmarks in the most extreme case.

Again, the main aspect to avoid here was object creation. However, in this case, the instantiation of different classes is performed at the beginning of the execution (it is not progressively done during execution). Particularly, the same instances of the `Matrix` class are used throughout the execution but processed recursively. Then, the matrix structure was redesigned decreasing the number of object creations by avoiding recursion. Then, improvements of 59.54% and 57.47% were achieved using Java 1.7 and 1.8, respectively.

Lastly, Knapsack is a combinatorial optimization problem to optimize the total weight that a backpack supporting a default weight W can contain. The backpack is filled with elements each having a value v and a weight w. Knapsack is the base of the first asymmetric encryption algorithm (or algorithm of "public key") [23]. Additionally, it has several applications in operation management and logistics.

Specifically, the original version employed is based on dividing the initial N elements into two subproblems recursively for $N-1$ elements, one with the lost item placed in the backpack, and the other without it. This methodology continues operating recursively until the backpack is full or there are not elements left. We then reduced the number of objects in memory by about a half. Another significant change for this application was removing methods that were called by only one method. Excellent results were achieved after such simple modifications (see Table 1). For Java 1.8, an improvement of 96.74% was achieved, while for Java 1.7 the improvement was similar, i.e., 96.61%.

4 Conclusion and future works

In this paper we have empirically assessed the energy impact of considering energy-friendly versions of common primitives (or micro-benchmarks) used in OO-based scientific programming. Particularly, we have focused on Java, and through three real applications, we have shown that energy improvements resulted from refactoring codes based on such versions are substantial. Our study hence represents a contribution towards providing scientific developers more guidelines to build more energy-efficient software.

We are extending this work in several directions. First, we will study how to automatically modify an existing application so as to use the energy-efficient version of the micro-benchmarks prior to compilation, or at least offer developers a tool to automatically spot potential improvement points in the code. For some micro-benchmarks, this is straightforward to do (e.g., object field access) but for others (e.g., reusing objects) automatic modification or recognition is highly challenging. However, having such a tool support will increase the practical value of our results.

Second, we are studying these ideas in the context of mobile device programming. Saving energy in battery-supplied devices not only improves user experience, but also indirectly reduces energy footprint due to the extended battery discharge-charge cycle. Preliminary works in this line include [17], in which the rate at which micro-benchmarks versions deplete batteries was assessed, and [18], which studies the trade-off between producing good class designs in object-oriented terms versus the inherent energy costs. Particularly, the latter explores to what extent it is advisable to introduce code refactorings to increase application extensibility and maintainability without compromising energy. These two works target Android, which is the most popular mobile operating system and features Java as its main high-level programming language. The motivation of these works is that it has been shown that mobile devices can act as resource providers in parallel environments to execute scientific applications [12,8].

We also plan to extend our study beyond scientific applications, since clearly many primitives are general enough. The golden age of data centers [3] has caused a proliferation of new kinds of Cloud-hosted applications including SaaS (Software as a Service) applications and Restful Web Services [16]. Even when the resource requirements of these applications might be much lower compared to scientific applications, the former are subject to much higher loads since they are simultaneously accessed from thousands of Web clients. Hence, small energy improvements could be very rewardful. Interestingly, Java is also very popular in backend development. Besides, new operations commonplace in Web programming could be considered. For example, extensively relying on type erasure and bridge methods intuitive could lead to higher energy consumption[2].

Acknowledgements

We acknowledge the financial support from ANPCyT through grant PICT-2012-0045.

References

1. M. Armbrust, A. Fox, R. Griffith, A. D. Joseph, R. Katz, A. Konwinski, G. Lee, D. Patterson, A. Rabkin, I. Stoica, et al. A view of cloud computing. *Communications of the ACM*, 53(4):50–58, 2010.
2. A. Barisone, F. Bellotti, R. Berta, and A. De Gloria. Jsbricks: a suite of microbenchmarks for the evaluation of java as a scientific execution environment. *Future Generation Computer Systems*, 18:293–306, 2001.
3. R. Basmadjian, P. Bouvry, G. Da Costa, L. Gyarmati, D. Kliazovich, S. Lafond, L. Lefevre, H. De, J.-M. P. Meer, R. Pries, J. Torres, T. Trinh, and S. Khan. Green data centers. *Large-Scale Distributed Systems and Energy Efficiency: A Holistic View*, pages 159–196, 2015.
4. A. Beloglazov, J. Abawajy, and R. Buyya. Energy-aware resource allocation heuris-

[2] `https://docs.oracle.com/javase/tutorial/java/generics/bridgeMethods.html`

tics for efficient management of data centers for cloud computing. *Future generation computer systems*, 28(5):755–768, 2012.
5. J. Bloch. *Effective Java*. Prentice-Hall, 2 edition, 2008.
6. A. S. Christensen, A. Moller, and M. I. Schwartzbach. Precise analysis of string expressions. In *10th International Static Analysis Symposium*, volume 2694 of *Lecture Notes in Computer Science*, pages 1–18, 2003.
7. European Commission. Code of conduct on data centres energy efficiency. Technical report, Institute for Energy, Renewable Energies Unit, 2009. Version 2.0.
8. N. Fernando, S. W. Loke, and W. Rahayu. Mobile cloud computing: A survey. *Future Generation Computer Systems*, 29(1):84–106, 2013.
9. Google. Caliper. `http://code.google.com/p/caliper/` .
10. A. Greenberg, J. Hamilton, D. A. Maltz, and P. Patel. The cost of a cloud: research problems in data center networks. *ACM SIGCOMM Computer Communication Review*, 39(1):68–73, 2008.
11. M. Gulamali, A. McGough, S. Newhouse, and J. Darlington. Using iceni to run parameter sweep applications across multiple grid resources. In *Global Grid Forum 10, Case Studies on Grid Applications Workshop*. Citeseer, 2004.
12. M. Hirsch, J. M. Rodriguez, A. Zunino, and C. Mateos. Battery-aware centralized schedulers for cpu-bound jobs in mobile grids. *Pervasive and Mobile Computing*, 2015. In press.
13. A. Nicolaos, K. Vasileios, A. George, M. Harris, K. Angeliki, and G. Costas. A data locality methodology for matrix-matrix multiplication algorithm. *Journal of Supercomputing*, 59:830–851, 2012.
14. E. Pacini, C. Mateos, and C. G. Garino. Distributed job scheduling based on swarm intelligence: A survey. *Computers & Electrical Engineering*, 40(1):252–269, 2014.
15. S. Papadimitriou, K. Terzidis, S. Mavroudi, and S. Likothanassis. Exploiting java scientific libraries with the scala language within the scalalab environment. *IET Software*, 5:543–551, 2011.
16. C. Pautasso, E. Wilde, and R. Alarcon. *REST: Advanced Research Topics and Practical Applications*. Springer, 2014.
17. A. Rodríguez, C. Mateos, and A. Zunino. Mobile devices-aware refactorings for scientific computational kernels. In *41 JAIIO - AST 2012*, pages 61–72, 2012.
18. A. Rodriguez, C. Mateos, A. Zunino, and M. Longo. An analysis of the effects of bad smell-driven refactorings in mobile applications on battery usage. In *Modern Software Engineering Methodologies for Mobile and Cloud Environments*. IGI Global, 2015. In press.
19. C.-H. Sun, B.-J. Kim, G.-S. Yi, and H. Park. A model of problem solving environment for integrated bioinformatics solution on grid by using condor. In *Grid and Cooperative Computing*, pages 935–938. Springer, 2004.
20. G. L. Taboada, S. Ramos, R. R. Exposito, J. Tourino, and R. Doallo. Java in the high performance computing arena: Research, practice and experience. *Science of Computer Programming*, 78(5):425 – 444, 2013.
21. R. V. van Nieuwpoort, G. Wrzesińska, C. J. Jacobs, and H. E. Bal. Satin: A high-level and efficient grid programming model. *ACM Transactions on Programming Language and Systems*, 32(3):1–39, 2010.
22. J. M. Wozniak, A. Striegel, D. Salyers, and J. A. Izaguirre. Gipse: Streamlining the management of simulation on the grid. In *38th annual Symposium on Simulation*, pages 130–137. IEEE Computer Society, 2005.
23. J. Zhang. Comparative study of several intelligent algorithms for knapsack problem. *Procedia Environmental Sciences*, 11:163–168, 2011.

Analysis of Materials Emissivity Based on Image Software

Rui Pitarma[1,i], João Crisóstomo[2] and Luís Jorge[2],

[1] Polytechnic Institute of Guarda – Unit for Inland Developement,
Av. Dr. Francisco Sá Carneiro, nº 50,
6300 – 559 Guarda, Portugal
[2] Polytechnic Institute of Castelo Branco - School of Engineering
Av. do Empresário - Campus da Talagueira
6000 - 767 Castelo Branco, Portugal
[i] rpitarma@ipg.pt; {jocap.jocap, luisfc}@gmail.com

Abstract. Thermography Infrared (TIV) is a nondestructive diagnostic technique, with non-contact, to evaluate the surface temperature of objects based on the emitted radiation. The surface temperature field is carried out using an image that reproduces color patterns. As a non-destructive, versatile, and non-contact technique, constitutes a very useful tool in various fields. Active or passive heating procedures may be used. Nevertheless, accurate measurement of temperature is strongly dependent on the emissivity value of the material. This study presents and discusses a methodology for measuring the materials emissivity using image processing software. The results show an effective and valuable contribution in this field, especially for application in active thermography.

Keywords: emissivity, infrared thermography, non-destructive diagnostic technique, image software.

1 Introduction

Thermal imaging is the result of a large and complex interaction between the heat source, the material and its defects. The mapped objects may be at room temperature or it may be used active or passive heating procedures. The infrared thermography (TIV) is a nondestructive diagnostic technique, with non-contact, to evaluate the surface temperature of objects based on the emitted radiation. The surface temperature field is carried out using an image that reproduces color patterns. There are two approaches for thermal analysis: qualitative and quantitative. Qualitative thermography focuses on the analysis of thermal patterns to reveal the existence and the location of anomalies while quantitative thermography uses temperature measurements as a criterion to determine the severity of anomalies [2]. TIV is a measurement technique based on the detection of radiation in the IR spectrum. It is based on the knowledge that all bodies emit electromagnetic radiation above the absolute zero degrees. The detection of radiation in the IR spectrum is usually made

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_70

between 2-5.6 μm and 8-14 μm, and these two spectral bands are commonly used due to its poor atmospheric absorption [3]. For example, in wood science, thermography is still a relatively new field of study [1].

However, without knowledge of the emissivity values of the materials, it is not possible to obtain accurate temperature readings and quantitative results. The emissivity is a term used to characterize optical properties of materials taking account the amount of emitted energy compared to an ideal black body [4]. The emissivity values are between 0 (perfect mirror reflector) and 1 (perfect blackbody emitter). The emissivity has an important role in thermography and it is dependent on the temperature, wavelength and surface conditions such as surface roughness. In fact, there is no IR camera able to perform readings if this factor are not present. All IR cameras interpret IR radiation coming from the surface of the object, depending on its emissivity. Some authors refer that the temperature depends not only on the object temperature but mainly on the environment reflected radiation, affecting the accuracy of the thermography [4,5]. A surface with a low emissivity value, e.g. aluminum or steel, acts as a mirror (high reflectance). However, these problems are usually solved by using tapes or high emissivity paints [4]. For example, most of the materials used in buildings are highly emissivity, usually above 0.8 [4].

The determination of the emissivity is usually performed applying the methodology of black insulating tape (i.e. material with known emissivity value) and an auxiliary thermometry. But in non-stationary phenomena or larger objects, this method does not produce accurate results and implies practical difficulties.

In this study, we determine the materials emissivity using analysis software and image processing in active thermography. The technique has proved to be effective and the results point to an effective contribution in this field. This work aims to guide and sensitize the IR camera user to the importance of careful determination of the material emissivity in order to minimize errors in the interpretation of thermograms.

2 Materials and Methods

In this study, it was used an Infrared Camera FLIR ThermaCAM B20 with a 36 mm lens as shown in Figure 1 (first 3 digits of the serial number are 234 and 36 mm lens). These data imply that the camera has a FOV of 22.6º. The minimum focusing distance is 0.3 m. For a 0.5 m distance between the camera lens and the sample surface, presents a HFOV 0.2 m, VFOV 0.15 m and IFOV 0.63 mm. The thermal camera works in the spectral band of 7.5 - 13 μm, with a thermal sensitivity of 0.10 °C to 30 °C and it has an accuracy of + 2° C or + 2% of reading. The focusing is manual or automatic. The type of detector is an uncooled microbolometer (FPA), with resolution of 320 x 240 pixels. The softwares used are the ThermaCAM QuickView 1.3 and the ThermaCAM Reporter 7.0. For measuring the emissivity it was applied the black tape method, having used black adhesive insulating tape Iso Tape Tesa. For temperature increasing of the samples, a P SELECTA laboratory oven was used. A weighing of the samples was performed with an electronic scale, with 5 kg capacity

and accuracy of ±1 g. For fixing the observed sample and the thermal camera, two tripods were used. For determining the environmental conditions it was used a thermo hygrometer Digital Multifunction Velleman DVM401 (Fig. 2).

Fig. 1. Thermographic camera used for emissivity determination.

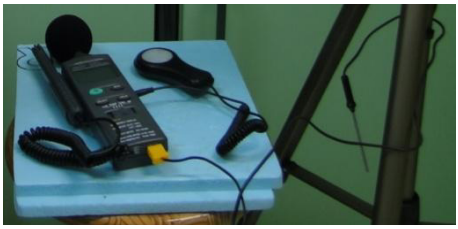


Fig. 2. Devices used to determine the environmental conditions.

2.1 Samples

The determination of the material emissivity according to the prescribed methodology was carried out through a series of lab experiments. The emissivity of five different lumber samples with similar texture was measured. The samples were taken from species grown in Portugal (Table 1). Two samples with similar textures and coloration belong to the species *Pinus pinaster aiton* (commonly known as *pinho bravo* or *pinho maritimo*). Even both samples belong to the same species, they have different densities because they come from two different locations with different climates – one comes from the region of Leiria (maritime pine) and the other one comes from the Serra da Estrela region (highland pine). The samples were used without any type of finishing, such as may be found in most structures. The dimensions of the samples are: 20 cm along the fibers length, 15 cm across the fiber and 15 cm thick. These dimensions were defined to minimize the effect of environment on the surface given the features of the IV camera. Also, the piece was intended to simulate a small section of a beam.

A thermal differential of approximately 20°C was assumed, as suggested in the FLIR ThermaCAM B20 manual [6]. The laboratory conditions are shown in Table 2. Table 3 shows the characteristics of the samples, including density and water content. Figure 3 shows the two samples of the *Pinus pinaster* Aiton.

Table 1. Lumber species of the samples.

Portuguese Common Name	English Common Name	Scientific Name
Acácia	Acacia	*Acacia dealbata* Link
Amieiro	Alder	*Alnus glutinosa* (L.) Gaertner
Carvalho	Oak	*Quercus rubra* L.
Castanho	Chestnut	*Castanea sativa* Miller
Cedro	Cedar	*Cedrus deodara* (D. Don)
Choupo	Poplar	*Populus tremula* L.
Pinho	Pine	*Pinus pinaster* Aiton
Pinho Serrano	Pine (maritime)	*Pinus pinaster* Aiton

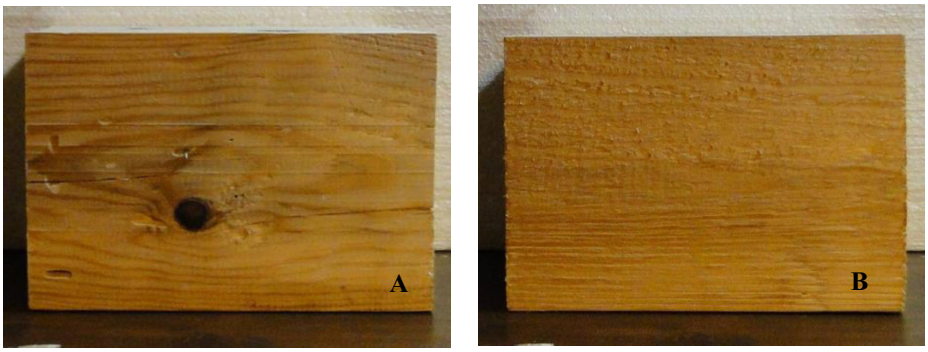


Fig. 3. Samples of *Pinus pinaster* Aiton (A - Leiria region: maritime pine; B - Serra da Estrela region: highland pine)

2 Experimental Methodology

Once a FLIR camera was used, to determine the reflected apparent temperature (reflective method) and the emissivity, the experiments were carried out applying, with some adjustments, the methodology suggested by the manufacturer of the FLIR thermal camera [6], also mentioned in Spencer et al. (2008) [7] and ASTM E1933-99a (Reapproved 2010) [8]. For each samples were observed the sides parallel to the length of the fiber (20 cm x 15 cm). The side chosen was the one with the fewer irregularities, avoiding cracks and knots.

The samples were heated at least 20°C above the temperature of the environment. In order to ensure temperature uniformity, samples were placed in the lab oven at 60°C for 24 h. With a K-type thermocouple it was assessed the temperatures of both zones (the area of the black tape and the exposed side of the lumber) until both temperatures were equal. The tests were performed in the absence of light (Table 2) in order to prevent reflections, because for a low light intensity the reflected temperature was equal to room temperature. In this study, the distance between the camera and the sample was 0.5 m. The sample was fixed on a tripod, so that the sample was observed perpendicular to the plane of the surface. Lab conditions were monitored for machine calibration: room temperature, relative humidity and light intensity as shown in Table 2.

The wood, as many other materials, is a very heterogeneous material. Then, thermographic assessments were carried out on a relatively large observation area, since measurements made at a single point lead to erroneous temperature readings and should therefore be avoided.

Determining the emissivity was performed applying the classical black insulating tape methodology (i.e. material with emissivity coefficient known). Black tape strips (with emissivity 0.970) were placed together perpendicular to the length of the fiber. It was filled half the face of the sample (i.e. 10 cm x 15 cm) (Fig. 4). This methodology is used to correct the emissivity value until the temperature reading in the camera is the same as indicated by the auxiliary thermometry system (in this case, a thermocouple). However, for relatively large objects and in the case of active thermography (transient events) where the spatial and temporal variations in surface temperature of the subject are significant, this technique could be ineffective. Thus, we used the aid of analysis software and image processing to obtain thermal surface pictures at successive times. The average of the surface temperature was obtained and this led to get its emissivity. The experimental steps were:

- Enter the emissivity value of the electrical insulating tape (0.970);
- Image focussing;
- Get a thermogram of the face of the sample (including the part of the face with electrical tape);
- Export the thermogram to the computer (ThermaCAM QuickView 1.3 software);
- Do the analysis and treatment of thermogram with ThermaCAM Reporter 7.0 software

This procedure was repeated 5 times in lab environment (LEC / IPCB - Laboratory of Castelo Branco Polytechnic Institute). The thermal images were analyzed using image processing software to determine the average temperature of the sample surface. The area was calculated to get a sufficiently large and representative sample observation of temperature. For this purpose, we used a square function to open an analysis box 100 by 100 (Figure 5) from the side covered by the tape in order to determine the average surface temperature in the area with the tape. This procedure

was repeated on the opposite side of the exposed wood. Thus, by varying the emissivity value, it was possible to vary the temperature value read on the exposed side of the lumber. Then, the value of the emissivity was fixed. When the temperatures were equal, it means that the value of the emissivity meter matches to the value of the sample surface emissivity, which in fact corresponds to the emissivity value of the sample to room temperature.

The samples were weighted for subsequent determination of water content (equation 1). For determining the water content of the samples it was applied the NP 614: 1973 [8]. Thus, the samples were introduced at 100°C during 48 hours and successively weighted until the weight remained constant (dry weight).

$$\text{Water content [\%]} = ((P_{Humid}-P_{Dry})/P_{Dry})x100 \quad (1)$$

Fig. 4. The eight lumber samples used in the experimental tests (exposed side/side with black tape insulating).

2 Results and Discussion

The thermograms shown in Figure 5 are examples of the applied methodology for determining the samples emissivity. Table 2 shows the average environmental parameters of the laboratory conditions for obtaining the thermograms. Table 3 presents the results of average emissivity of the lumber samples.

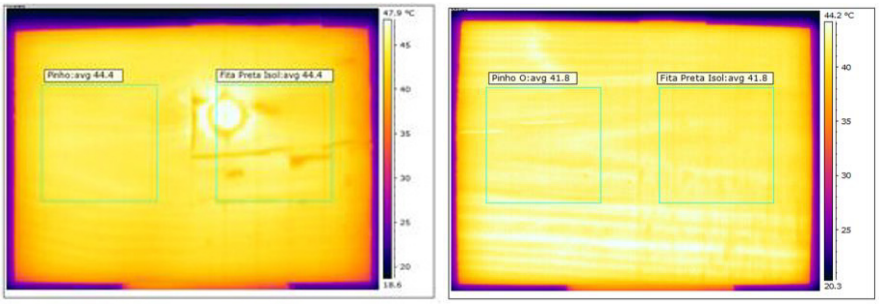


Fig. 5. Thermograms of *Pinus pinaster* Aiton samples (A - Leiria region: maritime pine; B - Serra da Estrela region: highland pine).

Table 2. Laboratory conditions.

Place	Room Temp. (ºC)	RH (%)	Refl. Temp. (ºC)	Light Int. (Lux)
Lab/IPCB	17.5	70	17.5	0.05

Table 3. Samples conditions and emissivity results.

Sample	Nº of Tests	Vol. (cm3)	Dry weight	Weight	Water content	Density	Superficial Temp (ºC)	Emissivity
Acacia	5	4500	2243	2336	4.1	0.519	44.7	0.963
Alder	5	4500	1985	2050	3.3	0.456	42.3	0.992
Oak	5	4500	3209	3466	8.0	0.770	44.9	0961
Chestnut	5	4500	2399	2566	7.0	0.570	44.9	1.000
Cedar	5	4500	1665	1703	2.3	0.378	44.7	0.919
Poplar	5	4500	1479	1515	2.4	0.337	43.6	0.953
Pine	5	4500	2507	2588	3.2	0.575	44.4	0.971
Pine (highland)	5	4500	1869	1922	2.8	0.427	42.9	0.995

The emissivity of each sample is the result of testing average. It varies from 0.919 for Cedar to 1.00 for Chestnut. For each case, the emissivity and temperature values were determined by taking the average of the area of a square function of the software used. The results are valid for the environmental and the sample conditions shown in the tables above. The resulting values are in accordance with those suggested in the bibliography, with high values of the order of 0.9. As indicated by Robert Rice (2004) in [9], measuring equipment manufacturers of temperature IR often recommend

values approximately between 0.94 and 0.95 for wood. FLIR manufacturer indicates even higher values, particularly between 0.96 and 0.98 [6].

Despite the good results correlation compared with the values suggested in the bibliography, comparison is difficult because the values in the literature refer to different test conditions or lack of description of test conditions. The conditions we refer to are the environmental conditions, ambient temperature, spectral observation window and the conditions of the sample. In the case of the samples, we refer to surface finished, water content, density and species of wood. Furthermore, it is very uncommon for authors refer the process used in heating the sample surface, being a key factor that affect the emissivity value [11]. Even more, not all types of heating are suitable [6].

The methodology using the software to 'freeze' the thermograms and perform image processing to obtaining temperature values for comparison and determination of emissivity, proved to be an expeditious and effective tool when compared with the conventional method, particularly for transient phenomena. In fact, in this type of phenomena, where variation of the temperature field on the surface, and in the time, is relevant, and/or in the case of large and heterogeneous objects, the physical method of measurement point has revealed very limited and inaccurate.

3 Conclusion

A method to determine the material emissivity using analysis software and image processing, with particular application for active thermography, was presented. In laboratory, the tests were applied to wood samples without any finishing to replicate conditions in situ. Emissivity values were obtained from different wood species samples. These values were obtained at room temperature of 17.5 ° C at a distance of 0.5 m from the sample. The dimensions of the observed face were 0.20 x 0.15 m in order to minimize errors from the surroundings. The spectral band used was that the camera FLIR B20 uses (7.5-13 μm).

For the application of the methodology it was used ThermaCAM Quick View 1.3 software to export the thermograms and the ThermaCAM Reporter 7.0 software for analysis and image processing.

The values obtained for the emissivity are similar to those suggested in the literature for wood. The technique has proved to be effective compared with classical methods, in particular for non-stationary phenomena. This work aims to guide the IR camera user to the importance of correct determination of the materials emissivity in order to minimize errors in interpretation of the thermograms.

Acknowledgments. The heading should be treated as a 3rd level heading and should not be assigned a number.

References

1. Bucur V.: Nondestructive Characterization and Imaging of Wood. Springer, NY, USA (2003)
2. Rosina, E., Robison, E.: The Aplication of Infrared Thermography on Wood-Framed North American Historic Buildings", APT Bulletin.4, 37—44 (2002)
3. Maldague, X.: Nondestructive Evaluation of Materials by Infrared Thermography. Springer-Verlag. London, UK (1993)
4. http://www.callsbsa.com/wp-content/uploads/2011/03/Emissivity-Measurements-of-Common-Construction-Materials.pdf
5. Avdelidis, N., Moropoulou, A.: Emissivity Considerations in Building Thermography, Energy and Buildings. 35, 663—667 (2003)
6. http://www.NDT.net/article/v06n03/Tanaka/Tanaka.htm
7. López, G., Basterra, L., Acuna, L., Casado, M.: Determination of the Emissivity of Wood for Inpection by Infrared Thermography. Journal Nondestruct Eval. (2013)
8. Spencer, M.: Applying Infrared Thermography for the Purpose of Identifying Concealed Wood Framing Member Type and Subsurface Anomalies with Intended Application Towards Historic Structures. Lexington, Kentucky, National Center for Preservation Technology and Training - Technology Serving the Future of America´s Heritage (2008), http://ncptt.nps.gov/wp-content/uploads/2008-06.pdf".
9. Rice, R.: Emittance Factores for Infrared Thermometers Used for Wood Products. Wood and Fiber Science. 36, 520—526 (2004)
10. Fronapfel, E.; Stolz, B.: Emissivity Measurements of Common Construction Materials. In: InfraMation Proceedings (2006). http://www.callsbsa.com/wpcontent/uploads/2011/03/ Emissivity-Measurementsof-Common-Construction-Materials.pdf
11. Tanaka, T.; Divós, F.: Wood Inspection by Thermography. In: Proceedings of the 12th International Symposium on Nondestructive Testing of Wood (2012). http://www.NDT.net/article/v06n03/Tanaka/Tanaka.htm
12. ASTM E1933-99a (Reapproved 2010), Standard Test Methods for Measuring and Compensating for Emissivity Using Infrared Imaging Radiometers. American Society for Testing and Materials, West Conshohocken, USA (2013).
13. FLIR Systems. Manual do Utilizador da FLIR ThermaCAM B20. FLIR (2006)
14. FLIR Systems. Manual do Utilizador do software FLIR ThermaCAM QuickView 1.3. FLIR (2006)
15. FLIR Systems. Manual do Utilizador do software FLIR ThermaCAM Reporter 7.0. FLIR (2006)

DDT: an IDE for an Aspect Oriented Software Development Platform

Fernando Alvarez, Jesus Perez and Luis Vinuesa

University of Oviedo, Computer Science Department,
C/ Calvo Sotelo s/n, 33007, Oviedo, Spain
{falvarez, vinuesa}@uniovi.es

Abstract. AOSD (Aspect Oriented Software Development) is a methodology that focuses on separating the crosscutting concerns of an application from its components. Among others, the main benefits of this separation are higher legibility of each concern, higher modularization of the application, more concern reuse and improved software maintainability. There exist a number of AOSD platforms that differ, mainly, in the way they weave components and crosscutting (aspect) concerns and the supported programming languages. DSAW (Dynamic and Static Aspect Weaver) is a .NET aspect-oriented platform. In an aspect-oriented program, different source files for components, aspects and pointcuts are used, making it difficult to the programmer to have a global view of the application. Other AOP platforms make use of IDEs to facilitate the programmer to apply the AOP methodology. We have extended the Visual Studio IDE to provide DSAW programmers the usual features they find in other AOP environments.

Keywords: aspect oriented programming, separation of concerns, aspect, integration, IDE support

1 Introduction

Aspect Oriented Software Development (AOSD) [1] is a methodology that focuses on the application of the Separation of Concerns (SoC) principle [2]. Separation of components and crosscutting concerns is desirable to avoid code tangling and scattering and to maximize code modularization.

The process of integrating aspects (crosscutting concerns) into the main application (core concerns) is called weaving [1]. The programmer has to describe a set of weaving rules that specify how to integrate the implemented concerns to form the final system. This integration takes place at identifiable points in the execution of the system called join points. You can select, using pointcuts, some of the join points to provide the desired augmented or alternative behavior defined in the aspects.

All AOSD platforms define concerns implementation languages, a weaving mechanism and a language for rule definition. For example, AspectJ [3] relies in the Java programming language to implement the application concerns and extends it to support crosscutting concerns and weaving rules specification.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_71

DSAW (Dynamic and Static Aspect Weaver) [4] is a language neutral and operating system independent AOSD platform. It is based on the standard specification of the .NET virtual machine, what makes it portable, being able to run on any of its standard implementations.

We present in this paper an extension of the Visual Studio (VS) IDE that helps DSAW programmers build correct applications. One of the most important difficulties of DSAW programmers is to write correct weaving rules that permit the accurate integration of all parts of the application. Therefore, we have extended the VS IDE to facilitate that process of rule specification. The IDE described is based on the 2008 version of Visual Studio.

2 The DSAW Platform

DSAW is an AOSD platform that provides both dynamic and static weaving. Static weaving is performed prior to execution time, when no runtime adaptation is needed or to obtain the best runtime performance. Dynamic aspects can also be used if the system requires dynamic adaptiveness.

Language neutrality has been another goal in the design of DSAW. It has been achieved by using the .NET standard reference [5] as the underlying infrastructure of the platform. Thus, a programmer not only can choose any .NET language to implement the application, but it is also possible to implement each concern in a different programming language.

DSAW performs weaving at virtual machine byte-code level, so the weaver does not require any source code to do its job. Any application or third-party library can be used in DSAW without being altered.

The Join-Point Injector (JPI) is the part of the DSAW platform that processes the application to add the necessary code that allows its dynamic adaptation at runtime. It also performs static weaving, if it has been specified. All these tasks occur at the .NET byte-code level. Fig. 1 shows the tasks involved in the development of a DSAW application.

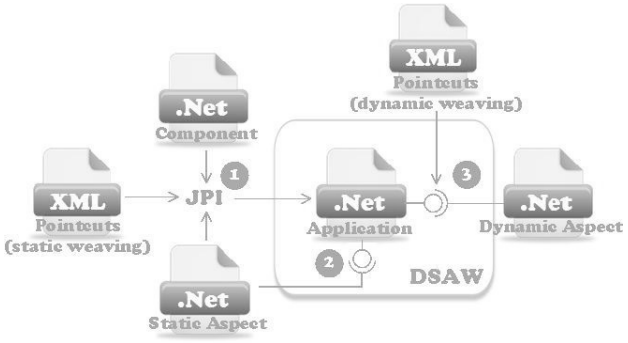


Fig. 1. Static and dynamic weaving in DSAW.

Pointcuts are specified by means of XML documents that describe the relations among join points and aspects. Decoupling aspects from the core application facilitates code reuse: even aspects may be adapted by other aspects.

From the AOSD point of view, the join point model of DSAW is similar to the ones offered by other AOSD platforms. It supports the following dynamic and static join points: method and constructor execution, method and constructor call and field and property read and write. It also provides before, after and around advice.

3 The IDE

We have chosen the VS IDE to develop our aspect-oriented services. DSAW has been built over .NET, so VS has been our first option. Despite that fact, and with the possibility of the migration of the platform in mind, we have made an important effort to separate the IDE dependent part of the platform from its model itself.

The main functionality provided by the IDE does not differ too much from the AJDT plug-in for Eclipse: creation of DSAW projects, creation and edition of aspects, a cross references view, etc.

Besides that functionality and due to the special features of the DSAW platform, the IDE provides the following extra features: a .NET Assembly Inspector and a Graphical Aspect Editor.

From the implementation point of view, the IDE has been divided into three main subsystems: the DSAW subsystem, the Model subsystem and the Integration subsystem.

3.1 DSAW subsystem

It is, strictly speaking, the DSAW platform.

3.2 The Model Subsystem

It comprises all the components that model the actual behavior of the DSAW platform. Those components make tasks such as assembly inspection, aspect definition analysis, aspect weaving modeling and IDE to file synchronization. Thus, all the relations among the component and aspect functionality of the application are available for any integration subsystem.

At this level, assembly inspection is necessary to build an in-memory representation of the application from the DSAW point of view: basically, the set of exposed and captured join points. Assembly inspection at the Model level is complemented at the Integration level by the Assembly Inspector, a visual tool that reminds the Object Inspector of VS.

The weaver element combines the information available in the in-memory representation of the application and in the aspect definition file to generate the cross references data, used at the Integration level by the cross references view.

3.3 The Integration Subsystem

It comprises all the components that interact with the Model subsystem, integrating them in the IDE (VS). Tasks accomplished by these components are those typical such as project administration, text editing, generation and execution of the DSAW application. Additionally, it will provide all the visual tools needed for managing projects. To achieve those goals, the Integration subsystem extends some MPF classes, uses the DSAW infrastructure to execute the application and exposes an integration package so the SDK can modify the environment.

The user can create DSAW projects that are composed of aspect definition files and references to assemblies. Those references can point to external assemblies or to any one belonging to projects in the same solution. Among other tasks, assemblies can be flagged either application components or aspects.

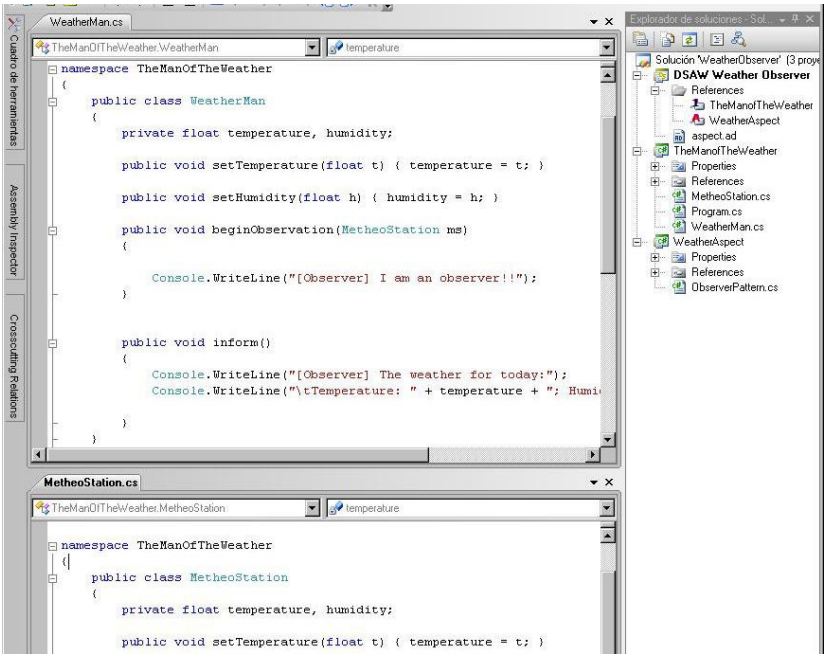


Fig. 2. The solutions explorer.

Fig. 2 shows an example application consisting of a potential use of AOP: the implementation of the Observer Design Pattern [6] using aspects. We want an object of one class to inform an instance of another class about certain event. In the example, a `MetheoStation` object records the value of some meteorological variables. A `WeatherMan` object is also capable of recording meteorological variables. The programmer

wants to connect both objects so that to the `WeatherMan` object is informed about every modification of the `MetheoStation` variables. Although in a more realistic example we will have several `MetheoStation` and `WeatherMan` objects, only one instance of each class has been considered for the sake of simplicity.

The observer pattern aspect is conceptually easy: it registers an observer (`WeatherMan`) object whenever a certain event occurs and informs him of any change on the observed object (`MetheoStation`) whenever such a change (`temperature` or `humidity`) is detected. Fig. 3 shows the aspect source code.

```
namespace WeatherAspect
{
    class ObserverPattern
    {
        static WeatherMan manObserver;

        public static object addObserver(string ns, string cl, string member, TypeOfMembers type, JPoint jp,
                                         Time time, Type resultType, object resultValue, Param[] parameters,
                                         object OBJECT_THIS, IReflection ir)
        {
            manObserver = (WeatherMan)OBJECT_THIS;
            Console.WriteLine("\t[Trace] Registering observer");
            return null;
        }

        public static object temperatureChange(string ns, string cl, string member, TypeOfMembers type, JPoint
                                         Time time, Type resultType, object resultValue, Param[] parameters,
                                         object OBJECT_THIS, IReflection ir)
        {
            Console.WriteLine("\t[Trace] Temperature in MetheoStation has changed. Informing observer");
            manObserver.setTemperature((float)parameters[0].val);
```

Fig. 3. The aspect code.

It is time to define the weaving rules to compose the resulting application. First, you must create a DSAW project and fill it with references to the assemblies that play the role of components and aspects. Fig. 2 shows such references in the example.

The Assembly Inspector shows a hierarchical representation of all the defined elements in an assembly. This view allows the user to inspect the exposed join points and to manipulate them to create or modify pointcuts and advice. Fig. 4 shows the Assembly Inspector presenting all the exposed join points found. The results of a pointcut creation operation can be seen in the Textual Aspect Editor (`aspect.ad`).

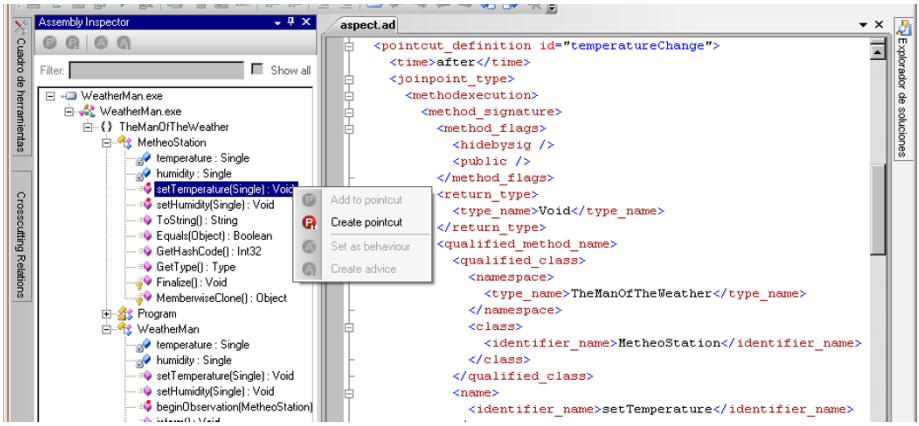


Fig. 4. Adding a pointcut.

Aspect manipulation through this textual view must be avoided as much as possible: if the aspect definition file is not valid (in the XML sense), weaving will fail. This has been one of the main reasons to build the IDE.

Aspect manipulation can be done, alternatively, using the Aspect Graphical Editor. It shows a visual representation of the contents of an aspect definition file and interacts with other elements in the view to allow the creation, edition and deletion of pointcuts and advice. Fig. 5 shows how pointcuts and advice relate to each other. Those relationships dictate how the weaving will take place.

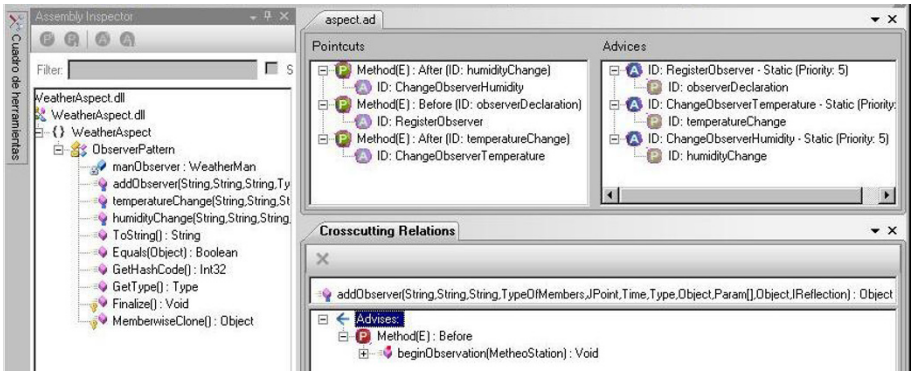


Fig. 5. Aspect Grafical Editor and Cross References View.

The Cross References View (Fig. 5) responds to events produced in other areas of the IDE, showing the relationships and dependencies defined in the aspect definition files that affect to pointcuts, advice, join points and behaviors. Again, the programmer has to focus on this information, because it describes, in a simple way, the expected interactions among the core and crosscutting concerns. In our example, we need to register the `WeatherMan` object as an observer of every station change, using a `Before` advice.

Once the concerns are implemented and the weaving rules are described, we can build our DSAW project. It is done like any other VS project, resulting in an invocation to the underlying JPI that composes the final application. If we then execute the DSAW project, we will see how the crosscutting part of the application alters its normal execution to make the necessary calls to the aspect. It is important to say, again, that the "new" version of the application has been built without any modification of the original source code. Fig. 6 shows the execution results when running the application with the observer aspect.

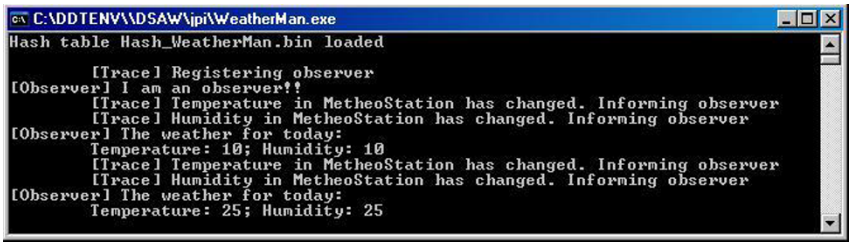


Fig. 6. Application execution with the observer aspect.

4 Related Work

AspectJ is the main reference in the field of AOSD. AspectJ Development Tools (AJDT) [7] is its natural complement for the Eclipse IDE. It is provided as an Eclipse set of plug-ins and integrates AspectJ in the infrastructure of Eclipse so the programmer can do all his ordinary tasks related to aspect development without leaving the IDE: aspect implementation, weaving rules specification, execution, debugging, etc.

Spring.Aop [8] is an aspect-oriented API and part of the Spring.NET framework. It comes with an aspect library containing aspects for caching, logging, etc.

5 Conclusions

AOSD promises to clearly separate concerns in order to maximize application modularity. Although concern implementation is carried out with the common methodologies (i.e. OOP), we need extra tools to deal with the weaving rules, so that the programmer could have a clear overview of the resulting system. Those tools must integrate with the IDEs where concern implementation takes place. That is the reason we have extended the VS IDE, providing features such as assembly inspection, aspect manipulation and interaction with the underlying DSAW platform. The programmer feels comfortable in such an IDE because it avoids him to do all the tricky tasks that could make the resulting application incorrect.

Future work will be centered in the next objectives: facilitate the edit-debug-test cycle within the environment, improve the navigational tools, and evolve the IDE features as the platform is now doing, providing support for dynamic weaving.

Acknowledgments. This work has been funded by the European Union, through the European Regional Development Funds (ERDF); and the Principality of Asturias, through its Science, Technology and Innovation Plan (grant GRUPIN14-100).

References

1. G. Kiczales, J. Lamping, A. Mendhekar, C. Maeda, C. V. Lopes, M.-M. Loingtier, and J. Irwin. Aspect-Oriented Programming, in ECOOP: European Conference on Object-Oriented Programming (Berlin), pp. 220-242, Springer Verlag (1997)
2. B.C. Pierce. Types in Programming Languages, MIT Press (2002)
3. AspectJ homepage. http://eclipse.org/aspectj.
4. Luis Vinuesa, Francisco Ortín, José M. Félix and Fernando Álvarez. DSAW – A dynamic and static aspect weaving plaform. In ICSOFT (PL/DPS/KE), pages 55-62. INSTICC Press (2008)
5. T.C. Ecma. TG3. Common Language Infraestructure (CLI). Standard ECMA-335 (2005)
6. E. Gamma, R. Helm, R. Johnson, J.M. Vlissides. Design Patterns: Elements of Reusable Object-Oriented Software. Addison-Wesley Professional (1994)
7. AspectJ Development Tools homepage. http://www.eclipse.org/ajdt/
8. Spring.NET homepage. http://springframework.net/

A predictive model for exception handling

João Ricardo Lourenço[1], Bruno Cabral[1], and Jorge Bernardino[1 2]

[1] CISUC – Centre of Informatics and Systems of the University of Coimbra
FCTUC – University of Coimbra, 3030-290 Coimbra, Portugal
[2] ISEC – Superior Institute of Engineering of Coimbra
Polytechnic Institute of Coimbra, 3030-190 Coimbra, Portugal
joaoml@student.dei.uc.pt, bcabral@dei.uc.pt, jorge@isec.pt

Abstract. The exception handling mechanism has been one of the most used reliability tools in programming languages for over four decades. Nearly all modern languages have some form of "try-catch" model for exception handling and encourage its use. Nevertheless, this model has not seen significant change, even in the face of new challenges, such as concurrent programming and the advent of reactive programming. As it stands, the current model is reactive, rather than proactive — exceptions are raised, caught, and handled. We propose an alternative exception handling model — PreX — where exceptions are no longer caught but, rather, predicted and prevented. Online Failure Prediction techniques generally work at a very high level, showing potential for prediction of program crashes. However, these techniques have never been at the hands of the programmers as an effective tool to improve software quality. By applying recent advances in Online Failure Prediction, PreX aims to fully prevent exceptions, bringing failure prediction techniques to a much more fine-grained level that the programmer can control. Predicting exceptions enables a range of preventive measures that enhance the reliability and robustness of a system, offering new revitalization strategies to developers.

Keywords: Exception Handling, Online Failure Prediction, Self-Healing

1 Introduction

The Exception Handling (EH) mechanism was proposed by Goodenough [1] and has been one of the most used reliability tools in programming languages for more than four decades. This model has gone unchanged, even in the face of concurrent software and programming languages for multi-core platforms (e.g. Scala, Erlang and Elixir). Thus, the sequential Exception Handling model remains the preferred Exception Handling model [2].

However, the ubiquity of the Exception Handling mechanism for error recovery does not imply its most correct or desirable usage. Most of the time, developers use EH language constructs as a way of hiding problems, performing log activities or informing the user of unexpected behavior, rather than recovering from it autonomously [3]. This kind of use of EH might be considered a

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_72

symptom of a design flaw in the mechanism – the system only acts when it is too late, thus making the problem unavoidable.

In this paper, we propose a new approach to Exception Handling, by providing the means for developers to act on an exception before it happens, thus broadening the range of their revitalization strategies. The approach reshapes the concept of "try-catch" blocks, so that programmers can be alerted of potential exceptions within a given time frame and take some action, much like in the conventional Exception Handling mechanism. This new approach is called **Preventive Exception Handling (PreX)**, and applies the methods and techniques of the Online Failure Prediction field to the lower-level concepts of programming languages, thus empowering programmers to act proactively. PreX introduces a new model for Exception Handling, with the goal of being easy to use, practical, and a successful integration of the fields of Exception Handling and Online Failure Prediction, as well as the first to act on potential exceptions before they have happened – errors are avoided, rather than handled. In contrast to Online Failure Prediction, which operates on a much higher level of abstraction, PreX allows programmers to produce code that is aware of possible predictions during its execution, so that very fine-grained solutions for exception prevention and reaction to potential exceptions can be applied. By acting on exceptions before they happen, developers get an increased range of techniques for dealing with exceptions. Thus, while traditional Exception Handling techniques can still be used, there is potential for new and hopefully more efficient strategies.

To illustrate the motivation for this new model, consider a system consisting of at least a database and several client applications. Consider also that these client applications are write-heavy, meaning they processes several thousands of write operations per second, sending them to the database. Due to the heavy load, the database may slowly become unresponsive and ultimately trigger a *ConnectionTimeout* exception on one of the applications. That application will then have to attempt to reconnect, and restart where it was previously, if such is really possible. This shows the aforementioned downfall of the conventional Exception Handling mechanism – the system only reacts to exceptions, it does not prevent them. Our motivation stems from this issue – we believe that the client applications would benefit from a prediction (i.e. a warning) that the database may trigger a *ConnectionTimeout* exception. With such a warning, they can, for instance, proactively slow their execution rate and prevent the exception from happening. Ultimately, slowing execution down could prove to be more efficient than triggering the exception and restarting the whole process.

The main contributions of this work are as follows: a) explanation of the need for a paradigm shift in Exception Handling; b) proposal of a new model for preventive handling of exceptions; c) presenting results that evidence the feasibility of the proposed model in the prediction and handling of likely exceptions.

The remainder of this paper is structured as follows. Section 2 presents background in Exception Handling models and mechanisms and Online Failure Prediction. Section 3 details the proposed model. Section 4 presents preliminary results of the model. Finally, Section 5 contains our conclusions and future work.

2 Background and Related Work

Exception Handling separates the operation domain into two distinct domains: the operation's *standard domain*, and the operation's *exceptional domain*. Normal program flow, absent of errors, is contained in the *standard domain*. If an exception or error condition is encountered, an exception is *raised*, followed by the invocation of an *exception handler*, that, in theory would deal with the abnormal condition and correct it. This invocation is done by a *signaller* (i.e. *callee*). An *Exception Handling Model* defines the interaction between the signaller and its handler. An *Exception Handling Mechanism* defines the language constructs within a programming language to express a given Exception Handling Model. [4]. In this section, we give an overview of the classical and current Exception Handling models and their limitations.

2.1 Exception Handling Models

Yemini et al. [5] identified four distinct Exception Handling Models, summarized in [6]:

- **Resumption model** – When an exception is raised, the control flow is transferred from the raise point to the handler and, after the exception has been handled, it is transferred back to the raise point. This model effectively binds the caller and the callee together and is prone to recursive resumption, thus being difficult to implement [6].
- **Termination model** – An exception is raised within a protected block, with the control flow transferred to the handler, terminating any intervening blocks. The control flow then resumes as if the protected block terminated without any errors. This is the most widespread model in use [6].
- **Retrying model** – The signaller is invoked after some operation has been made. This model is more appropriate to transient faults, where retrying the invocation might lead to no exceptions. The main disadvantages of this model are its inherent implications for non-idempotent operations, counters, etc – the programmer must be wary of how the code executes.
- **Nonlocal transfer** – The program flow can be transferred to any other location in the program. This model has the obvious drawback of being hard to maintain and much more error-prone [6].

Modern advances in Exception Handling, such as concurrent exception handling or alternative models in the context of the actor model and Functional Reactive Programming, still share a common characteristic with these classical models – an exception is raised, and only then can corrective actions happen. This, unfortunately, means that many incorrect uses of Exception Handling Mechanisms arise, with programmers focusing on hiding errors, rather than attempting to fix them [3]. PreX intends to shift the current practice and allow programmers to act before problems arise.

2.2 Failure Prediction

Recent trends in industry and academia have triggered a shift to new efforts on autonomic computing, trustworthy computing, recovery-oriented computing and other techniques for proactively handling failures. Several techniques have been proposed and used with success, to an extent, in Online Failure Prediction systems. Salfner et al. [7] present a lengthy survey and taxonomy of online failure prediction systems. In their work, these authors explain how Liang et al. [8] explored temporal and spatial correlation to successfully predict hardware component failures in IBM's BlueGene/L. Cheng et al. [9] presented an approach for failure prediction within a high availability cluster system. They showed that they could improve the availability due to accurate prediction and recovery mechanisms (backup nodes and system administrator notifications). Vilalta et al. [10] propose the eventset method, using a data mining approach (a rule-based model). Under specific conditions, they have a false negative error of only 0.16, although this value can be as extreme as 0.83 under other system conditions (false positives are always lower than 0.1).

These and other results show that Online Failure Prediction can be successfully used to predict failures. However, little work has been done for predictions at a more fine-grained level. Predictions are usually made at the system level, at most predicting a generic "crash" of some component. Thus, while promising, these techniques have no practical use for developers who wish to provide specific counter-measures when faced with the possibility of an exception. In this sense, some work has been done in the field of self-healing systems. For example, Magalhães and Silva [11] propose a general self-healing proactive framework for web-based applications. Their work introduces a general framework to create self-healing transactional web-based systems. The framework, although operating at a lower level than traditional Online Failure Prediction methods, does not support run-time notifications at code-level nor operate at the fine-grained level that might be desired for applying more efficient preventive measurements.

3 A New Model for Exception Handling – PreX

PreX is an Exception Handling model that focuses on preventing exceptions rather than catching them. The central idea was depicted with the example given in Section 1: it could be more efficient to temporarily reduce the throughput of a write-heavy application than to catch a *ConnectionTimeout* exception and have to restart the process. We believe that there are other scenarios, similar to this, where systems and developers would benefit from an easy-to-use proactive model for Exception Handling. We now present PreX. Note that this is not a formal description of the model, such work is out of the scope of this article due to the space limitation.

Preventing exceptions implies predicting them. To this end, the area of Online Failure Prediction provides valuable insight. There have been successful failure prediction systems, but these operate on a much broader level. In order to predict exceptions, the proposed model needs to adapt failure prediction techniques to a

per-exception basis. Furthermore, since no two systems are alike, the prediction models will have to be trained for specific deployments. Thus, the PreX model comprises different phases from development to successful prevention:

1. **Coding phase**. The programmer develops the application using a new set of programming language constructs introduced by the PreX model. These are similar to traditional *try-catch* blocks seen in several languages.
2. **Training phase**. In this phase, different machine learning algorithms are applied (after feature selection, data pre-processing, etc), determining which is the most applicable to the specific exception. Data is gathered for different runs of the application, using resource monitoring facilities.
3. **Detection phase**. The application is deployed with the trained model and executed. The model is used to detect potential exceptions. If the trained model becomes ineffective due to changes in environment conditions, the training phase might be required again. Alternatively, self-adapting pattern recognition algorithms can be used.
4. **Prevention phase**. If an exception is predicted, the application can apply preventive measures and try to avoid the potential exception from effectively being raised.

In the following sections, each of these phases is detailed from the perspective of the syntax and semantics of the model, followed by an overall perspective of the architecture and the necessary components of PreX. Lastly, the behavior of the system during its different phases is presented.

3.1 Syntax & Semantics

An example of the syntax of PreX is shown in Figure 1. Pseudo-code similar to Java is used. A database connection is established to send a number of pending writes (sent at line 15). PreX provides semantics similar to traditional *try-catch* blocks, although two different constructs are added to the language: *try { }-prevent(){ }-catch(){ }* and *try{ }-prevent_ async(){ }-catch(){ }*. Additionally, in PreX, predicting an exception does not necessarily terminate the execution of code within the *try* block (as opposed to the *termination* model). Instead, execution is resumed as if the exception had not been predicted, because preventing an exception should not halt normal execution of the current code.

If an exception is predicted, it can be handled in two different ways:

- **Synchronously**: execution within the *try* block is suspended and flow is transferred to the *prevent* block. In normal circumstances, the execution is then transferred back to the previous code within the *try* block.
- **Asynchronously**: execution within the *try* block continues normally, and the *prevent_ async* block is executed asynchronously.

Thus, the *try* block denotes the scope during which a program cares about predicting some exception, the protected region. This exception may then be predicted and raised synchronously. If the exception is not predicted or cannot be

prevented, it is effectively raised by the code, and the traditional (synchronous) Exception Handling model is used, with program flow being transferred from within the *try* block to the *catch* block.

When using the synchronous approach, predicted exceptions are not raised at just any point in time within the *try* block. Within this block, every program statement will be executed without any interruption from the exception prediction mechanism. The flow of execution only moves to the prevention handler between statements, thus eliminating the need for propagation in the call stack. Thus, unlike traditional Exception Handling models, PreX uses a static binding approach, meaning that exceptions are not propagated. Instead, they are tied to the handler of the *try-prevent-catch* or *try-prevent_ async-catch* to which they belong. Only the closest code, within the exact context of the particular exception, can know how to react to a specific prediction. If developers wish to prevent the delivery of predicted exceptions during the execution of a set of statements, a special *no_ interrupt* keyword can be used to denote a new scope within which interruptions are not possible. In Figure 1, lines 13-16 belong to one of these scopes. In the asynchronous approach, as in the synchronous approach, exceptions are only delivered when the program flow is outside the protected block. Thus, the *no_ interrupt* keyword can act as a synchronization primitive between the prediction asynchronous handler code and the code within the *try* block.

PreX allows programmers to periodically sample variables that they think will be useful for prediction, in addition to system variables monitored with custom probes. For instance, the remaining number of operations left might be useful in predicting connection timeouts. These variables can be supplied to the prediction system at any time using the *sample (<variable_ name>,<variable_ value>)* construct. Furthermore, since no two systems are alike, the prediction models will have to be trained for specific deployments. In particular, note that, for instance, *ConnectionTimeout* exceptions may be different depending on the workload (e.g. "write-heavy" vs "read-heavy") or the variables being provided by the program. This motivates the need to distinguish different blocks of code and assign them meaningful names. Thus, the *try* keyword requires an additional argument that uniquely identifies the block of code that it encloses: *try(<prediction context>)*. Write-heavy blocks can then use *try("write-exceptions")*, whereas read-heavy blocks can use *try("read-exceptions")* to handle two completely different models for the same kind of exception (*ConnectionTimeout*) under different contexts. The argument of the *try* keyword is the *prediction context*. Several exceptions can be predicted within the same *prediction context*, and a *prediction context* binds training data and a prediction model to a unique name. An example of this construct is in line 10 of Figure 1.

To train the model, the system administrator may specify which *prediction context*s he/she wants the program to be trained in during a training phase. When in this training phase, no prediction mechanism is used in those *prediction context*s and exceptions can only be caught. Data with the *sample* keyword is still fed to the training mechanism, and if the exception is raised and caught, this training mechanism is notified to adapt its prediction models.

```
1  // Connect to database and build list of data to write
2  DBConnection c = connectToDB();
3  List<Write> writes = fetchWrites();
4
5  // Try to predict exceptions using the "write-exceptions"
6  // prediction context  (a)
7  try("write-exceptions") {
8      for (int i = 0; i < writes.size(); i++) {
9          // Feed writes left to the prediction system
10         sample('writes_left', writes.size()-i);  (b)
11         // Write the data through the connection
12         // Don't allow prediction interruptions
13         no_interrupt{  (c)
14             print("Writing data!");
15             c.write(writes.get(i));
16         }
17     }
18 } prevent ( ConnectionTimeout e ) {  (d)
19     // Sleep for some time to prevent an exception
20     sleep(1000);
21 } catch ( ConnectionTimeout e ) {
22     // The exception could not be avoided...  (e)
23     error("Database timeout!");
24 }
```

Fig. 1. Example of PreX using synchronous *try-catch-prevent*.

3.2 Architecture

Within PreX, exceptions can be predicted using system-wide information. Several entities can share information used for prediction (more data, when appropriately filtered, implies better predictions). An entity need not be an independent machine on its own, and different entities might share the same machine. There are three main kinds of entities within a system using PreX:

- **Coordinator entities**: A (potentially replicable) coordinator entity, responsible for aggregating the data from the other two types of entities and running the prediction system.
- **Data gathering entities**: These entities feed periodic samples of data (e.g. memory and CPU usage) to the coordinator entities. Most of the prediction data comes from these entities, which don't execute any code that wants to predict exceptions. The sampling rate for each of these variables is not pre-determined and may vary according to system load and characteristics.
- **Code entities**: Whenever an application wants to predict exceptions (or train that prediction), it spawns a code entity that connects to its coordinator entity. Each code entity may want to register with the coordinator for a certain kind of exception within a *prediction context*. These entities are then notified whenever an exception of that kind has been predicted. It is the responsibility of the code entity to raise the local exception within the code.

It is then clear that each *try-predict-catch* or *try-predict_ async-catch* block spawns a new code entity. The coordinator entity is responsible for running the failure prediction methods for predicting exceptions. These can be selected *a priori* by a system administrator during the training phase.

The behaviour of the code and coordinator entities is different during the training phase. During this phase, the code entity registers that it will be sending

data and information regarding a given *prediction context* and a given exception. The coordinator then uses this data to train the model.

Since we are dealing with a distributed system, it is complex to generate samples at the exact same time in every entity. For this reason, the coordinator entity groups data within time windows. Precise information about when an event (e.g. a data sample) happened is lost in favor of a more general interval during which several events happened. This data can then be processed using Online Failure Prediction methods such as those presented in [10], [12] or [13].

3.3 Behaviour

To illustrate the behaviour of PreX, Figure 2 depicts the interaction between code, entities, and the prediction system for the code example in Figure 1 during a prediction. Notice that the code uses the synchronous prediction model. In the asynchronous prediction model, the *no_ interrupt* keyword would not be allowed. Also note that if the code was executed during the training phase, no exceptions would be predicted, so sections *c* and *d* would not be entered.

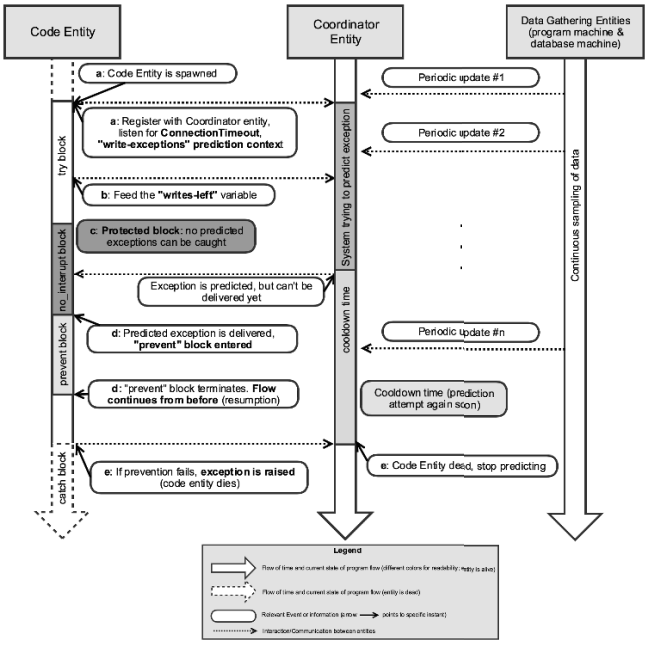


Fig. 2. Interaction between code and entities through time for the code example in Figure 1. For simplicity, in this example, the loop only runs once.

4 Preliminary Results

We have conducted experiments with the TPC-W benchmark to demonstrate that the proposed model is feasible in the prediction and handling of likely exceptions. TPC-W simulates the activities of a retail store Web site. It has a workload generator that emulates the behavior of users according to pre-specified configurations. In our experiments, the connection pool of the TPC-W server was exhausted due to client overload, resulting in different *NullPointerException*s. Using failure prediction methods, we attempted to predict these exceptions.

The setup consisted of three virtual machines running the Crunchbang Linux distribution (Irrera et al. [13] showed that virtualization did not significantly influence failure prediction results). These were allocated with 1 GB of RAM and a single virtual CPU core. They communicated through a local network bound to the host machine. One of the machines ran the TPC-W Server, the other the MySQL database, and the third the TPC-W load-generator. In this third machine, a custom-built data gathering tool was placed, sampling data at the rate of 100 samples per second. 49 variables were sampled, including CPU load, open TCP connections, and number of running processes.

After recording several *golden-runs* (executions with no failure), as well as several executions with failure, the final data was passed to a pre-processing window-based algorithm (the dataset was filtered to contain a balance between both kinds of runs). This algorithm involved two stages: (i) *time-window construction* and (ii) *window-merge*. In the first, fixed time windows of size T, starting at time $t = 0$ were created. For each of the 49 variables, samples within the same window were condensed using the mean, standard deviation, maximum, minimum, and derivative (rate of change). Thus, each window contained 245 variables (5×49). The second step, *window-merge*, involved concatenating N of the previously generated time-windows, appending them with a binary variable indicating if a crash was recorded within the next group of merged windows. In practice, each group of merged windows offers a *time-to-failure* prediction of $N \times T$. The final windows were then processed within *Weka*[3] as a classification problem. Empirically, we chose $T = 5$ s and $N = 2$, meaning a *time-to-prediction* of 10 seconds. The experiments were done for a TPC-W simulation of a "slow" and "fast" ramp up of users. This was done to assess if classifiers trained with one set of data could still be accurate on different data within similar circumstances.

The results were promising – with 10-fold cross-validation, a Naive Bayes classifier only failed to predict failures 1.52% of the time, and inaccurately predicted a failure 8.89% of the time. When this classifier was applied to data from the "faster" ramp of TPC-W clients, the false negative rate was of 23.3%, whereas the false positive rate was 7.01%. These results, although very preliminary, show that prediction of exceptions is within our reach, and that such a model can be useful for programmers – in this scenario, a time-to-prediction window of 10 seconds would allow the TPC-W clients to reduce their rate of requests, thus preventing or delaying the exception.

[3] `http://www.cs.waikato.ac.nz/ml/weka/`

5 Conclusions and Future Work

In this paper, we have proposed a new Exception Handling model that defies nowadays' Exception Handling preconceptions. Current research in exception handling and online failure prediction shows that a fine-grained system for predicting exceptions is currently missing. Instead of catching exceptions, this model proposes that the system, as a whole, actively work towards predicting and preventing exceptions. Applications can then be more resilient, robust, reliable and have increased performance. Our preliminary results also show that it is possible to predict exceptions, and that a paradigm shift towards prevention, rather then reaction, is quite within our reach. As future work, we intend to develop a proof of concept implementation of PreX in a modern programming language.

References

1. Goodenough, J.B.: Exception handling: issues and a proposed notation. Communications of the ACM **18**(12) (1975) 683–696
2. Fonseca, A., Cabral, B.: Handling exceptions in programs with hidden concurrency: New challenges for old solutions. In: Exception Handling (WEH), 2012 5th International Workshop on, IEEE (2012) 14–17
3. Cabral, B., Marques, P.: Exception handling: A field study in java and. net. In: ECOOP 2007–Object-Oriented Programming. Springer (2007) 151–175
4. Issarny, V.: An Exception Handling Mechanism for Parallel Object-oriented Programming: Towards the Design of Reusable and Robust Distributed Software. Inst. National de Recherche en Informatique et en Automatique (1992)
5. Yemini, S., Berry, D.M.: A modular verifiable exception handling mechanism. ACM Trans. on Programming Languages and Systems (TOPLAS) **7**(2) (1985) 214–243
6. Cabral, B.: A Transactional Model for Automatic Exception Handling. PhD thesis, Universidade de Coimbra (2009)
7. Salfner, F., Lenk, M., Malek, M.: A survey of online failure prediction methods. ACM Computing Surveys (CSUR) **42**(3) (2010) 10
8. Liang, Y., Zhang, Y., Jette, M., Sivasubramaniam, A., Sahoo, R.: Bluegene/l failure analysis and prediction models. In: International Conference on Dependable Systems and Networks, IEEE (2006) 425–434
9. Cheng, F.T., Wu, S.L., Tsai, P.Y., Chung, Y.T., Yang, H.C.: Application cluster service scheme for near-zero-downtime services. In: Proc. of the 2005 IEEE International Conference on Robotics and Automation, IEEE (2005) 4062–4067
10. Vilalta, R., Ma, S.: Predicting rare events in temporal domains. In: Proc. of the IEEE Int. Conf. on Data Mining (ICDM), IEEE (2002) 474–481
11. Magalhaes, J.P., Silva, L.M.: Showa: a self-healing framework for web-based applications. ACM Trans. on Autonomous and Adaptive Systems **10**(1) (2015)
12. Chen, X., Lu, C.D., Pattabiraman, K.: Failure prediction of jobs in compute clouds: A google cluster case study. In: IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW), IEEE (2014) 341–346
13. Irrera, I., Duraes, J., Madeira, H., Vieira, M.: Assessing the impact of virtualization on the generation of failure prediction data. In: Sixth Latin-American Symposium on Dependable Computing (LADC), IEEE (2013) 92–97

Reasoning Service enabling SmartHome Automation at the Edge of Context Networks

Hasibur Rahman*, Rahim Rahmani, Theo Kanter, Magnus Persson, Stefan Amundin

Department of Computer and Systems Sciences (DSV)
Stockholm University
Nod Buildning, SE-164 55 Kista, Sweden
{hasibur,rahim,kanter}@dsv.su.se,{mape3710,stam3524}@su.se

Abstract. The popular concept of SmartHome means that the appliances such as lighting, heating and door locks are controllable remotely through for example remote controls or mobile phones. The concept is becoming more and more realizable due to recent advancements in Internet-enabled technologies. SmartHomes can become even more intelligent and automated by exploiting such intelligent and affordable Internet-enabled technologies. However, this necessitates a context-aware system that provides services to respond to the context changes to enable such SmartHome automation at the edge of today's context-centric networks. To this end, this paper designs and develops a context-aware reasoning service for home automation which provides a novel way to connect SmartHomes through the use of a distributed context exchange network overlay. It enables mobility service application to communicate with and control SmartHomes remotely.

Keywords: Context-aware, Internet, reasoner service, SmartHome, ubiquitous

1 Introduction

The concept of SmartHome has been around since 1980s. The idea was to empower users to remotely control their homes. It can provide economic benefit by optimizing energy consumption, and it can also be used for security purposes [1]. Interactive technologies enable a home to be smart. With the emergence of new and novel interactive technologies, the implementation of SmartHome changes accordingly. One of the earlier implementations of SmartHome in 2001 exploited the GSM technologies where a home was connected to a network and server that enabled remote control of lighting, heating and other appliances in the home [2]. Further, web, wireless sensor network (WSN), and mobile and desktop computer based SmartHome implementations have been explored [3, 4, 5]. The recent advancements in Internet-of-Things (IoT) landscape and context-aware computing provide a better and efficient way of enabling SmartHome. This, however, requires designing and developing new innovative services to empower users to control their homes remotely for example by using their smarphones. Earlier approaches such as the GSM approach in [2] required

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_73

human intervention to enable the SmartHome automation [8]; this however is a bottleneck in today's cutting edge communication where more and more Internet-enabled devices are getting connected to the IoT landscape. A user's home appliances such as thermostat radiator for controlling heating, indoor and outdoor lighting, door lock, surveillance camera, etc. can be connected to Internet and user can monitor and control these appliances remotely via Internet-enabled services in real-time. HVAC (Heating, Ventilation and Air Conditioning) system provides such a way of controlling home appliances for optimizing energy [9]. However, the system lacks to provide mechanism for communication between user and her SmartHome. Recent advancement in automating home, for example, Honeywell's programmable thermostat allows to program thermostat and automatically turns on and off when a threshold value is met [12]; Tellstick allows wirelessly monitoring and controlling smart devices [13]. Vision of a universal SmartHome model implementation was earlier shown by Bregman and Korman in [6]. The model included a User Interface (UI), home appliances, central management system and the communication interfaces. The paper only suggested a model for standardizing the SmartHome model; it lacked the real implementation to enable the SmartHome. Therefore, in this paper, we demonstrate the design and development of a *Reasoning Service* as a Generic Enabler to enable true SmartHome automation independent of any particular home automation solution, for example, Honeywell's or Tellstick can be connected to it. Figure 1 shows the implementation scenario. The Reasoning Service is a context-aware service which would respond to context changes in the network. Such context-aware service would automate SmartHome upon user's changes in context by using a mobile application.

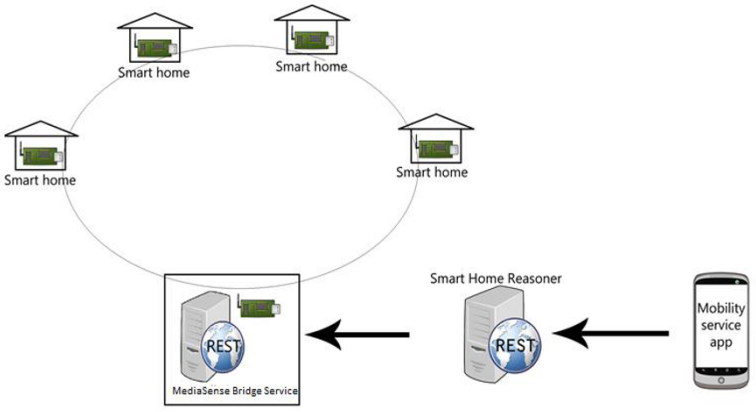


Fig. 1. SmartHome automation implementation

To enable true SmartHome automation via the novel Reasoner Service, we have designed and developed several sub-artifacts such as *SmartHome Reasoner* (SHR), MediaSense bridge service and a mobility service application (android application, i.e. user interface). Each of the sub-artifacts described in the following sections.

2 SmartHome Reasoner

SmartHome Reasoner (SHR) is a REST API, part of MobiS REST APIs [11], which connects with other services to enable automating a SmartHome. This reasoner provides other functionalities to the mobility service application and MediaSense bridge service. Therefore, it does the bulk of the work for providing generic solutions to enable novel communication between user and her SmartHome. These are tabulated in table 1 and further described below and followed by few descriptions of algorithms.

Table 1. Reasoner Services.

Services	Description
Status	Retrieves current status of a SmartHome. It connects to an external service (i.e. bridge service) that retrieves information from the SmartHome
Compare	Compares Time to Heat and Expected Time of Arrival, and alters thermostat radiator accordingly
Thermostat	Turns the heating ON or OFF in a SmartHome
Light	Turns the lighting ON or OFF in a SmartHome
Home	Starts the SmartHome arrival and automates temperature and light to "Home" status
Away	Starts the SmartHome departure and automate to away temperature (T_{away}) and light to "Away" status
CalculateTTH	Calculates Time to Heat (TTH) based on current indoor temperature (T_{indoor})and user's expected temperature at home (T_{home})
RegisterSH	Registers new SmartHome devices to the databases
Mapping	Maps user existing email address to available SmartHome ID and assigns its proper ID
Database	Stores SmartHome settings such as identification for each SmartHome devices, values for T_{home} and T_{away}, Light Status, SmartHome location, etc.

Each of the method calls makes a REST GET request to the SHR. Three different calls needed for a sensor (fetches current temperature, i.e. T_{indoor} and $T_{outdoor}$) and two actuators (thermostat and lighting are actuators), which are identified by unique IDs (UCI).

```
Algorithm 1: Status
Input: email id, user id, uci, smarthome id
if authorizeUser (email id, user id)
 getCurrentTemperature (user id, smarthome id);
 getThermostatSetpoints(user id, smarthome id);
 getLightStatus(user id, smarthome id);
else
 exit
Output: Tindoor, Toutdoor, Thome, Taway, LightOnorOFF
```

```
Algorithm 2: Thermostat
Input: email id, user id, action
if Thome && Taway are saved
 if authorizeUser (email id, user id)
  if trip action is home
  activateSmartHomeTrip(user id, home);
  showRoute(origin, destination);
  if TTH is less than 5 minute
   turn outdoor lighting ON
  else if trip action is away
   activateSmartHomeTrip(user id, away);
   turn outdoor lighting OFF
  else
   exit
else
 ask to save Thome and Taway
Output: Route, Thome or Taway at cottage, light ON
```

```
Algorithm 3: CalculateTTH
Input: Tindoor, Thome, tsecond
if Thome > (Tindoor + 1° C)
 Tdifference = Thome - Tindoor
 TTH = Tdifference /tsecond;
 TTH = TTH - (TTH % 1);
else
 TTH = 0;
Output: TTH
```

If the T_{home} is less than T_{indoor}, the algorithms will not return any TTH as there is no heating calculation required. The algorithms let the thermostat radiator to alter temperature by 1° C in every t_{second} (Δ_{time}).

Algorithm 4 returns the authorize user id for the fetched email id. The email id is the primary email address used on user's android phone; the SmartHome android application provides method for automatically retrieving the email id.

```
Algorithm 4: Mapping
Input: email id
Retrieve email id (primary) of the smartphone
Read and sort the list of authorized email ids and
corresponding user ids
if email id is in the list
 return corresponding user id
else
 no user id found
Output: user id
```

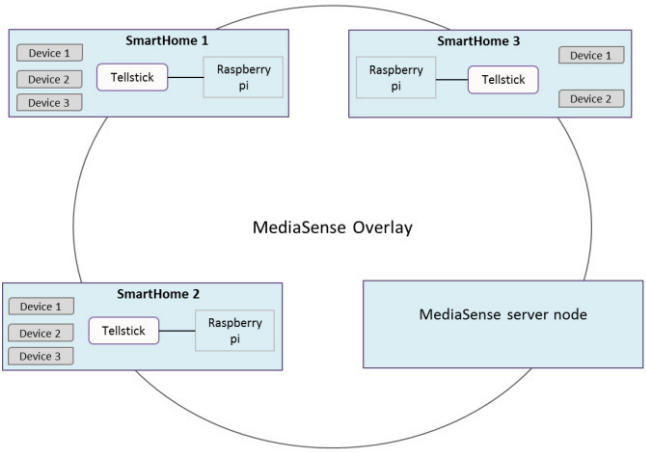


Fig. 2. SmartHome automation implementation

3 MediaSense Bridge Service

MediaSense bridge service is an extended service to the current MediaSense platform. MediaSense is an IoT context sharing platform [7], and it is implemented using Distributed Context eXchange Protocol (DCXP). DCXP offers simple way of communicating between entities. This bridge service runs as a MediaSense entity and each SmartHome registered on the platform is considered a MediaSense entity. These SmartHomes form a MediaSense overlay (Distributed Hash Table) as shown in figure 2 and communicates using DCXP. This newly developed bridge service is also a REST API which offers able-services to SmartHomes and to SHR. Each of the SmartHome devices gets registered on the MediaSense platform via SmartHome gateway. An advantage of using MediaSense for our solutions is that devices at home can continue communication even if it changes its IP address, since the devices are identified using UCIs which are on the MediaSense overlay and agnostic of IP address [8, 10]. Since the SHR is a generic enabler and any SmartHome gateway solution can be added to this SHR, the paper employed a SmartHome gateway which

consists of a Raspberry pi connected to a Tellstick which wirelessly controls and monitors the SmartHome devices. Figure 2 illustrates this. Raspberry pi can be connected to Internet by Wi-Fi or Cellular data or broadband. The SmartHome devices' data are saved on the MediaSense overlay as UCIs' respective context information. The UCIs are then forwarded to the SHR in order to save in the database for further communication between user's mobility application and her SmartHome. This bridge service provides following services:

- **Device registration**. This service makes sure that each SmartHome device gets registered on the MediaSense overlay and gets unique ID which in turn used for further communication between user interface and gateway.
- **Retrieve data**. This service provides mechanism to retrieve SmartHome data from the devices via SHR to the user's application, and vice versa.
- **Set values**. This service fetches value from the user settings via SHR and alters devices' value accordingly, e.g. turning on light, start heating, etc.
- **Save history**. This service is included which can be used for saving historical data about a certain SmartHome for improving the service, e.g. TTH, and further research.
- **Access data**. This service is intended for crowdsourcing purposes. It means that if user allows to crowdsource its data to other SmartHome users then data will be accessible to them [7]. This can be, for example, used for crowdsourcing current outdoor temperature ($T_{outdoor}$) to those that do not have sensor for getting current outdoor temperature.

4 User Interface

Earlier work done for enabling SmartHome addressed GSM based, web based solutions, etc. to access SmartHome. In GSM-based solution, SMS was used for automating without letting user know in real-time about the current status, and web-based solution provided user interface where user required log-in each time she would interact with her SmartHome. Furthermore, she would require opening a webpage on a web-browser which is not convenient for real-time communication and it does not provide user friendly interface as well. In light of this, we have developed a mobility service application, SmartHome android application, which would automatically map user's email address and its corresponding SmartHome ID- thus providing the required authorization in real-time. The application also provides a user-friendly interface to the users where user can check the status of the current indoor and outdoor temperature at the cottage in real-time. User can also save her desired temperature for T_{home} and T_{away}, and can turn light on and off. As part of the EU MobiS project, the application also provides route from user's current location to the cottage location [11]. MobiS application provides different criteria for choosing route to the destination. As for SmartHome application, it takes the fastest route to the cottage location as shown in figure 3 (b). Figure 3 shows part of the SmartHome application (settings and on trip scenarios).

Figure 3 (a) shows real-time T_{indoor} and $T_{outdoor}$, outdoor light status from a SmartHome gateway located at Kista, Stockholm, Sweden (at 01:54 pm, 27/10/2015), further it shows user's saved T_{home} and T_{away} (all temperatures are shown in ºC). When user clicks the "Start Trip to SmartHome" button, the application forwards an activation request to SHR by calling its *Home* service.

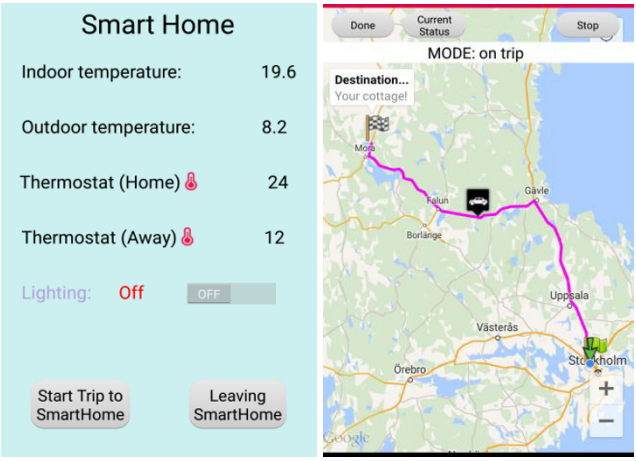


Fig. 3. SmartHome user interface

The activation requests include user's SmartHome ID which is automatically mapped in real-time by automatically retrieving user's primary email address from the smartphone. And if the authorization is successful, gateway starts heating the home to T_{home}. Start trip takes user to the route, where the application provides option to check current status, stop the trip which triggers the "*away*" status by default. Thus, user is able to check if the heating has started and if user changes her mind and wants not to travel to cottage; user can set SmartHome to away status. This away status is activated by calling SHR's *Away* service which sets indoor temperature to T_{away}. SHR also provides a service which automatically detects if user is few minutes (e.g. 5 minutes) away from home and application automatically asks if user wants to turn on the outdoor lighting upon her arrival at SmartHome.

5 Discussions

Figure 4 shows some typical scenarios user might be interested in a SmartHome. First of all, user would want to retrieve her home devices' current status and later, if needed, alter its status. The implementation described in this paper only looks into the four scenarios as shown in figure 4. However, the implementation can easily be extended to match other scenarios in any SmartHome solution. The reasoning services, i.e. SmartHome Reasoner (this includes the database) and the MediaSense bridge service, are already deployed and running on the MobiS server. All services that are listed in table 1 have been tested successfully. Figure 3 shows result of a test

case, where we have successfully tested our solution for most services. Table 2 further shows result of different scenarios for calculateTTH service.
In table 2, Δ_{temp} shows the difference between T_{indoor} and expected T_{home}. However, the TTH calculation is done using a simple algorithm which means that it will only provide the mean time for heating from one temperature to another which can be considered sufficient for our solution. This shows that calculateTTH can do an estimation of the needed TTH.

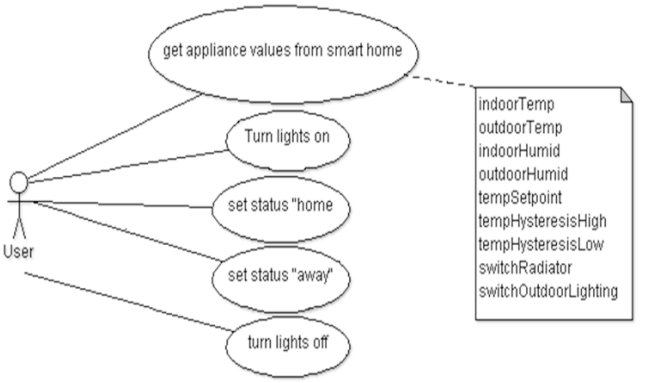


Fig. 4. Typical SmartHome use case

Table 2. Time to Heat (TTH) Calculation

T_{indoor}	Desired T_{home}	Δ_{temp}	TTH
30	20	-10	0
20	20	0	0
17	20	03	03.16
05	15	10	10.54
08	20	12	12.64
05	20	15	15.80
05	35	30	31.60

6 Conclusions and Future Work

The aim of this paper was to design and develop a context-aware novel *Reasoner service* to control the SmartHome with a mobility service application. This was accomplished by completing four objectives. The first of the objectives that would

make us achieve this was to enable communication and connect SmartHomes through a distributed information sharing system. This objective was achieved by creating a gateway for the SmartHome that makes SmartHome appliances accessible. The gateways were connected through the distributed information sharing system MediaSense. This solution enables SmartHome devices communication agnostic of IP addresses since devices are accessed by employing DCXP protocol's UCI.

The second objective was to be able to interact with the distributed information sharing system in order to provide information for context-aware application. To complete this objective, we have created a web service that interacts with the gateways through MediaSense and provides a REST interface so that SmartHome access can be communicated anytime, anywhere over the Internet.

The third objective was to develop a service that utilizes the context awareness and ubiquitosness provided by the distributed information sharing system. This was done by creating a REST web service that is able to deliver calculated results with the help of up-to-date values fetched from the SmartHomes and provide an easy access to SmartHomes for a user.

The fourth objective was to create a mobility service application for which an android application was created. The application enables to monitor and control a SmrtHome remotely in real-time. The application also ensures unauthorized persons do not have access to the SmartHomes. The application further borrows services from MobiS and provides users fastest route to the cottage location.

These objectives in combination have led to an artifact and each objective corresponds to a component in that artifact. By evaluating the artifact as well as each component it can be concluded that they interact to make it possible to control home automation via a mobility service application. Our solution eliminates burden of depending on any particular home automation solution; our solution enables novel communication between user and her SmartHome in real-time by the help of a mobility application.

Our solution helps in reducing energy consumption at home by being able to control heating and lighting anytime remotely; this (anytime, anywhere control) is an advantage over other SmartHome solutions such as: Honeywell's radiator which automatically starts heating after reaching a threshold and Tellstick which does not provide controlling devices remotely. Since our solution provided in this paper is generic, it can easily be extended to other services for further energy consumption reduction and other appliances capable of sensing and/or actuating can be connected to it, for example, coffee maker, door lock, refrigerator, surveillance camera, etc. Further our solution can easily be extended to other remote IoT applications services such as e-health, environmental monitoring and controlling, traffic management, etc. to enable context-aware reasoning services which is gaining growing attention from the IoT domain [13]. The SmartHome Reasoner (SHR) itself can be extended to include authentication such as provided by OAuth 2.0, SHR has been tested with OAuth 1.0 and it worked well. However, since OAuth 1.0 has been deprecated so SHR was redesigned to include the mapping service to ensure authorization for our solution.

In this paper, we did not focus on intelligence in the SmartHome scenario. The SHR can be extended to provide intelligence by analyzing the data collected from the SmartHome. Combining machine learning and IoT is an exciting prospect that will be

inseparable in future. SmartDevices in future would need to talk and interact to its user and vice versa- thus requiring intelligence. This could be explored in the future.

Acknowledgments. We would like to acknowledge the European Commission for its support and partial funding and the partners of the research project: FP7-318452 MobiS. We would further like to acknowledge our partner Swedish ICT ACREO for carrying out the field-tests and the result shown in figure 3(a) was generated from one of the gateways solution that they have developed which is currently running (at the time of writing this paper) at ACREO lab in Kista, Stockholm.

References

1. Dimitar. H. S, Zeungnam. B. and Won-Chun. B: The Smart House for Older Persons and Persons With Physical Disabilities: Structure, Technology Arrangements, and Perspectives, IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING, VOL. 12, NO. 2, JUNE (2004)
2. Harper, R. (ed.): Inside the Smart Home: Ideas, Possibilities, and Methods. Springer, London; New York (2003)
3. Okan. B., and Kubilay. T.: Web-based smart home automation: PLC controlled implementation. Acta polytechnica Hungarica, (2014), Vol. 11, No. 3, pp. 51-63
4. Mingfu Li; Hung-Ju Lin: Design and Implementation of Smart Home Control Systems Based on Wireless Sensor Networks and Power Line Communications, in Industrial Electronics, IEEE Transactions on , vol.62, no.7, pp.4430-4442, July (2015)
5. Zeeshan. A: Design and Implementation of an Automation System Based on the Desktop and Mobile Technologies, Send Orders for Reprints to reprints@benthamscience.ae 20 International Journal of Sensors, Wireless Communications and Control, (2014), 4, 20-31
6. David. B. and Arik. K: A Universal Implementation Model for the Smart Home, International Journal of Smart Home Vol.3, No.3, July (2009)
7. Hasibur. R., Rahim. R., and Theo. K.: Enabling Scalable Publish/Subscribe for Logical-Clustering in Crowdsourcing via MediaSense, IEEE Science and Information (SAI) Conference 2014, August 27-29, 2014, London, UK
8. Magnus. P, Stefan. A.: Enabling SmartHome via MediaSense, B.Sc thesis at the Department of Computer and Systems Engineering, Stockholm University, June (2015)
9. Parisio, A., Varagnolo, D., Molinari, M., Pattarello, G., Fabietti, L., & Johansson, K. H.: Implementation of a Scenario-based MPC for HVAC Systems: an Experimental Case Study, In Preprints of the 19th World Congress, The International Federation of Automatic Control, Vol. 10, p. 10, (2014)
10. Hasibur. R., Rahim. R., and Theo. K: "Enabling Distributed Context Entity Discovery for an Internet-of-Things Platform", in proceedings of IEEE Intelligent Systems Conference 2015, November 10-11, 2015, London, UK
11. [online] MobiS - Personalized Mobility Services for energy efficiency and security through advanced Artificial Intelligence techniques, available: http://www.mobis-euproject.eu/ , 2012
12. [online] Honeywell: 7-Day Programmable Thermostat, http://yourhome.honeywell.com/en/products/heating-and-cooling/7-day-programmable-thermostat-rth7600d [Last accessed: 2015-12-19]
13. Hasibur. R., Rahim. R., and Theo. K.: Entity Configuration and Context-Aware reasoNer (CAN) towards Enabling an Internet of Things Controller, Chapter in a book, Springer book series Studies in Computational Intelligence (Intelligent Systems and Applications 2016)

ROTA: A Smart City Platform to Improve Public Safety

Jazon Coelho[1], Nélio Cacho[2] Frederico Lopes[3], Emiliano Loiola[1], Tyago Tayrony[3], Thiago Andrade[3], Marcel Mendonça[3], Maychell Oliveira[3], Daniela Estaregue[3], and Brunna Moura[3]

[1] Secretariat of Public Safety of RN, IT Department, 59064-901, Natal, RN, Brazil, {falecomjazon, emiliano.loiola}@gmail.com,
[2] Federal University of Rio Grande do Norte, IT Department and Applied Mathematics, Lagoa Nova - 59078-970, Natal, RN, Brazil, neliocacho@dimap.ufrn.br,
[3] Federal University of Rio Grande do Norte, Metropole Digital Institute, Lagoa Nova - 59078-970, Natal, RN, Brazil, fred@imd.ufrn.br, {marcelluiz96, maychellfernandes}@hotmail.com, brunnamoura@rocketmail.com, {tyagotayrony, thlimandr, daniesta}@gmail.com

Abstract. This paper describes how the City of Natal in Brazil has been implementing technological systems in the context of public safety to transform itself into a smart city. In particular, this paper presents a smart city platform, named ROTA, that is able to collect, integrate, analyze and share sensitive information regarding citizens and patrol vehicles. A mobile application was developed to assess the feasibility of the proposed platform. Both platform and mobile application have been fully operational since 2014 and added value to the operational policing by providing a technological tool in the hands of patrol supervisors, providing precise and critical information that helps them in their duties.

Keywords: Public Safety, Smart City, IoT, Webservice, Mobile

1 Introduction

The population of cities is growing rapidly from 746 million in 1950 to 3.9 billion in 2014. As cities grow, so increases the complexity and management challenges for government authorities in dealing with the various urban problems that arise as a result of this high population density. For instance, according to the Brazilian Institute of Geography and Statistics ("IBGE"), in July 2009, Natal, the capital and largest city of the Rio Grande do Norte state in Brazil had a total population of 950,820 inhabitants. Natal is a diverse city with a strongly growing population (over 200,000 additional residents in the next 20 years), which faces a number of issues.

One of the main issues is related to public safety. Crimes statistics for 2012 reflect high levels of crimes in the city of Natal in the categories of robbery,

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_74

rape, fraud, and residential thefts. Moreover, Natal has significant problems with individuals who consume crack cocaine. Most support this habit by engaging in criminal activities, such as street robbery.

In this context, the great challenge to be faced by authorities is to ensure a harmony between sustainable urbanization, socio-economic progress and the safety of citizens. To tackle such challenge, Natal has engaged in an initiative to transform itself into a smart city. According to Caragliu et al. [9], a city becomes a smart city when investments in human and social capital and traditional and modern Information and Communication Technology (ICT) fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance.

Among the many challenges of implementing a smart city, monitoring and assessing the movement of police personnel is a key issue in improving the effective police activities, which in turn is directly applicable to the effective management of a smart city. For example, monitoring the movement of police personnel can help to: make plans effectively for emergency response, determine mitigation priorities, analyze historical events, and predict future events; it helps police officers to determine potential incident sites and facilitates to explore the relationship between incident and land use [11].

This paper describes how Natal has been implementing technological systems in the context of public safety to transform itself into a smart city. In particular, this paper presents a smart city platform, named ROTA, which aims to improve public safety. Moreover, this paper describes a mobile application that uses the data provided by the proposed platform. The remainder of this paper is organized as follows. Section II describes some details of the Natal Smart City initiative. Section III presents the architecture and the implementation details of the platform and the mobile application developed to support the smart city initiative. Section IV provides some concluding remarks.

2 Smart City Initiative of Natal

In order to ensure there is harmony between sustainable urbanization, socio-economic progress and the safety of citizens, solutions are sought for viable living conditions and sustainable city development. One solution adopted by many cities is to realize the smart city concept. The smart cities concept arises from the need to manage several problems caused by the expansion of urban population [24], that affect the quality of several services, such as transportation, security, water, tourism, entertainment, electricity, and so forth. The main goal is to improve quality of life for citizens and the challenge is how to guarantee sustainable urbanization in conformance to triple bottom line approach, take into account environmental, economic and social progress.

In this direction, the Natal City council in partnership with public and private sector defined a plan to transform Natal into a smart city. The purpose of the Natal smart city approach is to accelerate and enable the delivery of outcomes across various sectors, through a truly integrated approach. Many actions

have been implemented to realize such plan [4,5]. For instance, the plan creates a network infrastructure, named Giga Metropole, that has an optical backbone of approximately 160km, as well as a passive network of approximately 300km to interconnect public institutions in the state of Rio Grande do Norte. More precisely, the Giga Metropole will benefit around 650 public and private institutions in Natal's metropolitan area, including: 350 state and municipal public basic education schools, police stations, universities and technical schools, teaching laboratories, and 10 hospitals.

In addition to improve the connectivity infrastructure service, the Natal Smart City plan defines some strategies to improve the services provided to its citizens. Public safety is one of the key services. According to Brazil's Constitution, public safety was attributed basically to State Governments that hold, each one, two different and split law enforcement agencies, one civilian and the other military. The Civilian Police is responsible for criminal investigation. On the other hand, the Military Police is responsible for the operational policing [2] which is patrolling to respond to citizens' calls for help and civilian emergencies.

The operational policing comprises two main stakeholders: Patrol Supervisors and Patrol Officers. Patrol supervisors use Patrol Vehicles (PV) to monitor the execution of the patrol plan. The patrol plan covers the definition of area coverage (safe haven, ambush areas and crime prone areas), patrol teams, duration, stand-by points and route plan. The patrol officers use PV to respond to control-room calls, patrol the assigned beats defined by the patrol plan, observe and check suspicious people and vehicles. The closest and most important links for patrol offices are the control-room and the patrol supervisors with intense and ongoing communication though the vehicle radio communication system.

Information and communication technologies play a key role in the operational policing [10]. The promise of technology to improve the effectiveness of controlling crime, as well as enhancing professional status and organizational legitimacy, has resulted in a long-lasting close affinity between technology and police work [23]. This development has been labeled e-policing [18]. The main aspect of e-policing is that of mobilizing information in order to make it available to officers through mobile computing [19]. In this regard, the Natal Smart City plan defines a set of strategies and actions to create smart city applications and platforms. One of these platforms, named ROTA, will be described in the next section and is able to monitor the patrol vehicles in order to assess whether the patrol officers are committed to the patrol plan.

3 ROTA: A Platform to Improve Public Safety

ROTA is a smart city platform that aims to improve public safety through a software designed to leverage the infrastructure mechanisms behind the city. ROTA provides technologies to collect, process, share, store, and analyze a vast amount of data coming from multipart sources in order to turn data into powerful insights. ROTA integrates various information systems provided by different law enforcement agencies with the aim of providing two distinguishable benefits:

better-informed officers and improved coordination of limited resources at both individual and organizational level.

3.1 Platform Architecture

The ROTA platform is structured around three main layers (see Figure 1): Integration, Analytics Engine and Facade. The Integration Layer integrates scattered information from different sources and makes the integrated information available to the final user. The Integration layer plays a very important role in the ROTA architecture since smart city applications use multimodal information coming from heterogeneous sources[1]. Hence, the ROTA's Integration layer allows extracting data from different sources and performing transformations so that when the data is loaded within the Analytics Engine Layer, it will be within a format that reflects the analytics required.

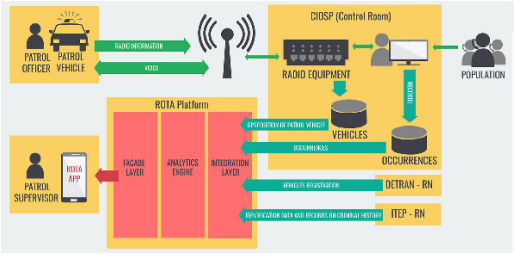


Fig. 1. ROTA Platform Architecture

For instance, Figure 1 shows how Integration Layer integrates information from different law enforcement agencies (Figure 1). The Integration Layer uses Web Services provided by the CIOSP agency to collect data regarding Patrol Vehicles and occurrences. CIOSP is a control-room responsible for answering calls to an emergency telephone number for police, firefighting, and ambulance services (similar to 911 in USA). The data flow normally begins when a person, usually a victim of a crime, makes a call to the CIOSP, at which point it is made the occurrence record. This service will be conducted by one of the telephone operators, who records information about both the event and of everyone involved in a database using a dispatch system. The telephone operator will send a patrol vehicle to the crime's location.

The communication between the patrol vehicle and CIOSP takes place via radio, which has digital technology that grants it a higher level of data transmission security, as they are encrypted and use a radio wave length exclusive to public security systems. Each of the radios installed in the patrol vehicle has a GPS that uses the radio's data channel to transfer some status (a set of metadata with their geographical position). Moreover, Integration layer collects from

DETRAN-RN and ITEP-RN information regarding vehicles registration, people identification data (id cards), and records on criminal history. DETRAN-RN and ITEP-RN are state level organization that handles vehicle registration, issues citizen identification cards and maintains public records on criminal history, respectively.

Smart city applications demand volume and variety of data that is greater than anything that has been usually used in enterprises[3].In order to gaining critical insights from processing this large volume of data, we have defined an Analytics Engine Layer to reason on patterns and on pertinent background knowledge (occurrences and patrol vehicle data), evaluate patterns' interestingness, refer them to geographic information and find out appropriate presentations and visualizations. The information provided by this layer allows: determining mitigation priorities, analyzing historical events, and defining patrol plans.

The Analytics Engine used HERMES [17] database to perform sophisticated moving object data mining. HERMES is a Moving Object Database that integrates many data mining functions including moving object pattern mining and trajectory mining based on state-of-the-art methods. HERMES has many application scenarios. For example, it can automatically detect an approximate period in movements; it can reveal collective movement patterns like flocks, followers, and swarms; and it can perform trajectory clustering, classification and outlier detection for geometric analysis of trajectories.

Finally the Facade Layer works as a portal to access the Analytics Engine Layer. The Facade Layer needs to cope with two issues: availability and data privacy/security. The data privacy/security issues will be described in Section 3.2. In terms of availability, It is not realistic to think of a centralized server to deal with all users requests in a smart city scenario. Hence, we use a cloud-based solution to provide high availability and prevent application disruption.

Cloud Computing can be defined as a new computing paradigm that enables ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g. networks, servers, storage facilities, services, applications, etc.) typically called cloud [15] so that such resources can be rapidly provisioned and released with minimal management effort or interaction with the service provider and are provided in a pay-per-use way to the user.

ROTA platform is deployed in a private cloud platform delivering the Infrastructure as a Service (IaaS) model. The private cloud is owned by the Public Safety organization and enables to use cloud computing technology as a means of centralizing access to IT resources. Due to its characteristics, the private cloud used to deploy the ROTA platform allows to maximized effectiveness of resources shared ubiquitously, through a converged and collaborative infrastructure with coherence and economies of scale.

3.2 Platform Evaluation

In order to assess the feasibility of the proposed platform, we have design and implemented a mobile application, named ROTA-app, to use the resources provided by the proposed platform. ROTA-app is an Android application that uses

the Google Play Services API, version 8.3.01, and Google Maps v2. It can be installed on devices running Android 4.0 (Ice Cream Sandwich) or above. The development target was Android v4.3 (Jelly Bean) which is the version used by the tablets available to patrol vehicles.

Fig. 2. Main screens of ROTA-app.

Application Functionalities Figure 2 shows a wide range of functionalities for patrol supervisors. From the top-left to the bottom-right: the main screen, the search for criminal history, the search for identification card and the search for vehicle registration. With these functionalities it is possible to improve the operational policing since it gives information in a credible and agile manner. For instance, it is possible to know whether a vehicle has any theft/robbery complaint or whether there is any arrest warrants issued for a person.

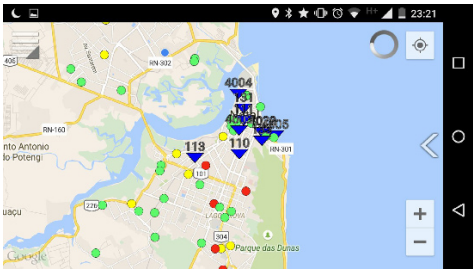


Fig. 3. Screen used to track patrol vehicles and CIOSP's occurrences.

However, the main functionality of the ROTA-app is described in Figure 3. This figure shows a screen of ROTA-App that displays in real-time the position of all patrol vehicles (blue triangle) and CIOSP's occurrences (colored circles).

This feature is essential to the patrol supervisor since it helps to figure out, in the field, the position of the patrol vehicles and whether they are following the patrol plan. For instance, the patrol supervisor can use this screen to find out which patrol vehicles should be (re)located in order to cover regions with a large concentration of events, and low policing. This is possible because the system displays a list of all the georeferenced events registered by CIOSP in the last twenty-four hours. The example depicted by Figure 3 demonstrates a moment when the application provides information to the patrol supervisor that allows him to intervene in the patrols, by conducting a redistribution of official cars, since their positions (represented by blue triangles) are not in accordance with the distribution of occurrences (represented by the green, yellow and red circles).

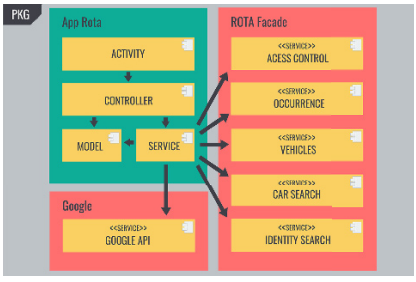


Fig. 4. ROTA-App Architecture.

Mobile Application Architecture The architecture of ROTA-App can be seen on the Figure 4. This figure shows the internal components (in green) and external components (in light red) used to support the application functionalities. The internal components are represented by four functional layers: activity, controller, model and service. The first one represents the view (screens) of the application. The second one is responsible for processing and providing the data to the activities. The third one is responsible for managing the application data. Finally, the fourth one allows connecting the application to the ROTA platform. As described in Figure 4, Rota-app uses different Web Services provided by the ROTA platform, such as: Authentication service, occurrences, track patrol vehicle, vehicle registration and Civil registration. In addition, Rota-App used some Google's Web Services to incorporate the city map and other functionalities.

As described in the previous section, data privacy and security is a key issue in the ROTA platform since ROTA manages sensitive information about citizens (identification data and criminal records) and patrol vehicles (GPS positions). In order to cope with such issues, the Façade Layer of ROTA platform provides some privacy and security control to prevent the sensitive information from being used by non-authorized personnel. For instance, a set of security procedures

were implemented and are applied during the application's installation, and especially during its use. An overview of the main security procedures are listed in Table 1. In this table it is possible to identify four types of existing controls: in device, during use, in the infrastructure, and in auditing. For instance, during the Rota-App use, each user must be registered before gaining access to the application. Moreover, all communication between ROTA platform and ROTA-App are validated and the user can access only the functionalities that they have permission. Those controls are justified by the strategic importance of the information in the public safety point of view given that its misuse can incur in serious problems to the police organization, as well as compromising police activities, putting their lives, and the population safety at risk.

Table 1. Privacy and Security Rules defined by ROTA platform

Control Type	Control Goal	Security Rule adopted
In devices	Control the application's distribution	Install ROTA on police vehicles and officers devices only
	Register Devices	Every application must be registered in a database
	Releasing/Locking Device	The application only works after the process of release
During usage	Register users	Every user must be registered before gaining access to the application
	Control Access Permissions	The modules visualized by the user depend on his permissions
	Validate Communications	All of the communication must be validated.
In the Infrastructure	Ensure Safety	Apply procedures to ensure the safety of information.
In the auditing	Data Logging	Every Access must be registered
	Auditing Users	Analyse the users' behavior

Initial Results The ROTA platform and ROTA-App were both deployed in the beginning of 2014. Nowadays, there are more than 30 patrol supervisors using the application to monitor their patrol teams and to define the patrol plan. The deployment of the ROTA platform and app has brought many benefits. For instance, it made available a (technological) work tool to patrol supervisors who now has real time information about patrol vehicles and occurrences. These information facilitate the process of defining patrol plan and designating vehicles' locations which in practice may contribute to the reduction of crime rate in the

Natal region. In fact, the most recent results[4] published by the Military Police shows that from January(2015) to October(2015) there was a reduction of 15.21% in the number of intentional lethal violent crime for the city of Natal. It is not possible to claim that such crime rate reduction was due to the utilization of ROTA platform and app, though we believe ROTA may contribute to it.

4 Conclusion

This paper presented a smart city initiative to improve public safety. This initiative is based on the design and implementation of a smart city platform that is able to collect, integrate, analyze and share sensitive information regarding citizens and patrol vehicles. A mobile application was developed to assess the feasibility of the proposed platform. Both platform and mobile application are fully operational since 2014 and added value to the operational policing by providing a technological tool in the hands of patrol supervisors. Supervisors have access to precise and critical information that helps them in their duties. From the use of ROTA-App, it was also possible to observe a change in the officer's paradigm, which now perceives the importance of technological solutions in aiding the execution of their daily activities. Besides them, it was also possible to observe benefits to the Military Police organization that can not be measured, such as the strengthening of the relations between the partner institutions, such as the Natal City. As future work, the Natal Smart City initiative is developing new application modules (for patrol vehicles and citizens) which will add new services that allow the military police to work in integration with citizens.

Acknowledgments

This work was partially supported by the National Institute of Science and Technology for Software Engineering (INES), grants 573964/2008-4(CNPq) and APQ-1037-1.03/08 (FACEPE), and by the Smart Metropolis Project.

References

1. ARORA, Payal. Typology of Web 2.0 spheres: Understanding the cultural dimensions of social media spaces. Current Sociology, v. 60, n. 5, p. 599-618, 2012.
2. BRAZIL, Constituição. Constituição da república Federativa do Brasil. 1988.
3. BARNAGHI, PAYAM; BERMUDEZ-EDO, MARIA; TONJES, RALF. Challenges for Quality of Data in Smart Cities.
4. CACHO, A. et al. A Smart Destination Initiative: the Case of a 2014 FIFA World Cup Host City. Proceedings of the IEEE International Smart Cities Conference. IEEE, 2015.

[4] http://www.rn.gov.br/Conteudo.asp?TRAN=ITEM&TARG=96090&ACT=&PAGE=&PARM=&LBL=Materia

5. CACHO, A. et al. Social Smart Destination: A Platform to Analyze User Generate Content in Smart Tourism Destinations. Proceedings of the 4th World Conference on Information Systems and Technologies. Springer, 2016.
6. CLARKE, Frank H.; EKELAND, Ivar. Nonlinear oscillations and boundary value problems for Hamiltonian systems. Archive for Rational Mechanics and Analysis, v. 78, n. 4, p. 315-333, 1982.
7. CLARKE, F.; EKELAND, Ivar Solutions périodiques, du période donnée, des équations hamiltoniennes. Note CRAS Paris 287, 1013–1015 (1978)
8. CANARY, Vivian Passos. A tomada de decisão no contexto do Big Data: estudo de caso único. 2013.
9. CARAGLIU, Andrea; DEL BO, Chiara; NIJKAMP, Peter. Smart cities in Europe. Journal of urban technology, v. 18, n. 2, p. 65-82, 2011.
10. DE MENDONÇA, Cláudio Márcio Campos; DE SOUSA NETO, Manoel Veras. O perfil do Chief Information Officer (CIO) e a sua percepção com relação aos arranjos de governança de TI. Revista de Economia e Administração, v. 11, n. 2, 2012.
11. FAJEMIROKUN, Francis et al. A GIS approach to crime mapping and management in Nigeria: A case study of Victoria Island Lagos. Shaping the Change, p. 8-13, 2006.
12. FUGITA, Henrique Shoiti, and Kechi Hirama. SOA: Modelagem, análise e design. 2012.
13. JIN, Jiong et al. An information framework for creating a smart city through Internet of things. Internet of Things Journal, IEEE, v. 1, n. 2, p. 112-121, 2014.
14. LI, Zhenhui et al. MoveMine: mining moving object databases. In: Proceedings of the 2010 ACM SIGMOD International Conference on Management of data. ACM, 2010. p. 1203-1206.
15. MELL, Peter; GRANCE, Tim. The NIST definition of cloud computing. National Institute of Standards and Technology, v. 53, n. 6, p. 50, 2009.
16. MICHALEK, Ray; TARANTELLO, Gabriella. Subharmonic solutions with prescribed minimal period for nonautonomous Hamiltonian systems. Journal of differential equations, v. 72, n. 1, p. 28-55, 1988.
17. PELEKIS, Nikos; THEODORIDIS, Yannis. Mobility Data Management and Exploration. New York: Springer, 2014.
18. POVEY, Andrew. Plans, plans, plans: An education policy based on central control. Centre for Policy Studies, 1999.
19. POVEY, Keith. Open all hours: A thematic inspection report on the role of police visibility and accessibility in public reassurance. London: HMIC, 2001.
20. RABINOWITZ, Paul H. On subharmonic solutions of Hamiltonian systems. Communications on Pure and Applied Mathematics, v. 33, n. 5, p. 609-633, 1980.
21. TARANTELLO, Gabriella Subharmonic solutions for Hamiltonian systems via a $\mathbb{Z}_p$ pseudoindex theory. Annali di Matematica Pura (to appear)
22. WALRAVENS, Nils; BALLON, Pieter. Platform business models for smart cities: from control and value to governance and public value. Communications Magazine, IEEE, v. 51, n. 6, p. 72-79, 2013.
23. WESTERMAN, George; HUNTER, Richard.Risco de TI: convertendo ameaças aos negócios em vantagem competitiva. São Paulo: M. Books do Brasil Editora Ltda, 2008. 204 p.
24. WINPENNY, J. The united nations world water assessment programme: Investing in information, knowledge and monitoring. Technical report, United Nations Educational, Scientific and Cultural Organization, 2008.

Open Drugstores Mobile App

Liliana Enciso[1], Pablo Quezada[1] Luis Barba-Guamán[1], Lida Solano[2], and Pedro-Pablo Alarcón[3]

[1] Departamento de Ciencias de la Computación y Electrónica, Universidad Tecnica Particular de Loja, San Cayetano Alto, 1101608, Loja, Ecuador,
[2] Departamento de Lenguas Modernas y Literatura, Universidad Tecnica Particular de Loja, San Cayetano Alto, 1101608, Loja, Ecuador,
lenciso, paquezada, lrbarba, lmsolano@utpl.edu.ec,
[3] Departamento de Sistemas Informaticos CITSEM, Technical University of Madrid, Ctra. De Valencia, Km. 7. E-28031, Madrid, Spain
pedrop.alarcon@eui.upm.es

Abstract. Nowadays, various mobile applications are used to solve everyday problems, saving time, and resources to users. The present research aims to solve one of the needs from the city of Loja that is related to health services. The city of Loja as well as the rest of the Ecuadorian country does not have the technology that facilitates quick search of the drug stores on duty. The model of the proposed mobile app includes interactivity features, automatic update of easy use for users that do not offer other applications of similar characteristics. During the development of this work, it has been considered various aspects related to the users that will make use of this application as: the type of mobile device that is used, the operating system, and software architectures. Considering the features and services, it was chosen the SOA-based architecture. Through this work, it is intended to measure the impact that the application might have in the city of Loja and the benefits that this can bring. Likewise, it has been specified the operation of the application as well as the options of search; in the same way, it is presented all the prototype from the perspective of the user in order to provide an efficient service to customers, who are looking for a drug store on duty according to the sectors of the city during 24 hours a day.

Keywords: SOA, Network mobile, Service, Health, Software.

1 Introduction

In today's world it is presented the problem of not being able to find in the shortest time possible a shift drugstore at the moment of wanting to acquire a medicine. There are some projects [1], [2], which present not very ideal solutions since they do not allow the easy access to the user or consume large number of resources due to its difficult access since these jobs should allow people simply perform a query and get access; to the product or service that they wish at that moment, so that they do not have to perform several activities, after that, in order to be able to access. The problem is very broad since in Ecuador and specifically in Loja there is not an application that displays at least the location

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_75

of drugstores or the information of all the drugstores on duty; there is simply a web page [3] which allows to see all shift drugstores of some cities including Loja. In this context, mobile applications today allow immediate access to a service; in this case, we are going to talk about shift drugstore, which represent a great impact at the time of talking about health because many people need this service. Jobs [4] contain few arguments that allow establishing an optimum control on drugstores; they only provide information such as address, but they do not allow that a person can get access to their location from any location, schedules of drug stores in service. There are several applications that have been implemented in some countries; cities about shift drugstore as example, [1], [2], but which have not been received for not providing the necessary information or have not given updates so that a person can perform different types of search.

2 Related Works

The work done has been based according to some articles in which it is shown some different ways to perform a location-based application of places or specific sites within a city, country, etc. Mobile applications are having, or are already the most popular worldwide because a large number of people in all countries have a Smartphone or a cell phone with internet access which allows them to use a browser which can access Google Maps for geo positioning. In this case, the work was developed taking into account important aspects of other documents which are listed below. The article has several important aspects to emphasize as the use of Google maps for the location of each of the restaurants, which was taken as a base to apply it in our research work. In Cabshare system [5]which helped us in our work in order to be able to synchronize in real time the drugstores that are on duty since in this article the use of Google Maps is considered in the same way, in order to explain in detail the methodology used, which made it possible to prepare a prototype of our application. It is a mobile application that has allowed all the users of Spain have a greater and easier access to all the drugstores when they need [6], [7]. In our case, we can say that the reason for developing a mobile application that allows to settle the problems of finding shift drugstores in the city of Loja happens due to the big demand that this one presents; it is also because a big need was seen as the one presented in this article. The application that is presented in this study differs from previous ones since it allows a better search of drugstore as it is not the case of my open drug store [8], since in our application people can search by sectors from the city of Loja, they can also search by dates in which some drug stores are on duty, and also by the location, where somebody is, which is the initial part of our application. Drugstores online are attracting most attention [9], [10]. Potential benefits of telemedicine include improved access to care, greater efficiency in diagnosis and treatment, higher productivity, and market positioning for the coming century [10].

3 Literature Review

3.1 Publication of the data in Google Maps

To present the information about drug stores represents the second phase of this research project, which was used for the development of the application done in

the city of Loja. It was carried out the record of 90 drugstores that consist in the National Agency of Regulation, Control, and Sanitary Alertness regulatory organism of the drug stores in Ecuador [11]. In the phase of elaboration of the map, it has been taken all drugstores that are enabled to sell their medicines in the city of Loja, in accordance with the regulatory agency, taking into account the locations of each of them within the map. It has been taken the GPS coordinates of the drugstore, which will be used to locate points on the interactive map. In addition to the names of drugstores, it was recorded additional information of each one of them such as these addresses, opening hours, as well as the phone number. All collected data was stored in a spreadsheet; then it was imported it into a database that will be created for the storage and inquiry of the data[7].

The main objectives of the tool that is intended to develop are to facilitate the search of the drugstores that are available in the city of Loja, which is going to help the users to optimize this way its time at the moment of looking for an available drug store; another objective is that it is intended that citizens should start to familiarized themselves with the use of the technologies, which will facilitate its life.

3.2 Android and Geolocalization

Android Android is an operating system based on Linux[12] for mobile devices created by Andy Rubin. In 2005, it was acquired by Google Inc. [13] and Andy Rubin became part of the company as director of mobile platforms for Google. In the year 2007, 100 big companies within the telecommunications, mobile devices, development software and marketing formed the Open Handset Alliance [14] its main objective was to develop open standards for mobile phones. Android is a fundamental part of this Alliance and part of its code is released under the Apache license. In October 2008 year was opened the Android Market to download applications. From that moment and due to the characteristics of the operating system as open source, portability and adaptation, optimization in the consumption of memory or high-definition graphics and sound[12].

Android has experienced tremendous growth to be dominant in terms of market share platform as we can see in figure Fig.1.

After the characteristics described above and the relative ease when developing applications in terms of available information from official web sites for developers have made that Android has been selected as the ideal platform for the realization of this project. In the table of section 3.2 it can be seen the evolution in terms of versions and API of the Android platform-level [14] [15].

GeoLocation(GEO) is also called geo-referencing. It consists on relating certain information with a geographic position [16]. The information can refer to any object such as a restaurant, a theater, a University, drug stores, and even people. The position of each object is known by coordinates that allows its location on the map. Currently, there are helpful tools as Google Maps [17], an application server maps on the web through which it is possible to locate any

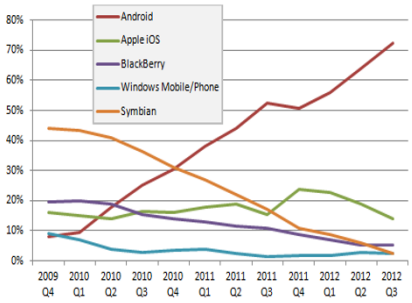


Fig. 1. Comparison of market share for various mobile platforms [12]

Table 1. Versions of the Android operating system

Version	Codename	API	Distribution
2.2	Froyo	8	0.4%
2.3.3-2.3.7	Gingerbread	10	7.4%
4.0.3-4.0.4	Ice Cream Sandwich	15	6.4%
4.1.x	Jelly Bean	16	18.4%
4.2.x		17	19.8%
4.3		18	6.3%
4.4	Kitkat	19	39.7%
5.0	Lollipop	21	1.6%

type of business in a specific area to anywhere in the world; thus, it determines the location where a user is located at one point, as well as it measures the distances between coordinates.

The API of Google Maps for Android An important feature of our application is to represent the location of the drug stores in the city of Loja, which is recommended in the map[18].

3.3 Architectures SOA, SOAP y REST

SOA A concise definition for SOA can be found in [19]: A service oriented architecture (SOA) that is a set of architectural tenets for building autonomous and yet interoperable systems. Moreover, the concept of SOA supports that these autonomous systems provide self-contained functionalities are created independently of each other, operate independently of their environment, are loosely coupled,etc". This architecture defines and provides the necessary infrastructure for exchanging of information. In addition, participation in business processes is carried out independently of the hardware-software platform on which it is worked: operating system, programming language, characteristics of the equipment,etc [20]. The functionality that is needed in SOA breaks down in services that can be distributed on different nodes connected through a network and, in the same way, combined to achieve the desired goal.

SOAP It is a simple mechanism to express the information using a modular data packaging model and a series of mechanisms for encoding data [21], this

allows SOAP to be used in a wide range of application servers that work through RPC communication model (Remote Procedure Call)[22].
SOAP functionality is to provide a simple and lightweight interchange mechanism of information between two points using the XML language. SOAP consists on three parts: the SOAP envelope that determines the operations, the SOAP encoding rules that define the serialization mechanism that will be used to encapsulate various data types in messages and the SOAP RPC that is representation that defines a mode of operation when making remote procedure calls.

REST It is acronyms in English (Representational State Transfer). As a promising software architecture style, has been used in large scale since proposed [23] or an architecture style of hypermedia software systems distributed such as the Web; indeed, REST strictly refers to a collection of principles for the design of architectures in network. Representational State Transfer (REST) is an architectural style that defines the architectural quality attributes of the World Wide Web, seen as an open, loosely coupled, massively distributed and decentralized hypermedia system. REST has seen a large uptake for the last several years, as it is largely regarded as a simpler and more Web-like way of exposing service interfaces [24].

4 Methodology

4.1 Used Architecture (SOA)

For our application, we have seen necessary to use the SOA architecture for all the facilities it presents since it does not have restrictions or standards at the moment of starting the design. SOA architecture has allowed us to make easier the design and implementation of our application for reasons provided by SOA web services; likewise, it allows better communication between services within its architecture. In our application, we use it in the following way, firts it was usedfor communication with google maps services and direct communication with the development. Android platform, this architecture is very stable and very useful since it helps in such a way that one can use methods or standards that allow developing the application more easily. SOA has been implemented so that it allows us to transmit a service-specific data to another allowing direct communication between them. The main reason to apply this architecture because functions since it allows us that our application has scalability, generality of interfaces, and compatibility with intermediate components.

4.2 Web Technologies and Resources used

A web application requires the integration of several technologies to manage and control the different processes of manipulation of data that occur between the user and the server. For the development of this application, the programming language PHP and HTML has been used, which allowed the creation of dynamic pages that communicate with a database. The data has been connected with Google Maps API for its representation in maps. The google maps service and

its Google Maps application have become a world reference; this service allows performing various actions as a simple search of an address in any city, ask about how routes reach the site by vehicle or to stroll virtual form at the level of the street with its "Street View" option. The Google service is of great interest since it offers web developers a programming interface application that allows the creation of applications hybrid that take advantage of the full potential of your service. With the aim of displaying the data collected, it has been created an interactive tool where it will be integrated with Google Maps and through a dynamic connection to our data base it can be possible to consult and display the map with the drugstores. The database was composed by several related tables each other where the related data was registered. The map contains of general data of the drugstores located in the city of Loja with a respective representation and Location of the addresses of the drugstores in the city of Loja. The application to develop is going to modifiable in the case that somebody wants to add new fields to register in the database, only if it is necessary for future updates. The use of some software resources have seen suitable for our application: JavaScript Google Maps API, Google Maps Android API, Android SDK for Windows, MYSQL, PHPMYADMIN, PHP, HTML 5, SublimeText and PhoneGap.

4.3 Use of Information Technology and Communications (TICs)

Within the information technologies, we have easy access to many statistics or informative data through the web; in our case, we obtained the hours of drugstores on duty which represent the more important entity within our application. In the table below, in section 4.3, we may observe drug stores on duty in Loja city.

4.4 Interactive Application

The application is designed for having access to it through a cell phone. In this way, any citizen that has a Smartphone can access the application, where some queries that find relevant about the drug stores in the city of Loja maybe perform. The application was structured in a such way that any person can handle it. 1. Users can search the application in order to know the drugstore. 2. The application present the drugstore that are available. 3. Drugstores are contrasted with the Google servers to obtain the location of the pharmacies that are on duty. 4. The result are sharing with the users of the application.

4.5 Algorithms Search for drugstores

The following algorithm explains the steps of how are going to be carried out the queries of the drugstores in the city of Loja inside will be held application:

1. The user enters in the mobile application.
2. The application presents four options; among them are that nearest drugstores, open drugstores, search all droug store, search by sector or search by date.
3. If the user performs a search for the nearest drug store, it should be necessary the use of the GPS to check the users location.

Table 2. Drugstores on duty of City of Loja

DRUGSTORE	ADDRESS	START DATE	FINAL DATE
"Jerusalen"	Guaranda Y Gran Colombia	03/01/2015	10/01/2015
"Manantial"	Avda Manuel A Aguirre Y Venezuela	03/01/2015	10/01/2015
"San Gregorio"	Calle Nogova/Las Pitas	03/01/2015	10/01/2015
Cruz Azul "La Salud"	18 De Noviembre Y Coln	03/01/2015	10/01/2015
Pichincha Principal	Ancon Y Machala	10/01/2015	17/01/2015
"Espaola"	Av. Universitaria Y Rocafuerte	10/01/2015	17/01/2015
"Sai Fydde"	Av. Pio Jaramillo Y Max. A. Rodriguez	10/01/2015	17/01/2015
"Santa Fe"(Sucursal)	Av. 8 De Diciembre Y Jaramijo	10/01/2015	17/01/2015
Cruz Azul "Su Farmacia"	Juan Jose Samaniego Lauro Guerrero	17/01/2015	24/01/2015
"San Gerardo"	Dolores Cacuango Entre Transito Amagua Y Tiradentes	17/01/2015	24/01/2015
"Iberoamerica"	Atahualpa Y Caran Shiri	17/01/2015	24/01/2015
"Ana Mara"	Guayaquil Entre Machala Y Santo Domingo	17/01/2015	24/01/2015
"Pichincha Sucursal"	Jose Antonio Eguiguren Entre Ramon Pinto Y Lauro Guerrero	17/01/2015	24/01/2015
Sana Sana" Jose Felix"	Avda. Universitaria Y Jose Felix	24/01/2015	31/01/2015
"Del Pueblo"	18 De Nov. Y 10 De Agosto	24/01/2015	31/01/2015
Su Farmacia Angelica	Mercadillo Y Av. Universitaria	24/01/2015	31/01/2015
Fybeca "Rio Zamora"	Orillas Del Rio Zamora Y Guayaquil	24/01/2015	31/01/2015
"San Isidro"	Av. Pio Jaramillo Y Einsten	24/01/2015	31/01/2015
" Jerusalen Pricipal"	Machala Y Ancon	31/01/2015	07/02/2015
"Iv Centenario"	Manuel Agustin Aguirre Y Miguel Riofrio	31/01/2015	07/02/2015
"San Luis"	Av. Pio Jaramillo Y Reinaldo Espinoza	31/01/2015	07/02/2015
"Santa Mara"	Av. 8 De Dicieimbre Y Jaramijo	31/01/2015	07/02/2015
Cruz Azul "Americana"	18 De Noviembre Y 10 De Agosto	31/01/2015	07/02/2015
"Cuxibamba Vida"	Bolivar Y Miguel Riofrio	31/01/2015	07/02/2015
"Galenos Cruz Azul"	Av. Universitaria Y 10 De Agosto	07/02/2015	14/02/2015
"Auxiliadora"	Gran Colombia Y Ancon	07/02/2015	14/02/2015
"Maria Fernanda"	Argentina Y Brasil	07/02/2015	14/02/2015
Cruz Azul "Katerine"	Bernardo Valdivieso Y Mercadillo	07/02/2015	14/02/2015
" Familiar "	Av. Universitaria E Imbabura	07/02/2015	14/02/2015
"Cuxibamba Bayer"	18 De Noviembre Y Azuay	07/02/2015	14/02/2015
Santa Fe Sucursal 2	Av. 8 De Diciembre Y Santiago	07/02/2015	14/02/2015
"Francesa"	Manuel Agustin Aguirre Y Miguel Riofrio	07/02/2015	14/02/2015
Sana Sana "Miguel Riofro"	Miguel Riofrio Y Bolivar	14/02/2015	21/02/2015
"Gran Colombia"	Manuel Agustin Aguirre Y Rocafuerte	14/02/2015	21/02/2015
"Bioquimicos"	Tomas Alba Edison Y Sldo. Carlos Robles	14/02/2015	21/02/2015
" Sana Alonso De Mercadillo	Gran Colombia Y Ancon	14/02/2015	21/02/2015
"Loja"	Bolivar - Rocafuerte	14/02/2015	21/02/2015
" Israel"	Avda Pio Jaramillo Y Pasaje	14/02/2015	21/02/2015
"San Camilo De Lellis"	Av. Paltas Y Rusia	14/02/2015	21/02/2015
"Farmared"	Manuel Agustin Aguirre Y Azuay	14/02/2015	21/02/2015

4. After obtaining the results of the GPS, it is necessary to make a query to view the drug store that are closest to the users current location.
5. If the user performs a search of the open drug store it is going to be necessary to consult to the database of the drug store that are available and the results will be presented in Google Maps.
6. If the user decides to search all drug stores in the city of Loja either those which are available or not a query to the database of all drug stores is going to be performed; after, the results will be showed.
7. A search by sector of Drugstore or schedule may be done.

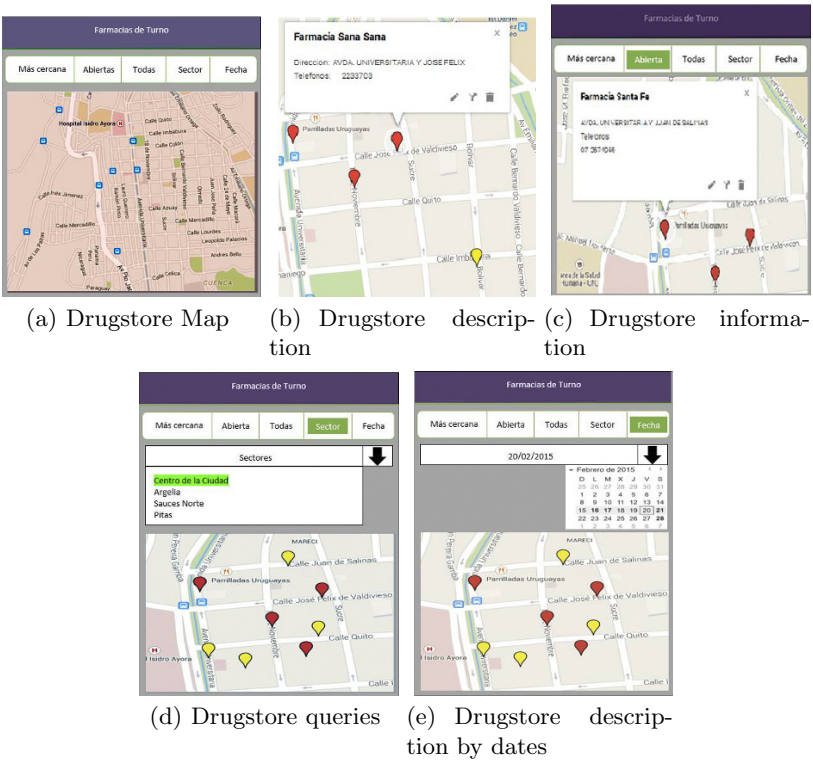
4.6 Data Visualization and Prototype

The display of the data in the application was held in Google Maps, within the application, there will have several ways to view the drugstores in the city of Loja. The prototype was developed thinking about the well-being of the user, which is a friendly environment in which the user has easy access to each of the

options presented. It also allows a direct interaccion between user and application, which helps people that are interested in related applications that facilitate the purchase of products or services as in the case of our work. The aplicacion prototype allows to display information from drougstores on duty so that users can easily see the data and can have access to any drugstore that they want.

4.7 Results

The results obtained from the application are shown in the following screenshots made from the testing of the application. In figure 2(a), it can be seen that if the user can make use of the option of the drug stores that are closer. To take as a reference the location of the user it is necessary to choose the option Closer, so then the application will show all pharmacies that are close to the user without distinguishing between the pharmacies that are on duty (red color)and pharmacies that are not available (yellow). By clicking on the icon on the map 2(b), it shows the location of the drugstore and contact information.



(a) Drugstore Map (b) Drugstore description (c) Drugstore information

(d) Drugstore queries (e) Drugstore description by dates

Fig. 2. Prototype of drugstore application

As it is observed figure 2(c), if the user wants to see all the droug stores that are on duty it is necessary to enter the choice of drug stores Open, which will appear on the map with red icon all drugstores available to the user. In the same way, by clicking on the icon of each one of them is show a description of drugstore as the address and telephone number. In figure 2(d), it can be seen that if the user wants to perform a query of the drug stores by sectors from the city of Loja, in this case it is presented a drop-down list where you can choose the sector that wishes to consult the drougstore; pharmacies that are found in this sector will be presented accordingly. In figure 2(e), it is shown the case where the user decides to perform a query of the drug stores by dates of availability of the drugstore in the city of Loja, in this case arose that will be available on the date indicated by the user. In the table below, in section 4.7, we may observe parameter of usability evaluation of aplication in Loja city. This evaluation involved 25 people with smartphones.

Table 3. Usability evaluation of the application

	Totally agree	Agree	Parcial agree	Not agree	Totally desagree
The app is easy to use	14	6	4	1	0
Drugstores were easy to find	13	7	3	2	0
Drugstore Information is clear	18	6	1	0	0
Time schedule Drugstore is correct	22	0	0	0	3

5 Conclusions:

- The use of new technologies facilitates people to have access to information about existing drug stores in the city of Loja, helping in this way, to make life easier.
- The integration of a tool extended worldwide and known use as Google Maps is appropriate to achieve the objectives proposed for the development of the aplication.
- SOA brings important advantages such as stability, robustness, ease in the adaptation of new services, ease in rebuilding systems, collect information and process it for more useful results, time implementation savings which makes a well known architecture that is used by many organizations.

References

1. G. de Chile, “Modernización lanza aplicación móvil para buscar farmacias de turno,” http://datos.gob.cl/noticias/ver/17, 2013.
2. eFarmacias, “efarmacias, encuentra rápidamente una farmacia abierta cerca de tu posición,” http://goo.gl/In9sBz, 2013.
3. M. Valarezo, “Farmacias de turno a nivel nacional,” http://goo.gl/In9sBz, 2013.

4. J. Perez, M. Zarazaga, "Farmacias ahora zaragoza. desarrollo de aplicaciones para dispositivos móviles sobre servicios ide y datos libres," http://www.idee.es/resources/presentaciones/JIIDE12/jueves/H51.Articulo.pdf, 2013.
5. M. L. M. C. J. Scolari, C. Guerrero, "Aplicación móvil para la recomendación de restaurantes en jaén. españa: Universidad de jaén," http://profesional.turismodecantabria.com/contenidoDinamico/LibreriaFicheros/564B7D93-8498-B92E-D3E1-A05C40071054.pdf, 2013.
6. J. Lopez, "Sistema para compartir taxi mediante smartphone. españa: Universidad pontificia comillas," 2013.
7. J. Piero, G. Navarro, "Aplicación web basada en google maps para la publicación de mapas de ruído en internet españa: Universidad católica san antonio de murcia," 2010.
8. F. Farma, "Mi farmacia abierta," http://www.mifarmaciaabierta.com/, 2013.
9. L. S. and U. C., "Web medical sites, drugstores on-line: How do they rate?" *Drug Topics*, vol. 144, no. 23, p. 115, 2000, cited By 0. [Online]. Available: http://www.scopus.com/inward/record.url?eid=2-s2.0-0034638894partnerID=40md5=a4c0a183414b84e49e6349687f379079
10. A. D.M., "Telemedicine and telepharmacy: Current status and future implications," *American Journal of Health-System Pharmacy*, vol. 56, no. 14, pp. 1405–1426, 1999, cited By 0. [Online]. Available: http://www.scopus.com/inward/record.url?eid=2-s2.0-0033565486partnerID=40md5=2224b7a153f0a244a227d368e22c1678
11. C. S. del Ecuador, "Farmacias de turno zona-7," 2013.
12. J. Tomas, *El gran libro de Android*, 2nd ed. Marcombo, 2004.
13. J. Wallace, *Android Apps for absolute beginners*, 1st ed. Apress, 2013.
14. O. H. Alliance, "Open handset alliance,," www.openhandsetalliance.com, 2013.
15. S. Singh, "Global smartphone market trends: Android, iphone lead, windows phone struggles," http://www.tech-thoughts.net/2012/07/global-smartphone-market-share- trends.html, 2013.
16. L. Hill, *Georeferencing: the geographic associations of information*, 1st ed. MIT Press, 2009.
17. G. M. Inc., "Google maps," https://maps.google.es/, 2013.
18. G. M. Incv2., "Google maps android api v2," https://developers.google.com/maps/documentation/android/intro?hl=es, 2013.
19. R. Welke, R. Hirschheim, and A. Schwarz, "Service oriented architecture maturity," *Computer*, vol. PP, no. 99, pp. 1–1, 2010.
20. C. S. Architect, "Certified soa architect," http://cac-ti.com/certified-soa-architect, 2013.
21. V. Autores, "Rest vs. soap: Making the right architectural decision," http://www.jopera.org/files/soa-amsterdam-restws-pautasso-talk.pdf, 2012.
22. F. M. Joachim W. Schmidt, "Simple object access protocol (soap)," http://www.sts.tu-harburg.de/pw-and-m-theses/2001/Koft01.pdf, 2001.
23. Y. Tang, X. Wu, H. Zhu, and J. Guo, "Formalization and verification of rest architecture in viewpoints," in *High Assurance Systems Engineering (HASE), 2015 IEEE 16th International Symposium on*, Jan 2015, pp. 197–206.
24. P. C., W. E., and A. R., *Introduction*, 2014, vol. 9781461492993, cited By 0. [Online]. Available: http://www.scopus.com/inward/record.url?eid=2-s2.0-84929908600partnerID=40md5=2ffd6c0ddbaa16218c6062e2a9993680

A Platform Approach to Personalizing Web Applications with Social Network User Profiles

Reinhard Klemm

Avaya Labs Research
211 Mount Airy Road, Basking Ridge, NJ 07920, USA
klemm@research.avayalabs.com

Abstract. Application personalization holds the promise of enhancing the effectiveness of software, facilitating its use, and creating a stronger emotional bond with its users, thus contributing to a user-centered application experience. Traditionally, the development of personalized applications and the acquisition of quality user data as the basis for personalization have posed significant challenges. This article presents a novel experimental development and execution platform that enables a simple, general, systematic, and consistent approach to developing personalized Web applications according to long-term user characteristics. The platform leverages social network user profiles as a source of user characteristics. We describe the key conceptual and technical goals as well as the platform design challenges in detail. An example demonstrates the programming methodology and its benefits.

Keywords: Application personalization, programming platform, social networks, software development, user interfaces, Web.

1 Introduction

Application personalization can create a stronger emotional bond between end users and software, thereby leading to a more human-centric application experience. It can facilitate the use of software and enhance its functional effectiveness by accommodating differences between users [1]. In 2001, Pancake [2] predicted that users and computers will interact very differently in the future because "software must become more responsive to humans in all their diversity. The software interfaces we know today will be transformed so they can respond and adjust to each user." Although a significant amount of research and development has been devoted to the personalization of software since Pancake's prediction, in particular, of Web applications, we believe that software personalization is far from reaching the level envisioned by Pancake and from fulfilling its theoretical potential.

Mobasher et al. [3] define personalization of Web applications to be "any action that makes the Web experience of a user personalized to the user's taste". We extend this definition to include personalized differentiation of content, appearance (*look and feel*), and functionality in a Web application user interface (UI) based on *all* of the user's personal characteristics, including name, age, gender, address, education, profession, interests, hobbies, disabilities, preferences, affiliations, favorites, and

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_76

relationships. In this article, we focus on "long-term" user characteristics and exclude those that can change frequently such as mood, activity, or geolocation.

Users nowadays routinely engage with personalized Web applications, from online shopping portals to entertainment services. In most of these applications, personalization is largely based on internally and transparently collected observations about user interactions with the application, with some additional, explicitly gathered data such as user interests, preferences, and product ratings. Despite the promise and success of these systems, however, a number of challenges have limited the attained degree of personalization. One challenge is the transparent acquisition of accurate, up-to-date, and detailed user characteristics that are not directly observable by monitoring user interactions with the application. Examples of such data are age, gender, skills, education, interests, and preferences. A transparent collection of user characteristics – with user approval - is generally preferable over an explicit data collection because the latter requires a considerable effort on the part of the user [4]. Another challenge in developing personalized Web applications is the lack of a systematic, generally applicable, consistent, and simple to implement software engineering approach supported by a development and execution environment.

In this article, we describe our research in designing a platform for developing and executing personalized Web applications. The overarching objective of our work is to address the current deficiencies in the state of the art in software personalization, as stated above, to popularize personalization in general Web applications. We specifically aim at reconciling two different goals:

A facilitating the development of personalized Web applications for traditionally skilled Web application developers and for a wide range of applications;

B providing users of personalized applications with a convenient, reliable, and meaningful experience that is consistent across different applications.

The main contributions of this article are:

- We outline high-level criteria that a platform must fulfill to attain Goals A and B.
- We present technical platform goals derived from these criteria.
- We describe our experimental *per*sonalization plat*form PerForm* for developing and executing personalized Web applications with social network user profiles as a data source for personalization.
- Using a running example, we illustrate *PerForm*'s programming methodology.

2 Related Work

Nasraoui [1] describes the benefits of personalizing Web applications, from increased customer loyalty in e-commerce applications to greater ease of use. Wu et al. [5] support the claim that personalization of Web applications fosters user loyalty. Teevan et al. [6] study personalization in Web search engines and conclude that personalized search results can greatly increase their user relevance. An example of a Web application personalization method, predating social networks, is given in [7]. Hong et al. [8] document the reliance of many personalization approaches on sensor data and manual user input and describe the disadvantages of such techniques. The authors argue in favor of transparently collecting user characteristics, which we also

pursue in our work. While Hong et al. propose a personalization system that targets recommender applications, our approach has more general applicability.

Mobasher et al. [3] present a Web usage mining technique for personalizing Web applications. It internally and transparently collects data about a user's interactions with the application and personalizes recommendations for further reading and online resources based on the knowledge gained about the user. Surveys of Web usage mining techniques can be found in [9] and [10]. We take an orthogonal approach by leveraging social networks as application-external data sources for personalization, as do Akther et al. [11] who aim at personalizing recommender systems. However, their work relies on explicit mention of user interests and preferences in social network *posts*. While such posts and Web usage mining allow application- and domain-specific personalization with a focus on short-term user behavior and interests, our work enables less topical personalization with long-term validity. Both approaches complement each other. Enriched with user *context* from sensors, they form a comprehensive data foundation for context aware, personalized applications. Schilit et al. [12] and Dey [13] published some of the seminal work on context awareness.

Bonnet [4] explains why personalization systems that transparently determine user characteristics tend to be more successful than those requiring user participation. Bonnet's work predates the large-scale adoption of social networks that act as central repositories for user profiles. Bonnet therefore assumed that personalized applications themselves must perform the management of user characteristics, thus raising the challenge of finding the right balance between minimizing the required user involvement in the personalization process while giving users maximum control over it. Similarly, the Object-Oriented Hypermedia Method in [14] mandates creation and storage of user profiles for each family of personalized applications, and also a specialized programming language. Blechschmidt et al. [15] argue in favor of a standardized XML-based user profile model for generating personalized application UIs. In contrast, our work leverages the availability of user profiles on social networks and does not impose a special-purpose programming language.

3 Requirements for an Application Personalization Development and Execution Platform

Our long-term research in software personalization and context awareness inspired a list of key criteria for any personalization development and execution platform that aims at fulfilling Goals A and B stated in Section 1 of this article. The platform must

1. facilitate the design and implementation of personalized Web application UIs, where personalization extends to the UI presentation, content, and functionality; in particular, the platform should
   a. require little learning effort for a software developer with a typical mix of Web application development skills
   b. scale adoption and implementation complexity with the desired level of personalization; simple personalization should be built into the UI code itself
   c. not impose a new software development approach but allow integration into a preferred development style when needed and to the extent necessary

2. provide a uniform approach to building personalized Web application UIs across applications and in different application domains
3. lead to a consistent personalization of UI elements in different Web applications and thus to a consistent personalization experience for users
4. allow personalization based on long-term (static or semi-static) user characteristics
5. transparently retrieve user characteristics as the basis for personalization
6. use reliable (high-quality, highly available) data sources for user characteristics

From these conceptual objectives we derived the following technical goals.

3.1 Acquisition of Personalization Data

3.1.1 (Semi-) Static User Characteristics

Through social network profiles, users disclose vast amounts of carefully curated and thus high-quality, in-depth personal data. Many social networks provide APIs for a programmatic retrieval of user profiles. The programmatic access to social network user profiles promotes a complexity shift in personalizing Web applications from acquiring quality user data to generating application variations for different users and user populations. Transparent, programmatic retrieval of user profiles from a variety of social networks therefore is an important technical platform goal.

3.1.2 Dynamic User Data

In our work, we focus on personalization based on (semi-) static user characteristics because it is a much less researched area than the collection and mapping of dynamic, contextual user data – from current location to mood – to personalized UIs. However, an actual personalization development and execution platform should also support the acquisition and use of dynamic user data in the personalization process. Such data may be retrieved from social networks as well as from other data sources.

3.1.3 Time-Sensitive Personalization

Personalization in a Web application without explicit user involvement carries the risk of counterproductive personalization. Using outdated user profile data in the personalization process aggravates this risk. Imagine a personalization element that provides local news based on the user's address and the user moves to a new, faraway address but the personalized element keeps assuming the previous address. It is important, therefore, that the personalization programming platform regenerates the application's UI frequently and based on a recent version of the user's profile.

3.2 Application Responsiveness

The acquisition of up-to-date user profiles and the computations necessary to personalize UI elements take time, especially in the presence of a large number of concurrent application users. User adoption of personalized Web applications would suffer if the application felt less responsive than a non-personalized application. Hence, the responsiveness of a personalized application is a concern. Note that

personalization of UI elements may be required whenever the application regenerates parts of the UI, triggered by user input/clicks or asynchronously (AJAX).

3.3 Programming Language Considerations

Web UI designers are often reluctant to code in a general-purpose application programming language but feel comfortable with the Web development languages HTML, JavaScript, and CSS. To facilitate the division of labor between UI and backend development, it is important to allow pure UI developers to specify as much of the UI personalization as possible in HTML, JavaScript, and CSS with few modifications. All non-UI programming tasks should be performed in a widely used application development language such as Java. We therefore mandated that the platform offers a simple Java backend API that supports fine-grained personalization.

3.4 Managing the Complexity of Personalization

Social network user profiles allow fine-grained, sophisticated personalization of UI elements in Web applications. However, with this new potential for personalization comes the danger of an increasing effort to build Web applications. It is important, therefore, that the platform helps reduce the complexity of mapping user profiles to personalized application elements. This subsection introduces specific platform requirements intended to reduce this complexity.

3.4.1 Personalization through UI Selection

For many UI elements, the desired personalization applies to an entire *user segment* that shares a set of characteristics. An example would be *Spanish-speaking users in the United States, aged 40-55*. A simple approach to personalizing for a user segment is to design a separate UI for each defined user segment and program the platform so that it simply selects the appropriate UI at runtime (*UI selection*). The platform must facilitate the development of a fundamentally similar UI for all users in the same segment and to add fine-grained personalization for individual users if so desired.

3.4.2 UI Element Defaults

Often, personalization of a UI element is intended for a small subset of users, whereas all other users receive generic (non-personalized) content, appearance, or functionality. For example, if a retail chain wants to publicize the opening of a new store location as part of a Web application, it would make sense to only inform customers in the vicinity of the new location of the opening while others might see a default store location widget. The platform therefore has to facilitate the specification of UI element defaults with the option to define personalized *override* values.

3.4.3 Variable Substitutions

Many types of personalization amount to simple variable substitutions in the UI, and thus the platform must support variable substitution. A greeting in an e-commerce

Web application, for example, might be generically expressed as *Hello, <firstName>, welcome to <businessName>'s online store!* Personalization would replace the *<firstName>* variable with the actual first name of the user and *<businessName>* with the name of the business in that user's geographic area. Personalization of a conditional JavaScript statement checking for the user's age *if (<age> > 65)* would result in the replacement of *<age>* with the actual user's age.

3.4.4 Standard and Custom Variables

The *<firstName>* and *<age>* variables above suggest that the platform should provide a predefined set of *standard* variables that map to the attributes in social network profiles, such as *firstName*, *age*, *gender*, *language*. Standard variables must be automatically replaced by the respective values in the user profile. A mechanism for substituting a standard variable with a *generic* value must exist, in case a user's social network profile does not provide a value for that variable. For example, some users decline to enter their age in their social network user profiles. The platform must also support developer-defined (*custom*) variables such as the *businessName* in the above example. The platform must offer a simple *configuration* mechanism for substituting custom variables with values at runtime, as well as a Java API that supports more complex instantiations of custom variables at runtime.

4 The *PerForm* Programming Model

In this section, we illustrate the *PerForm* programming model and how it meets the goals outlined in the preceding section using the example of a personalized Web application that we call a *user support widget* (USW). An organization such as a business or university can deploy USWs online to provide personalized content and support to its users. A USW can display organizational news, events, location openings, recommendations, promotions, marketing, etc., tailored to the user's presumed needs and interests. For live support to its users, the USW can establish a voice or video call or text chat with a representative of the organization.

Fig. 1 shows the USW opening screen for a fictitious electronics retailer *Acme Online*. The USW is personalized through Facebook social network user profiles. This USW was generated for a user whose Facebook profile indicates that he speaks English, loves consumer electronics, is college-educated with a degree in information technology, middle-aged, and presumably affluent given his employment history.

When the user launches the USW for the first time, *PerForm* asks the user for permission to retrieve the Facebook user profile. If the user consents, *PerForm* retrieves the profile through Facebook's API (cf. Section 3.1.1) and generates the USW UI from a set of HTML, JavaScript, and CSS *templates.* A template is a parameterized HTML page, JavaScript code, or CSS specification. It differs from a non-parameterized version only in the use of *PerForm* variables _@*<variable name>* that the application developer inserts in places where content, appearance, or UI functionality needs to be personalized. The developer can thus use customary Web development languages to build a personalized Web application (cf. Section 3.3).

Through an extensive set of internal caches, *PerForm* stores the user profile as well as all templates and instantiated templates for a limited amount of time. Caching increases the application responsiveness during repeat access to the same UI elements by the user (cf. Section 3.2). The developer can choose to turn off caching for personalization elements that require always up-to-date content.

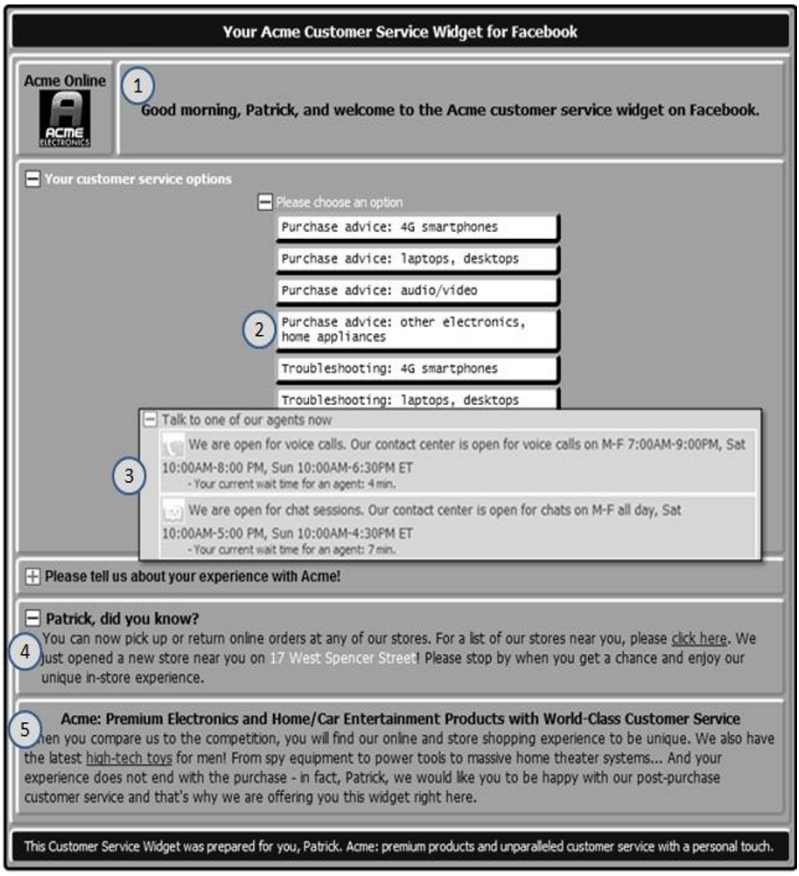


Fig. 1. Opening screen of a personalized user support widget

Fig. 2 shows a simple example of a *PerForm* HTML template. It contains eight variables, indicated by the prefix _@. The variables *_@brandingClass* and *_@greetingClass* allow a selection of the CSS classes that determine the appearance of HTML elements based on the user's social network user profile. The CSS class specifications themselves may be parameterized and therefore personalized in a CSS template or a *style* entry in this HTML template. *PerForm* substitutes the*_@businessName* and *_@greeting* with personalized content. For example, the business may appear under different names in different geographic regions, and the greeting can be made language and time-specific. The user's USW thus displays *Acme Online* and *Good morning, Patrick, and welcome to the Acme user support widget on Facebook*. The *_@businessPageUrl* and *_@logoUrl* are substituted with

URLs that may change based on user characteristics such as location, language, age, gender, etc. For a female customer, for example, the *_@businessPageUrl* may point to a Web page of the business that includes products that are primarily offered to female customers. Lastly, *_@hover* and *_@hoverText* exemplify how JavaScript can be personalized as well. The *_@hover* variable can be replaced with the name of a JavaScript function that itself may be parameterized, and *_@hoverText* determines a personalized parameter for the *_@hover* function.

To replace template variables with actual values (cf. Sections 3.4.3-4), *PerForm* draws on two possible sources for the actual values: one is a collection of *default values*. The other is a set of dynamically generated personalized values for this user that override the default values. Default values are stored in an XML *variable mappings specification*. Fig. 2 shows two alternative examples of mappings from the *_@greeting* variable to values. The first example maps *_@greeting* to the default value *<h4>Hello, _@firstName! Welcome to your Acme shopping portal.</h4>*. This default value itself contains another variable *_@firstName*. *PerForm* automatically replaces standard variables with their corresponding values in the user's social network profile. The second example variable mapping in Fig. 2 illustrates a hybrid approach where the variable substitution is a combination of a default and a personalized value. The default value for the *_@greeting* variable includes *_@timeOfDay*, which is not a standard variable because it does not reference an attribute in the user's social network profile. Therefore, it must be replaced with a dynamically computed, personalized value (a greeting for the current time of the day) by a *custom variable mappings handler* as explained further below.

Therefore, simple personalization that relies on the values in the user's social network profiles and in XML variable mappings specifications can be performed without the need to write any code (cf. Section 3.4). If, however, the developer omits a mapping from *_@greeting* or *_@timeOfDay* to a default value in the variable

```
<td id="branding" class="_@brandingClass">
    <div>_@businessName</div>
    <div>
        <a href="_@businessPageUrl" onmouseover="_@hover('_@hoverText');">
            <img src="_@logoUrl" height="48" width="48">
        </a>
    </div>
</td>
<td id="greeting" class="_@greetingClass">
    <div>_@greeting</div>
</td>
<greeting>
  <![CDATA['<h4>Hello, _@firstName! Welcome to your Acme shopping portal.</h4>']]>
</greeting>
<greeting>
  <![CDATA['<h4>_@timeOfDay, _@firstName! Welcome to your Acme shopping portal.</h4>']]>
</greeting>
```

Fig. 2. An HTML template and two mappings from the *_@greeting* variable to values

mappings specification or wishes to override the default value for some users with more personalized values, it is necessary to write a *custom variable mappings handler* that implements an interface in a simple *PerForm* Java API. By inspecting the first

```
public VariableMappings getUserVariableMappings(User userProfile)
{
    VariableMappings variableMappings = new VariableMappings();

    int timezone = userProfile.getTimezone(),
        hours;

    String language = userProfile.getLanguage();

    if (timezone >= 0)
        hours = Calendar.getInstance(TimeZone.getTimeZone("GMT+" + timezone)).get(Calendar.HOUR_
    else hours = Calendar.getInstance(TimeZone.getTimeZone("GMT" + timezone)).get(Calendar.HOUR_

    if (hours <= 10)
        if (language.equals("en"))
            variableMappings.addVariableMapping("_@greeting", "Good Morning, " + userProfile.get
                                                ", welcome to the _@businessName customer servic
        else if (language.equals("es"))
```

Fig. 3. A custom variable mappings handler that generates personalized values

name, language preference, and time zone, the handler can, for example, map *_@greeting* to *Good morning, Patrick, and welcome to the Acme user support widget on Facebook*. Fig. 3 shows an excerpt from a custom variable mappings handler producing the greeting for an English-speaking customer before 10:00 AM in that user's timezone. A more creative greeting could be based on the user's interests, hobbies, and activities and display an online "article of the day" that might appeal to the user. If only select users should see a personalized UI element (Section 3.4.2), the custom variable mappings handler returns a *null* value for all other users, in which case *PerForm* uses a generic value in the XML variable mappings specification.

PerForm also supports personalization based on user segmentation (cf. Section 3.4.1). To this end, *PerForm* offers a *user segmentation handler* interface in its Java API. For each user segment, the application developer creates two types of artifacts: a set of templates and a variable mappings specification. The user segmentation handler simply maps a representation of a user's social network profile to a tuple *(template URI, variable mappings URI)* pointing to the two types of artifacts. For example, user segmentation may be desired along language lines and so the developer can provide different HTML templates and variable mappings for each page in the application's Web UI, one for each supported language.

The USW incorporates additional personalization as shown in Fig. 1 (annotated with circles ❶-❺) according to users' long-term characteristics: age-appropriate font sizes, a customer service menu according to user interests, user location-specific announcements, and a personalized set of live communication modalities (voice, video, and/or chat) based on the user's perceived value to the business.

5 Conclusions

A consistent, general approach to application personalization, with reliable, convenient sources of personalization data, low development effort, and little required developer training has so far been an elusive goal. We propose a platform approach to personalizing (Web) applications and postulate several conceptual and technical goals that a successful personalization development and execution platform has to fulfill. We present our experimental platform *PerForm* that transparently retrieves social

network user profiles as a personalization data source and maps them to personalized application UI elements under developer guidance. Social network user profiles reveal in-depth personal characteristics, background, preferences, interests, affiliations, relationships, and more. This data allows *PerForm* to produce fine-grained application personalization based on individual long-term characteristics. We envision broadening *PerForm* to also draw on dynamic user activities, expressions, and context in application personalization, retrieved from social networks and other online sources as well as from context data sources such as mobile sensors. This way, personalization that is more reflective of a user's current situation becomes possible.

References

1. Nasraoui, O.: World Wide Web Personalization. Encyclopedia of Data Mining and Data Warehousing, Idea Group (2005)
2. Pancake, C.: The Ubiquitous Beauty of User-Aware Software. Communications of the ACM 44(3), 130 (2001)
3. Mobasher, B., Cooley, R., Srivastava, J.: Automatic Personalization Based on Web Usage Mining. Communications of the ACM 43(8), 142–151 (2000)
4. Bonnet, S.: Model Driven Software Personalization. In: Smart Objects Conference SOC 2003, 114-117 (2003)
5. Wu, D., Im, I., Tremaine, M., Instone, K., Turoff, M.: A Framework for Classifying Personalization Scheme Used on e-Commerce Websites. In: 36th IEEE Annual Hawaii International Conference on System Sciences, 12-21 (2003)
6. Teevan, J., Dumais, S.T., Horvitz E.: Potential for Personalization. ACM Transactions on Computer-Human Interaction 17(1), 4-38 (2010)
7. Rossi, G., Schwabe, D., Guimarães, R.: Designing Personalized Web Applications. In: 10th ACM International World Wide Web Conference, 275-284 (2001)
8. Hong, J., Suh, E.-H., Kim, J., Kim, S.: Context-Aware System for Proactive Personalized Service Based on Context History. Expert Systems with Applications 36(4), 7448-7457 (2009)
9. Pierrakos, D., Paliouras, G., Papatheodorou, C., Spyropoulos, C.D.: Web Usage Mining as a Tool for Personalization: A Survey. User Modeling and User-Adapted Interaction 13(4), 311-372 (2003)
10. Eirinaki, M., Vazirgiannis, M.: Web Mining for Web Personalization. ACM Transactions on Internet Technology 3(1), 1–27 (2003)
11. Akther, A., Alam, K.M., Kim, H.-N., El Saddik, A.: Social Network and User Context Assisted Personalization for Recommender Systems. In: 2012 IEEE International Conference on Innovations in Information Technology, 95–100 (2012)
12. Schilit, B., Adams, N., Want, R.: Context-Aware Computing Applications. In: First Workshop on Mobile Computing Systems and Applications, 85--90. IEEE Computer Society (1994)
13. Dey, A.K.: Understanding and Using Context. Personal and Ubiquitous Computing 5(1), 4-7 (2001)
14. Garrigos, I., Gomez, J., Cachero, C.: Modelling Dynamic Personalization in Web Applications. In: Lovelle J., Rodríguez B., Gayo J., Puerto Paule Ruiz M. del, Aguilar L. (eds). LNCS vol. 2722, pp. 3–27, Springer, Heidelberg (2003)
15. Blechschmidt, T., Wieland, T., Kuhmunch, C., Mehrmann, L.: Personalization of End User Software on Mobile Devices. In: Second IEEE International Workshop on Mobile Commerce and Services, 130–137. IEEE Computer Society (2005)

Social Smart Destination: A Platform to Analyze User Generated Content in Smart Tourism Destinations

Andrea Cacho[1], Mickael Figueredo[2], Arthur Cassio[3], Maria Valeria Araujo[4], Luiz Mendes[1], José Lucas[2], Hiarley Farias[2], Jazon Coelho[3] Nélio Cacho[3]and Carlos Prolo[3]

[1] Department of Tourism, [2] Metropole Digital Institute, [3]Department of Informatics and Applied Mathematics, [4]Department of Management
Federal University of Rio Grande do Norte, Natal, Brazil
{deiacacho, mickaelfigueredo, arthurcassio, valeriaaraujoufrn, luiz.mendesfilho, joselucas-20, hiarley.farias, falecomjazon, neliocacho, carlosprolo}@gmail.com

Abstract. The purpose of this paper is to present a platform that uses social media as a data source to support the decisions of policymakers in the context of smart tourism destinations initiatives. The proposed platform was implemented and tested during the 2014 FIFA World Cup. In total were analyzed 7.5 million tweets. The results show that it is possible to identify the nationality, language of the posts, points of agglomeration and concentration of visitors. Overall the initial results suggest that data collected from Twitter posts can be applicable to the effective management of smart tourism destinations.

Keywords: Smart Tourism Destination; Smart City, Social Media; Twitter.

1 Introduction

The concept of smart city arises due to the complexity and management challenges faced by the authorities to deal with the rapidly urban population growth. The authors on [4] argue that a city can be defined as 'intelligent', when there is investment in human and social capital, as well as in information and communication technology (ICT) infrastructure. Smart city initiative may comprise many different areas of the city administration. For instance, smart tourism destination concept emerged from the development of smart cities [3]. Smart tourism destination can be perceived as places utilizing the available technological tools and techniques to enable demand and supply to co-create value, pleasure, and experiences for the tourist and wealth, profit, and benefits for the organizations and the destination [2].

Smart city incorporates a large number of systems, which represent the most basic infrastructure for integrating the real and virtual worlds. One of the great challenges of deployment of smart cities is the extraction of relevant information from the ICT infrastructure of cities. Such extraction usually relies on the use of sensors that are installed to capture the flow of vehicles, water and energy consumption, thus requiring high public investment for the development of smart cities [7]. To overcome such difficulty, some studies suggest using social media to identify the perception of residents and visitors about a particular city [1, 5]. For example, social media can be

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_77

used to obtain relevant information on the situation of public transport, traffic and environmental conditions, public safety and general events in cities. In this sense, the purpose of this paper is to present a platform that uses social media as a data source to support the decisions of policymakers in the context of a smart tourism destination.

2 Smart Destination Initiative of Natal

Natal is located on the northeast of Brazil by the Atlantic Ocean. The capital city of the state of Rio Grande do Norte is home of approximately 862.000 thousands people. The city and the surround area are well known due its sandy beaches and natural resources which attract thousands of tourists every year. Although Natal was not the location for the World Cup knockout stage, Natal hosted 4 games in the group stage with an average attendance of 40,000 fans at each game. In total, Natal received around 173,000 tourists during the World Cup period. According to a study performed by Forward Data together with Pires & Associados in Brazil [11], Natal presented the highest growing number of bookings among all host cities when compared to the same period in 2013, for which bookings have grown by more than 1000%.

The high number of tourists puts severe pressure on the urban infrastructure and services related to transportation, safety and water consumption. In order to handle such pressure, the Natal city council in partnership with public and private sector have engaged in an initiative to create a smart tourism destination. In fact, smart city concept covers a variety of industries, including the tourism industry [12]. Caragliu et al. [4] claimed that cities can be defined as smart "when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance". The development of Smart City facilitates seamless access to value-added services such as access to real-time information on public transportation network, enriches tourist experiences and enhances destinations competitiveness [3].

Due to the complexity to define a smart city initiative that may comprise many different areas of the city administration, the Natal initiative decided to focus on some specific areas [17, 18]. This paper describes a smart city initiative to create a smart tourism destination. Hence, the initiative to create a smart tourism destination is a first step towards the creation of a smart city initiative for Natal. A smart tourism destination is perceived as places utilizing the available technological tools and techniques to enable demand and supply to co-create value, pleasure, and experiences for the tourist and wealth, profit, and benefits for the organizations and the destination [2]. Guo, Liu, and Chai[12] argue that Smart Tourism Destination is a relevant part of the construction of the smart city's application system since it depends on the infrastructure of the smart city, utilization of information resources, and development of the intelligence industry.

Among the many benefits of defining a smart tourism destination, gathering the tourist's perceptions about the city is considered one of the most important ones [3]. When tourists use the internet to express their perception by means of words, terms and phrases that form their spoken language, this perception is said to be a user generated content (UGC). A UGC has been described as creative work that is published on publicly accessible websites and is created without a direct link to

monetary profit or commercial interest [14]. UGC websites have evolved into multiple forms [14]: virtual communities (e.g., LonelyPlanet), consumer reviews (e.g., Yelp), personal stand-alone blogs, blog aggregators (e.g., LiveJournal) and microblogging platforms (e.g., Twitter), as well as social networks (e.g., Facebook), and media sharing tools (e.g., Flickr, YouTube). This paper focus on microblogging UGC since it is carried out usually by mobile phone text messages and is currently restricted to just 140 characters. Twitter is possibly the best known microblogging site where users post messages ("tweets") sharing views on topics and news stories and ask advice and help [15]. Twitter produce millions of posts being broadcast over time. These posts need to be analyzed in order to extract situation awareness about tourists behavior in a smart tourism destination. Litvin et al. [16] claim that UGC on social media is a substantial source of strategic information which can be used for the development of a number of business strategies—including enhancing visitor satisfaction through product improvement, solving visitor problems, discovering visitors' experience, analyzing competitive strategies as well as monitoring image and reputation of a tourism destination.

Based on the importance of the UGC to the tourism industry [14, 15, 16], the Natal initiative decided to define and implement a platform to support the monitoring of tourist perception and movement during their visits in Natal. The Natal initiative comprises many actions [17, 18] in terms of management and organization, governance, policy and technology. Due to space constraints, next section presents only the technology solutions implemented to support the creation of a smart tourism destination.

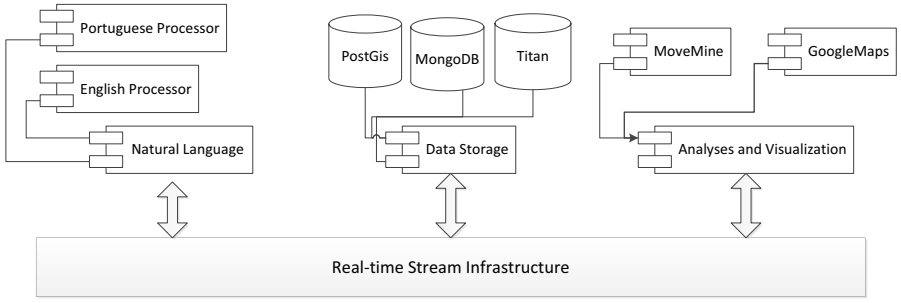


Fig. 1. SSD Platform Architecture.

3 Social Smart Destination Platform

This work has adapted and optimized a set of machine learning and natural language processing techniques to deal with real-time and high-volume text streams. These techniques are packaged in a proposed software platform named Social Smart Destination (SSD). This platform provides capabilities that include identifying early indicators of tourism industry, exploring the presence of tourism issues and monitoring tourist's behavior. In order to provide such technologies, SSD

encompasses four components (Figure 1): a real-time stream infrastructure, a natural language component, a data storage component, and an analyses and visualization component. Next subsections describes in details each of these aforementioned components.

3.1 Real-time Stream Infrastructure

The SSD platform uses real-time processing infrastructure as a central component. This infrastructure is implemented through the use of *Apache Storm* [13]. *Storm* is a free and open source stream-processing framework capable of processing one million 100 byte messages per second per node [13]. A *Storm* cluster is formed by a distributed network of processing nodes that process a set of data compartmentalized in tuples. For this, three components are defined: (i) *zookeeper*, (ii) *Nimbus* and (iii) the *supervisor*. *Zookeeper* is a high-performance service that coordinates distributed applications through configuration management, appointment and work services group synchronization. On *storm's* architecture, it stores the synchronization of data and the processing state of *tuples* that will be performed at the nodes *supervisor*. The *Supervisor* is the nodes of the cluster *Storm* responsible for the data processing. Finally, *Nimbus* is the primary node of the cluster *Storm*, responsible for distribution of code to be processed, assigning tasks to nodes *supervisors* and fault monitoring.

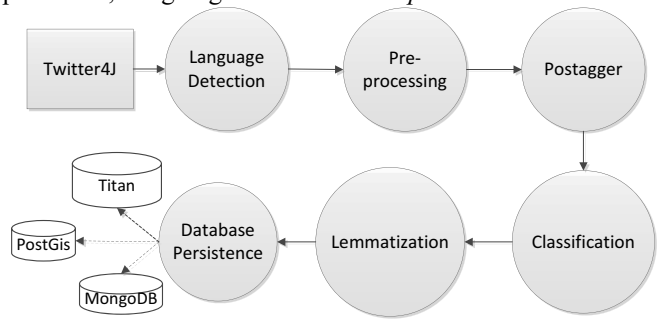


Fig. 2. Natural Language processing Topology.

Storm uses *topologies* as mechanisms for computational organization. *Topologies* are defined as a processing graph where each node in a topology contains a logic processing and links between them. The links indicate that data can be exchanged between nodes. The data stream is represented by *Streams* elements. *Stream* is a sequence of tuples that can be affected by *Spouts* components and *Bolts*. For instance, Figure 2 shows a topology to process natural language. *Spouts* and *bolts* have interfaces that can be used by developers to implement the program logic. *Spouts* (rectangles in Figure 2) are elements that receive a data stream and organize them in tuples. *Bolts* (circles in Figure 2) consume stream elements from a spout or a bolt. Each topology can still be seen as a spouts and bolts package.

3.2 Natural Language Component

Due to the great variety of spoken languages that visitors in a smart tourist destination may use to create UGC, the Natural Language Component (NLC) was design with extension points, which are well-defined places where other language processing components can be added. For this version, Figure 1 shows that SSD support two languages: English and Portuguese. Moreover, the Natural Language component is structured around the Storm abstractions. Figure 2 shows how Storm frames the natural language processing techniques used in this work. The top-left of this topology takes inputs from a public streaming Twitter API (Twitter4J). This *spout* creates a *stream* with tuples that contain the following data: name, age and city of Twitter users, tweet ID, latitude, longitude, date and time of the post, and body of the tweet. Some of these data, such as the user's city, are only obtained when the user allows access to your profile on Twitter.

Tuples created by *spout* are passed onto the Language Detection Library[1] *bolt* which detects the language of the post. The Language Detection bolt allows performing specific actions for the feelings of tourists from different countries that may visit a smart destination. The next bolt performs a preprocessing that includes the removal of special terms (RT, via, etc.) and hashtags treatment according to the language. The Postagger *bolt* performs the *Part-Of-Speech Tagger* (POS Tagger) using the Apache OpenNLP API[2]. The *Postagger bolt* receives a tuple with the tweet text in some language and assigns parts of speech to each word, such as noun, verb, adjective, etc. For instance in the post "I really loved this city," the *Postagger bolt* creates a tuple with the words properly classified with its context, like "I" being a personal pronoun, 'really' an adverb and "loved" a verb. Then the *Classification bolt* implements a Naïve Bayes classifier based on [9], reaching accuracy levels of about 82% with only the positive, neutral and negative classes. The *bolt Lemmatization* takes into account the language of the post to reduce inflectional forms and sometimes derivationally related forms of a word to a common base form (lemma). For instance, in English, if confronted with the token “saw”, *Lemmatization bolt* would attempt to return either “see” or “saw” depending on whether the use of the token was as a verb or a noun.

3.3 Data Storage Component

The data storage is executed by the bolt *Database Persistence*. This bolt stores the processed tweets in three databases: MongoDB[3], PostGIS5[4] and Titan6[5]. *MongoDB* is an open-source document database that provides high performance, high availability, and automatic scaling. *MongoDB* was used to create two data collections. The first

[1] https://code.google.com/p/language-detection/
[2] https://opennlp.apache.org/
[3] https://www.mongodb.org/
[4] http://postgis.net/
[5] http://thinkaurelius.github.io/titan/

collection stores all tweets, creating a log for tweets. In turn, the second collection stores the most commonly used terms, their common base form (lemma) and the time they were collected. In order to understand visitor behavior, the platform uses the *PostGIS* database to create a cross-reference among the spatial information (latitude, longitude and time) generated by the Twitter posts and the list of georeferenced tourist attractions obtained from *Google Places*. This cross-reference allows identifying: (i) which are the most or the least visited places, (ii) what are the tourist perception about the attractions, (iii) and which kind of attractions are preferred by different target groups. Finally, *Titan* is used to store, in the form of a graph, the relationship between users and tweets. *Titan* is a distributed graph database optimized for storing and querying graph structures. Like *Storm* and *MongoDB*, *Titan* databases can run as a cluster and can scale horizontally to accommodate increasing data volume and user load. The graph structure of *Titan* facilitates the implementation of algorithms to discover the underlining rules governing the behavior of people in a social network, such as centrality and closeness.

3.4 Analyses and Visualization

The analysis and visualization component also uses bolts and functions to implement the data analysis. These elements have not been described in Figure 2 for the sake of simplification of the figure. The spouts are used to retrieve data from databases and bolts are used to generate the results that will be displayed by the graphical interface of the platform. The Analyses and Visualization components leverages the *MoveMine* [17] tool to perform sophisticated moving object data mining. MoveMine integrates many data mining functions including moving object pattern mining and trajectory mining based on state-of-the-art methods. MoveMine has many application scenarios. For example, it can automatically detect an approximate period in movements; it can reveal collective movement patterns like flocks, followers, and swarms; and it can perform trajectory clustering, classification and outlier detection for geometric analysis of trajectories. The graphical interface is a web interface in the form of a dashboard, implemented in HTML / JavaScript using the Google Maps API V3 and Google Charts library to generate maps and graphics, respectively.

3 Assessment Methodology

In order to assess the SSD, the platform has been run to collect and process the Twitter posts during the 2014 FIFA World Cup, which took place in Brazil. The platform ran from the 10th of June 2014 to the 15th of July 2014. The initial date was two days before the opening ceremony and the closing date was two days after the closing ceremony. The decision to collect tweets during the World Cup was primarily based on the fact that during the same period many organizations perform surveys to identify the tourist perception, nationality, etc. Hence, the intention is to compare our results with other researches performed during the same period. The platform collected automatically all tweets containing at least one of the following terms:

Salvador, Manaus, Natal, RiodeJaneiro, Recife, SaoPaulo, BeloHorizonte, PortoAlegre, Fortaleza, Cuiaba, Brasilia and Curitiba. These terms corresponds to the World Cup host cities names. The platform processed during the assessment period approximately 7.5 million tweets.

4 Results

The SSD platform allows performing different analysis and use different filters to be applied to the collected dataset. For instance, when only the tweets with latitude and longitude are taking into account, the number of tweets drops from 7.5 million to 286,000 tweets. Based on this subset (tweets with latitude and longitude), the SSD platform shows that 81.16% of all posts were originated in the Brazilian territory. Other South America countries accounted for 5.69% of the posts whereas the North and Central American accounted for 4.89% and 2.75%, respectively. Despite being a continent with great tradition in football, Europe appears only with 3.05% of the posts.

These data shows an implicit feature of Twitter, i.e., to be used to share information and describe day-to-day activities of people lives [6]. According to [10], 80% of users use Twitter to update their followers on what they are doing, while the remaining 20% use Twitter to send general background information. The small number of posts outside Brazil helps to confirm this notion that Twitter users have little reciprocity in the exchange of messages among users [8], unlike other social media, suggesting that the main goal of Twitter is not maintaining relationships, but disseminating personal news.

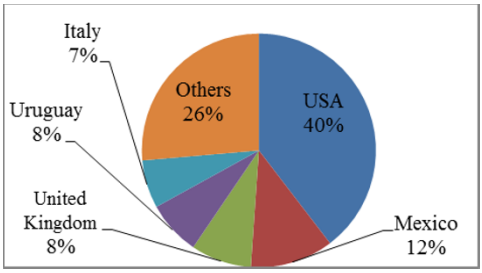


Fig. 3. Tourist nationality.

In order to analyze the tourism demand, it has been defined two additional filters. The first selected only the posts of Twitter users whose original location was not in Brazil (based on the user profile information), and the second restricted to tweets posted within the perimeter of the metropolitan region of Natal (i.e., posts sent from Natal, but from foreign users). These two filters have generated a subset that comprises 7,465 posts. Based on this subset, it was found that Natal received during the FIFA World Cup tourists from 25 different nationalities (see Figure 3), such as Americans (39.60%), Mexicans (11.56%), British (8.38%), Uruguayans (7.51%), and Italians (6.65%).

In addition, it was possible to identify the languages used in Twitter posts. In total, it was identified 11 different languages: English being the most used with 41% of the posts, followed by the Spanish (25%), and Italian (18%). For example, it was observed a majority presence of posts in English on the date of the match between USA and Ghana (i.e., 16th June).

Real-time identification of tourist's behavior is another information relevant to the context of smart destinations. With such information, the public managers of the tourism sector can improve the tourist infrastructure in those areas while the public safety managers can optimize the distribution of vehicles to cover the places of greatest tourist presence.

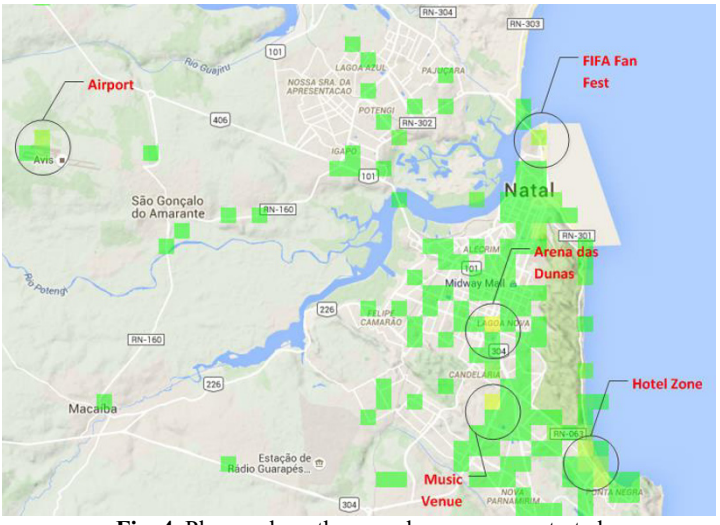


Fig. 4. Places where the crowds were concentrated

According to Figure 4, the area of greatest concentration of posts was in the Arena das Dunas Stadium, then a live music venue near by the stadium, followed by the hotel zone, the airport, and lastly, FIFA Fan Fest. These results revealed that the location of this music venue close to the Stadium probably was favored in comparison with FIFA Fan Fest (official music venue). Finally, it was observed that 72% of posts in English were positive, 18% neutral and 10% negative. Most of the negative posts were related to the bus service, since during the competition in Natal, bus drivers went on strike.

As described in Section 3, the purpose to analyze tweets during the world cup was to compare our results with other researches that usually performed in the same period. This comparison aims to assess the validity and reliability of the data provided by the SSD platform. One of the studies was performed by the Spanish company Forward Data [11] that in partnership with Pires & Associados in Brazil researched the nationalities of foreigner tourists to Brazil. This research looked at five billion reserves issued by 180,000 online travel agencies around the world. These results showed that for the city of Natal, 29% of bookings were made by North Americans, 14% of Uruguayans and 7% by Italians. Moreover, the greatest concentration of post in the Arena das Dunas Stadium was expected for a football competition and may

suggest that the SSD can be used to identify crowd concentration in other circumstances.

6 Related Work

Social networks are widely used to collect information about people and events. For example, [1] and [5] describe approaches that capture tweets on a certain radius starting from an application point. Then those approaches used probabilistic models to identify problems relating to traffic and on other events. Our approach is based on the solutions defined by [1, 5] and describes additional contribution as a platform that supports the treatment and identification of events in real time using multiple languages and supporting analysis and geo-referenced data visualization. There are many researches[14, 15, 16] in the tourism and hospitality area that analyse the use of UGC as a data source. For instance, Lua and Stepchenkovab [14] surveyed 122 peer-reviewed journals articles and conference proceedings to investigate among many other thing the use of software that has been used to collect and extract information from UGC. According to [14], there is no tool with the same capabilities of the SSD platform.

7 Conclusion

This paper presented a platform that uses social media as a data source to support the decisions of policymakers in the context of smart destinations initiatives. The Social Smart Destination platform aims to enhance tourists' travel experience through collecting and analyzing in real-time Twitter posts. This paper detailed the topology responsible for collecting, processing, and storing the Twitter posts. Some of the data gathered by the platform was analyzed to show how the platform can be used by a smart destination. The results showed that it is possible to identify the nationality, the language of the posts, the sentiment, and the points of agglomeration of visitors during a big event. Overall results suggest that data collected from Twitter posts can be applicable to the effective management of smart tourism destinations. As future work, we intend to use the comments obtained from of the *tripadvisor* web site to train our sentiment analysis component. We believe this will improve the precision of our approach since real comments from tourists in Natal will be used to better train the machine learning algorithms. Finally, we intend to add new domains to the platform, such as the support identify issues in the public safety of a smart city.

Acknowledgments

This work was partially supported by the National Institute of Science and Technology for Software Engineering (INES), grants 573964/2008-4(CNPq) and APQ-1037-1.03/08 (FACEPE), and by the Smart Metropolis Project.

References

1. Anantharam, Pramod, et al. "Extracting City Traffic Events from Social Streams." ACM Transactions on Intelligent Systems and Technology 9.4 (2014).
2. Boes, Kim, Dimitrios Buhalis, and Alessandro Inversini. "Conceptualising Smart Tourism Destination Dimensions." Information and Communication Technologies in Tourism 2015. Springer International Publishing, 2015. 391-403.
3. Buhalis, Dimitrios, and Aditya Amaranggana. "Smart tourism destinations." Information and Communication Technologies in Tourism 2014. Springer International Publishing, 2013. 553-564.
4. Caragliu, Andrea, Chiara Del Bo, and Peter Nijkamp. "Smart cities in Europe." Journal of urban technology 18.2 (2011): 65-82.
5. Doran, Derek, Swapna Gokhale, and Aldo Dagnino. "Human sensing for smart cities." Proceedings of the 2013 IEEE/ACM International Conference on Advances in Social Networks Analysis and Mining. ACM, 2013.
6. Java, Akshay, et al. "Why we twitter: understanding microblogging usage and communities." Proceedings of the 9th WebKDD and 1st SNA-KDD 2007 workshop on Web mining and social network analysis. ACM, 2007.
7. Komninos, Nicos, Marc Pallot, and Hans Schaffers. "Special issue on smart cities and the future internet in Europe." Journal of the Knowledge Economy 4.2 (2013): 119-134.
8. Kwak, Haewoon, et al. "What is Twitter, a social network or a news media?." Proceedings of the 19th international conference on World wide web. ACM, 2010.
9. Silva, Mário J., Paula Carvalho, and Luís Sarmento. "Building a sentiment lexicon for social judgement mining." Computational Processing of the Portuguese Language. Springer Berlin Heidelberg, 2012. 218-228.
10. Naaman, Mor, Jeffrey Boase, and Chih-Hui Lai. "Is it really about me?: message content in social awareness streams." Proceedings of the 2010 ACM conference on Computer supported cooperative work. ACM, 2010.
11. Forward Keys and Pires & Associados. (2014) . Fifa World Cup shakes Brazilian Tourism Trends.
12. Guo, Y., Liu, H., and Chai, Y. (2014). The embedding convergence of smart cities and tourism internet of things in China: An advance perspective. Advances in Hospitality and Tourism Research, 2(1), 54-69.
13. Apache Software Foundation. *Apache Storm.* Avalilable : https://storm.apache.org/. Lu, W. and Stepchenkova, S. User-Generated Content as a Research Mode in Tourism and Hospitality Applications: Topics, Methods, and Software. Journal of Hospitality Marketing & Management, Feb, 2015, Vol. 24, N0. 2, p.119-154
14. Akehurst, Gary, (2009), User generated content: the use of blogs for tourism organisations and tourism consumers, Service Business, 3, issue 1, p. 51-61.
15. Litvin, S. W., Goldsmith, R. E., & Pan, B. (2008). Electronic word-of-mouth in hospitality and tourism management. Tourism Management, 29(3), 458–468.
16. Wu, F., Lei, T., Li, Z., and Han., J. (2014). MoveMine 2.0: mining object relationships from movement data. Proc. VLDB Endow. 7, 13, 1613-1616.
17. Cacho, A. et al. A Smart Destination Initiative: the Case of a 2014 FIFA World Cup Host City. Proceedings of the IEEE International Smart Cities Conference. IEEE, 2015.
18. Coelho, J. et al. ROTA: A Smart City Platform to Improve Public Safety. Proceedings of the 4th World Conference on Information Systems and Technologies. Springer, 2016.

An Automated Approach for Requirements Specification Maintenance

Jorge Esparteiro Garcia[1,3] and Ana C. R. Paiva[2,3]

[1] Polytechnic Institute of Viana do Castelo
Praca General Barbosa, Viana do Castelo, Portugal
jorgegarcia@esce.ipvc.pt
[2] INESC TEC,
[3] Faculty of Engineering, University of Porto
Rua Dr. Roberto Frias, s/n, 4200-465 Porto, Portugal
apaiva@fe.up.pt

Abstract. The requirements of a website are constantly changing and evolving. In this context, managing the changes related to the baseline and reviewing the requirements' prioritization is critical. Nowadays, web analytics tools are used to analyze the behaviour of users on a website in order to improve its usability and user experience. The analysis of the usage of websites may also help software requirements maintenance which can be a contribution to the overall quality of the service provided. This paper presents an approach through a recommender system that collects the information about the usage of a website using a web analytics tools and generate recommendations reports that may help the requirements maintenance and increase the quality of the software requirements specification of the website. This paper presents also an experimental evaluation of a case study based on an online newspaper website. The results of the proposed approach provide more readable reports in a language more closer to the business and suggest requirements priority change, identify new requirements and functionalities that may be removed.

Keywords: Software Requirements Specification, Requirements Management, Web Usage Mining

1 Introduction

In Software Engineering, software quality has become a topic of major concern. Particularly, websites are being used not only for displaying static information but increasingly as core business tools, particularly through web services, intranets and web applications that run as support applications to business development. The web services are a type of software that must be available 24 hours a day. Furthermore, should please the customer and must be continued permanently. Currently, web analytics tool are able to collect diverse data about the usage of a website. The use of websites generates large amounts of information that may be used for different purposes like assessment of quality of

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_78

web-products [10] or to statistical analysis of website data usage [6]. However, these tools only generate reports with the navigation statistics, duration of navigation on the website and other metrics that are mostly often used simplistically to see which content with more adherence by users [12]. Either, web analytics has focused on analysis and reporting of business metrics of interest mainly to marketers [8]. The potential of the analysis of this data is yet to be explored [1]. An analysis directed to the improvement is not currently done and this data is disregarded for the improvement of the quality of a web application.

The remainder of this paper is organized as follows: Section 2 gives an overview of requirements management and web usage mining, discussing the related work. In Section 3 we describe the approach of the recommender system developed to assist the requirements maintenance, and in Section 4 we present some results achieved with this approach on an Experimental Evaluation of a Case Study based on an online newspaper website. Finally, we conclude the paper and set future directions in Section 5.

2 Background and Related Work

In the last years, Requirements Management is increasingly recognized as crucial [7], due to the needing of writing requirements readable and traceable, in order to manage their evolution over time. The requirements evolution consists in the changes made to the requirements after the initial deploy of the requirements specification document [2]. Requirement changes may consist in additions, omissions or change and can occur in any process, elicitation, analysis, specification or validation. Today, the World Wide Web is used by billions of people all over the world. This expansion has led to a large amount of data. However, this kind of data is heterogeneous, semi structured or unstructured in contrast to the standard data that the common data mining methods have to deal with [13]. Web usage mining refers to the discovery of user access patterns from Web usage logs. Web Mining has an immense potential in itself for recommendations to users based on their preferences [12]. Web usage mining is also a field with immense potential itself for recommendations for systems developers to help in the website improvement [6].

2.1 Related Work

Research in the field of Requirements Management based on data collected of the usage of website is at an early stage or not exactly related with the proposed approach on this paper. For instance, Gao [4] proposed a solution where models software requirements evolution based on the feedback collected, however this solution does not use any kind of web usage data. Banerjee [3] presented a methodology to manage requirements based on errors that may occur in the introduction or updating of the software requirements. Ghezzi [5] presents an approach that automates the acquisition of user-interaction requirements through web logs to identify navigation anomalies and emerging users behaviours. Web

analysis tools available do not provide functionalities that enable a more intelligent analysis to suggest improvements to the website [10], such as identify and remove unused features or present more readable and intelligible reports. In a survey related to software requirements specification, Valderas [11] demonstrated that few of the existing approaches are specifically defined for the specification of web application requirements. Furthermore, once requirements are specified, there is little support for allowing the systematic or automatic derivation of the conceptual model that properly satisfies the software requirements specification. The proposed approach differs from all the related work presented, because we propose a recommender system (REQAnalytics) that supports the requirements maintenance through its lifecycle by using web analytics data of the website. Using the data gathered from a web analytics tool, REQAnalytics generates recommendations to the software requirements specification that may help to the task of the Requirements Management and Maintenance.

3 REQAnalytics

In this section, we present the REQAnalytics tool (Figure 1).

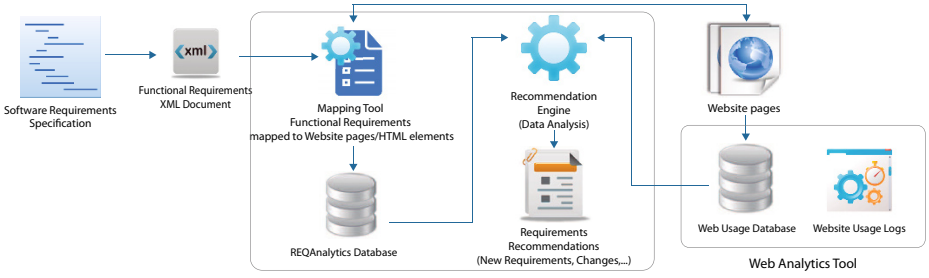


Fig. 1. An overview of the proposed tool - REQAnalytics

The approach propose and supported by REQAnalytics analyzes the web usage data of a specific website to generate recommendations that may help the process of software requirements management during its lifecycle. To generate these recommendations, first we need to map the requirements with the implementation artifacts. So, REQAnalytics, includes as mapping tool (similar to the one presented in [9]) as is shown in Figure 1 that allows to map the functional requirements of the website with its functionalities. Then, the requirements are extracted from their specification and a XML document is created and imported to REQAnalytics. Each requirement has a priority level: Low, Medium or High. This priority level is a requirements' attribute indicating the priority order of a requirements change request. To collect the web data usage from the website, REQAnalytics uses a web analytics tool (Open Web Analytics) that allows to collect data and save it to a database. Then REQAnalytics analyses the web

usage data with the mapping information stored by the mapping tool. After this analysis, a detailed report is generated with several recommendations to the website requirements specification under review. These recommendations are written in a language closer to the business (than the language used by existing web analytics tools).

4 Experimental Evaluation

This section describes the results of an experimental evaluation of REQAnalytics on a online newspaper website - http://www.cidadetomar.pt. Along the experiment, we wanted to analyze the ability of REQAnalytics to suggest recommendations to the requirements specification and therefore help the requirements maintenance. The focus was to assess the capability of REQAnalytics to:

- Suggest recommendations to assign the priority to requirements under analysis
- Suggest recommendations to create new requirements
- Suggest recommendations to delete existing requirements

The study started by setting up the date range period to collect the web usage data. On this case study, it was defined a time period of 1 month, before the recommender system analysis being carried out. Then, using the REQAnalytics mapping tool, the functional requirements were mapped with the web pages and HTML elements present in the website. With the data collected by the web analytics tool, REQAnalytics linked the web usage data with the mapping information of the requirements in order to analyze the gathered information. After this data had been analyzed, REQAnalytics generated a set of recommendations.

4.1 Experimental Results

This section evaluates the recommendations generated by REQAnalytics. Figure 2 shows the recommendations to the priority of each requirement. The possible recommendations defined for prioritization of the requirements are: Maintain, Increase or Decrease the priority of the requirement.

The algorithm of the recommendation is based on the ranking of visits of each page/HTML element associated with its requirement. First, REQAnalytics creates a ranking with the most visited requirements. After, based on this ranking, our system suggests the recommendations of prioritization (Table 1).

Table 1. Prioritization of the Requirements

Requirement Visits Ranking	Requirement Priority
Rank 1-20	High Priority
Rank 21-50	Medium Priority
Rank >50	Low Priority

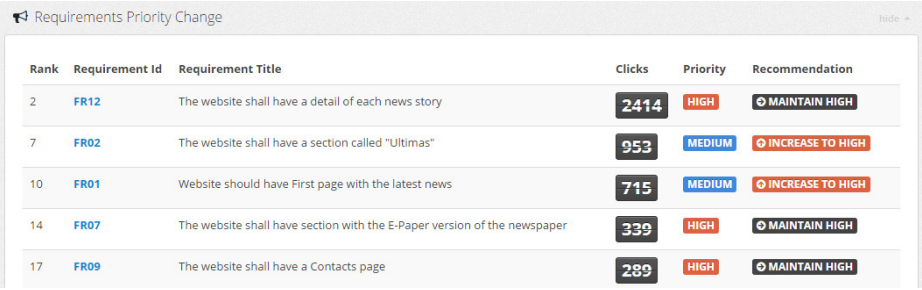


Fig. 2. Recommendations to Requirements Priority Change

The second type of recommendations generated by the recommender system is the creation of new requirements. This recommendation is generated based on the pages/HTML elements that have been visited for at least 10 times during the period of analysis and do not have any requirement associated. During previous empirical experiments, we have noticed that when this occurs it is because there exists a functionality that has been probably implemented after the deploy of the website and has not been updated in the requirements specification. So, the recommender system, analyzes what are the visited pages that meet these conditions and suggests the creation of new requirements as is shown in Figure 3.

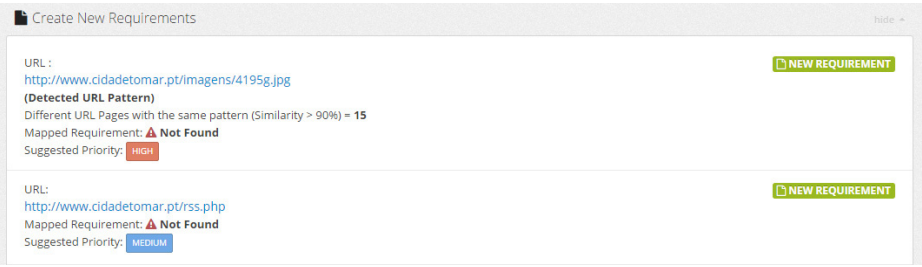


Fig. 3. Recommendations to Creation of New Requirements

In addition to this analysis, the system also analyzes if there are several pages with an high similarity pattern URL (>90%). This occurs when there are pages that have the same functionality and the same name but with different values in the URL variables. REQAnalytics aggregates these pages and suggests the creation of a single requirement for these pages.

Finally, the last type of recommendation provided is the removal of existing requirements. In this type of recommendation, we had to previously parametrize what were the requirements that even do not have any visit during the period of the experiment, are requirements that can not be removed. For instance, if website's Contacts page does not have any visit, it does not mean that the associated

requirement should be removed. Then, with this parametrized precondition, the system suggests to remove the requirements which pages/HTML elements do not have any visits during the period of the experimental evaluation. Figure 4 shows a screenshot of the suggested requirement that may be removed.

Summarizing, after finishing this experimental evaluation, the recommendations given by REQAnalytics were: Changing the priority of the requirements; Creation of new requirements and Delete existing requirements.

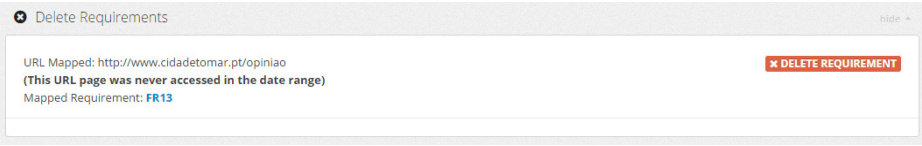


Fig. 4. Recommendation to Delete Requirement

5 Conclusions

This paper presents an approach that collects information about the usage of a website through a web analytics tool and generate recommendations reports that may help the requirements maintenance and increase the quality of the software requirements specification of the website. It also presents an experimental evaluation on a case study of an online newspaper where some relevant results of recommendations to requirements specification of the website were achieved. These recommendations allow to change the priority of requirements and create or remove new requirements.

The kind of analysis performed by REQAnalytics is not performed by existing web analytics tools that only generate reports with navigation statistics. In addition, the recommendations generated by REQAnalytics are presented in a language more closed of the business.

The results obtained in the experiments suggest that recommender systems for software engineering can be used in a meaningful way to help the requirements maintenance during the lifecycle of a website during which requirements are constantly changing and evolving. Overall this can therefore help to improve the quality of the website.

As future work, we intend to develop other experimental studies on more complex websites to allow suggesting different kind of recommendations and to validate the approach proposed on this paper. We also expect to find new requirements dependencies and analyze the requirements paths that can be extracted using the information that the mapping tool included in REQAnalytics provides.

References

1. Akerkar, R., Badica, C., Burdescu, D.D.: Desiderata for research in web intelligence, mining and semantics. In: Proceedings of the 2nd International Conference on Web Intelligence, Mining and Semantics - WIMS '12. p. 1. ACM Press, New York, USA (2012)
2. Anton, A., Potts, C.: Functional paleontology: system evolution as the user sees it. In: Proceedings of the 23rd International Conference on Software Engineering. ICSE 2001. pp. 421–430. IEEE Comput. Soc (2001)
3. Banerjee, A.: Requirement Evolution Management: A Systematic Approach. In: 2011 IEEE Computer Society Annual Symposium on VLSI. pp. 150–155. IEEE (2011)
4. Gao, T., Li, T., Xie, Z., Xu, J., Qian, Y.: A process model of software evolution requirement based on feedback. In: Proceedings - 2011 International Conference of Information Technology, Computer Engineering and Management Sciences, ICM 2011. vol. 2, pp. 171–174 (2011)
5. Ghezzi, C., Pezzè, M., Sama, M., Tamburrelli, G.: Mining behavior models from user-intensive web applications. In: Proceedings of the 36th International Conference on Software Engineering - ICSE 2014. pp. 277–287. ACM Press, New York, New York, USA (2014)
6. Kumar, L., Singh, H., Kaur, R.: Web analytics and metrics. In: Proceedings of the International Conference on Advances in Computing, Communications and Informatics - ICACCI '12. p. 966. ACM Press, New York, New York, USA (aug 2012)
7. Nuseibeh, B., Easterbrook, S.: Requirements engineering: a roadmap. In: Proceedings of the conference on The future of Software engineering - ICSE '00. pp. 35–46. ACM Press, New York, New York, USA (may 2000)
8. Pai, D., Ravindran, B., Rajagopalan, S., Srinivasaraghavan, R.: Automated faceted reporting for web analytics. In: Proceedings of the 4th international workshop on Web-scale knowledge representation retrieval and reasoning - Web-KR '13. pp. 9–16. ACM Press, New York, New York, USA (nov 2013)
9. Paiva, A.C.R., Faria, J.C.P., Tillmann, N., Vidal, R.F.A.M.: A model-to-implementation mapping tool for automated model-based gui testing. In: ICFEM. Lecture Notes in Computer Science, vol. 3785, pp. 450–464. Springer Verlag (2005)
10. Singal, H., Kohli, S., Sharma, A.K.: Web analytics: State-of-art & literature assessment. In: 2014 5th International Conference - Confluence The Next Generation Information Technology Summit (Confluence). pp. 24–29. IEEE (sep 2014)
11. Valderas, P., Pelechano, V.: A Survey of Requirements Specification in Model-Driven Development of Web Applications. ACM Transactions on the Web 5(2), 1–51 (may 2011)
12. Verma, V.: Comprehensive Survey of Framework for Web Personalization using Web Mining. International Journal of Computer Applications 35(3) (2011)
13. Zhang, Q., Segall, R.S.: Web Mining: A survey of current research, technoques, and software. International Journal of Information Technology & Decision Making 07(04), 683–720 (dec 2008)

A visualization-based approach for project portfolio selection

Celmar Guimarães da Silva[1], João Meidanis[2,3], Arnaldo Vieira Moura[2], Maria Angélica Souza[3], Paulo Viadanna Jr.[3], Gabriel A. Costa Lima[4], Rafael S. V. de Barros[5]

[1] School of Technology, University of Campinas, Limeira, SP, Brazil
celmar@ft.unicamp.br,
[2] Institute of Computing, University of Campinas, Campinas, SP, Brazil
[3] Scylla Bioinformática, Campinas, SP, Brazil
[4] AREMAS, Campinas, SP, Brazil
[5] AES-Tietê, Bauru, SP, Brazil

Abstract. We propose a 2-step interactive approach for solving a project portfolio selection problem as a single-criterium optimization problem. Our approach innovates by using two coordinated charts: an interactive project timeline with drag-and-drop functionalities for project reallocation in time; and an interactive cost and risk chart that combines a line chart and several bar charts in order to present multidimensional time-based datasets. These functionalities enable users to refine the model fed into optimization software in order to achieve results that better correspond to their expectations. We discuss the use of our prototype in real scenarios, and present preliminary positive feedback from users.

Keywords: Information Visualization; interactive displays; portfolio selection

1 Introduction

Optimization approaches model the entities of a problem as well as preferences and requirements provided by decision makers in order to calculate one or more optimized solutions of a Pareto frontier for the problem. However, models may not capture entirely all user requirements and preferences, and so they produce optimum solutions in terms of the *modeled* problem only, instead of dealing with the *real world problem*. Interactive approaches may complement this scenario [3]. In the Project Portfolio Selection (PPS) problem, given a set of projects, an optimization software must determine when each project begins, in order to optimize technical criteria, such as reducing the portfolio makespan or determining minimum funding necessities. After that, some approaches use interactive visualization techniques to present these solutions to decision makers, in order to enable them to further explore the solution set.

In this work, we show how single-objective optimization problems may also benefit from interactive approaches. A single-objective optimization problem aims to achieve a single best solution of a problem, *i.e.*, it wants to reveal the best value of a function related to a single objective [2]. Enabling decision makers to modify a solution will help them to better express their preferences about which criteria this solution should comply with. Besides, our visualization-based approach, based on interactive coordinated graphics, enables users to explore alternative solutions in a incremental,

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_79

reversible and easy-to-learn way. Our main contributions are: *(1)* an interactive visualization approach for insertion of decision maker's preferences into the optimization problem; *(2)* an interactive coordinated view of costs, risks, and project allocation in time, based on timelines, barcharts, and line charts. First, we present a theoretical background and review interactive approaches and visualization solutions. After that, we explain our visualization-based methodology for dealing with our single-objective PPS problem. Then we show the use of our approach in a real world scenario and report on preliminary user opinions about it. Lastly, we conclude and present ideas for future work.

2 Theoretical background

A literature review about interactive approaches for the PPS problem reveals that a majority of works deals only with multi-criteria methods. Nowak [9] argues that interactive approaches are frequently used in conjunction with such methods. Fisher [3] presents three reasons why such approaches should be applied to optimization scenarios: it may facilitate model specification and revision; it helps dealing with problem aspects that are hard to quantify; and it may assist in the solution process. Nowak [9] completes this list with two advantages of these approaches: the diminished need of a priori information about decision maker's preferences; and a higher reliance in the generated solution, which in turn may contribute to its adoption.

There are distinct classes of multi-criteria methods, according to decision makers' engagement in the solution selection process [7]. We highlight the class of *interactive methods*, which comprise alternating phases of preference elicitation and solution generation until the decision maker chooses a most preferred solution [8]. Our approach is also an interactive method, but with a single initial solution. Interactive methods may be classified according to at least three ways of *preference information specification* [8]: methods based on trade-off information, reference point approaches, and classification-based methods. Our approach differs from these, as we explain in Section 3.2.

The PPS literature [3] [1] discusses interactive optimization works applied to such diverse problems as vehicle scheduling and routing, location and general scheduling problems, military procurement, management of R&D, planning healthcare provisions, and prioritizing funds for public infrastructure, among many others. However, many of these examples provide few details about how interaction was implemented, if at all. Regarding visualization solutions for PPS problems, Salo et al. [10] argue that scenarios in which decision makers must choose a solution among a large set of feasible solutions pose challenges. Kiesling et al. [4] point out that developing suitable representations and interactions for decision support systems is less understood. Lotov and Miettinen [6] point out that visualization approaches for PPS solutions should be *simple*, *persistent* in decision makers' minds, and it must be *complete* by presenting all relevant information. Lotov and Miettinen [6] argue that visualizing the Pareto frontier helps the decision maker form a mental picture of the problem, which in turn may support a mental search for a preferred solution in the Pareto frontier.

There are many techniques that can be used to represent the Pareto frontier. We will focus only on techniques for representing discrete solution spaces, such as the ones

used when visualizing point-wise approximations to the frontier. At least the following techniques are already in use [6]: *(1) Heatmap*: a matrix with painted cells. The X-axis represents names of decision variables and objective functions; the Y-axis represents alternative solutions; and cell colors indicate values of each variable and function in each alternative. *(2) Scatterplot matrix (SPLOM)*: a $M_{n \times n}$ matrix, in which each cell $M(i, j)$ has a 2D-scatterplot. The axes of each scatterplot are the objective functions i and j. *(3) Decision maps*: a kind of scatterplot representing three or more objective functions. Two of them are represented at the X- and Y-axes, and colors represent a third one. Values of other objective functions may be indicated using sliders. It is worth noting that none of these methods fits our scenario, as we explain in Section 3.2.

3 Methodology

Inspired by Fisher's and Nowak's arguments in favor of adopting interactive techniques in conjunction with multicriteria decision making approaches [9] [3], we propose the use of visualization-based interactive optimization methods for our single-objective PPS problem. In our proposal, two phases alternate until a decision maker is satisfied. In the first phase, the interactive one, we present graphical versions of the current portfolio and values of variables related to it, especially a variable that embodies a measure of risk value, which is important to our objective function as we explain in Section 3.1. In this phase the decision maker may interact with portfolio data and adjust optimization parameters. In the second phase, an optimization algorithm, started by the user, chooses a new portfolio according to the selected parameters.

This paper focuses on the interactive phase of this process. Our approach aims to be simple, persistent and complete, as proposed by Lotov and Miettinen [6], in order to enhance a decision maker comprehension about the data presented. This section describes our characterization of system data, users (*i.e.* decision makers), and user tasks (see Section 3.1). We also define which visual mappings we use to represent data and to provide insights to users (see Section 3.2).

3.1 User, data, and task characterization

Inspired by the work of Kulyk et al. [5], our design methodology defines who are the users, which data will be presented, which tasks may be done with these data, and what insights the visualizations will offer. We consider users as domain experts which have already solved many PPS problems manually. They are interested on many alternative solutions for a given PPS problem instead of just a single solution. Working with timelines, bar charts, and line charts is common ground for them.

Our main objects are projects, portfolios, and warning points. Users provide a set of projects which must be scheduled along the time. Every temporal variable of our problem is measured in months. A project may be classified as mandatory or non-mandatory. Mandatory projects have predefined starting times. Non-mandatory projects have a suggested starting time, and may be subjected to rescheduling by the optimization software. Each project has a duration and monthly costs associated to it. Projects may use one of two types of resources, named CAPEX (capital expenditure) and OPEX (operational

expenditure). The real data stems from a large power generation company, and each project is associated to a particular power generation plant.

Users execute projects in order to reduce risks at their business. To each risk is associated a user-provided *risk value*, a measure of how serious the risk is. Each risk is eliminated if a set of projects (*i.e.*, a warning point) related to it is completed. Therefore, the sooner this set is completed, the sooner the risk is diminished.

A portfolio is a set of projects where each project has a starting time attributed to it. A typical real input instance consists of about 1,400 projects and 450 warning points. A portfolio is feasible if it satisfies two criteria, namely: *(1)* the annual amount of resources used by all projects under execution in a year is within pre-specified limits, for both kinds of resources taken individually; *(2)* the risk associated to each warning point is totally controlled by the end of the planning horizon.

We characterize user tasks as follows. First of all, decision makers start the interaction with a given initial suggested portfolio provided by field experts. Next, the optimization algorithm builds an optimized portfolio for them. The optimization strives to schedule projects as soon as possible, in order to minimize the sum of risk values associated to risk that have been controlled up to this point, these values being weighted by how soon the control takes effect.

According to previous experience, decision makers want to move projects along the execution time line and be immediately informed of how these changes modify risk control and the usage of resources. Enabling decision makers to change annual cost restrictions is also necessary. Such changes may affect the portfolio feasibility, and decision makers probably will want to optimize the portfolio again after these actions are taken. It is worth considering that the optimization algorithm will only change the scheduled start time of non-mandatory projects; however, decision makers may manually change the scheduled start time of any project, including mandatory ones.

Besides, the development team hypothesizes that decision makers may need answers to questions such as:

Q1 What happens if I change a project scheduled start time? Is the new portfolio still feasible? If not, what restrictions did I break?
Q2 How do the budget restrictions interfere with project allocation? Are there unused financial resources?
Q3 How fast is exposure to risk controlled by a given portfolio?
Q4 Are there too many, or too few, projects associated to a given power generation plant in a certain time interval?

Hence, we should provide insights about the following data for a given portfolio: *D1* - Monthly absolute costs; *D2* - Monthly year-to-date costs; *D3* - Available annual amount of resources; *D4* - Portfolio feasibility; *D5* - Monthly exposure to risk; and *D6* - Distribution of project by plants, along the execution time line.

3.2 Visual mapping and visual structures

First of all, we must note that heatmaps, scatterplot matrices and decision maps, which are used in some related works [6], do not fit our problem. Heatmaps with "Variables ×

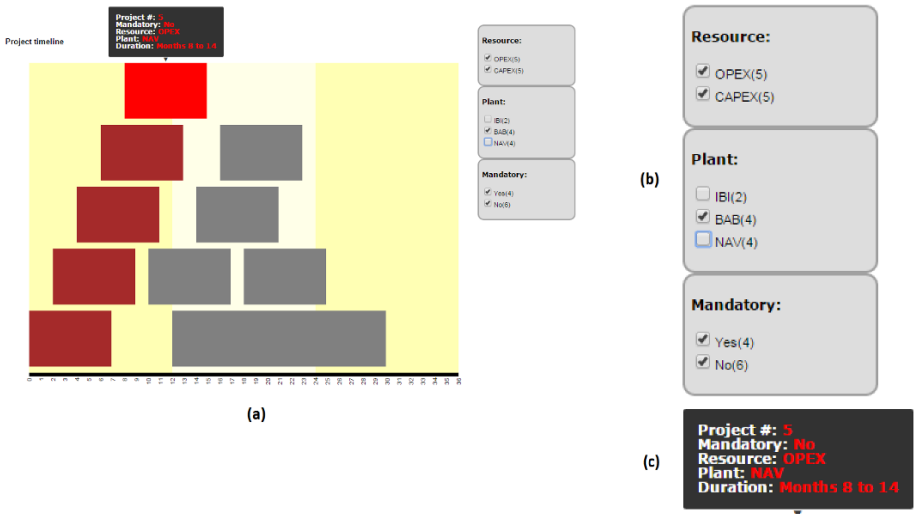
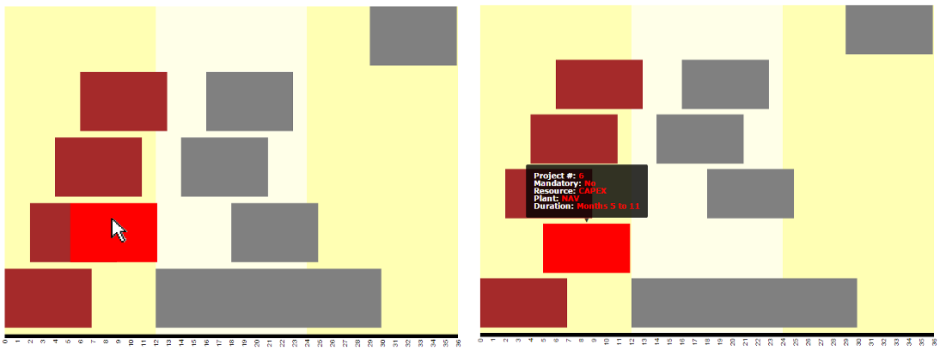


Fig. 1. (a) Project timeline; (b) details of its controls; (c) details of details-on-demand box.

alternative solutions" do not fit our scenario, given that we have only one solution per time. Besides, our heatmaps would have too many input variables to be represented (at least the amount of projects times the amount of months in the portfolio). Scatterplot matrices and decision maps are based on scatterplots, which present two variables in their axes. Due to the predominant temporal aspect of the studied scenario, the presence of a (commonly horizontal) temporal axis is essential, and this will not happen in many scatterplots of a scatterplot matrix. In addition, scatterplots do not support exhibition of time intervals, which are relevant to our problem. Therefore, we opted to develop our own visualization approach for this scenario.

Our visualization proposal comprises two coordinated visual structures: an interactive *project timeline* and an interactive *cost and risk chart*. This section details these structures and their visual mapping, *i.e.*, the matching between data variables and graphical and interactive characteristics in our charts.

Our *project timeline* (Fig. 1) is similar to other timelines [12]: its X-axis represents time, in months, and each rectangle represents a project. Leftmost and rightmost positions of a rectangle represent the start and end time of a project, respectively. This chart has also some interactive features. First, decision makers may drag rectangles along the X-axis in order to change a project scheduled start time. This feature implements direct manipulations [11], and provides a fast and easy-to-learn input procedure that avoids user mistakes such as filling forms with wrong values. Second, when the mouse pointer hovers over a rectangle, a detail window is shown (Fig. 1). As a third feature, decision makers may use filters to select which projects should be highlighted. Each filter checkbox presents a field value, like a plant or the kind of resource the project uses, and how many projects have this particular value. Figure 1 presents all selected projects from plant "BAB" highlighted in brown.



(a) (b)

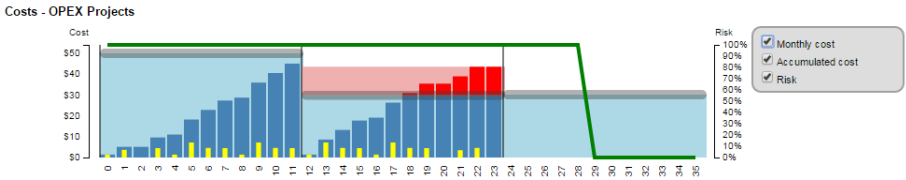
Fig. 2. (a) User drags a project rectangle and drops it over another one. (b) The same portfolio from Fig. 2(a), after solving overlapping problem.

We use a different method, as opposed to timelines and Gantt charts, for the *Y*-axis. Many approaches define a categorical variable for this axis, *e.g.* human resources. In our scenario, we do not map any variable to this axis, and therefore each rectangle may be placed in any vertical position so that it does not ovelap another one. In this scenario, and expecting a large number of projects, we wanted to enlarge the height of each rectangle representing a project, in order to facilitate dragging actions. To achieve this, we developed a layout algorithm that enables rectangles to share the same timeline row, while avoiding visual overlapping. This algorithm defines the vertical position of a project as the first empty position, from bottom up, in which the project fits.

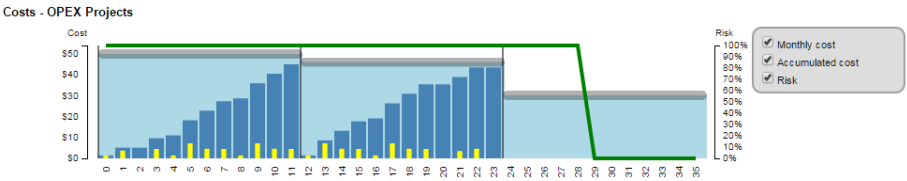
Given that a set of rectangles may share a common row, users may drag and drop a rectangle over another one. In order to resolve overlap problems without causing extra cognitive efforts to the users, a new layout, with few changes when compared to the current one, must be provided and with a smooth transition between the two. To achieve this, we create a new empty row under the current one and move the dragged project to it. Figure 2 illustrates the approach.

Our second interactive graph is a *cost and risk chart*, in which we combine bar and line charts. We represent the following time-dependent variables: *a*) monthly absolute costs: presented as thin vertical yellow bars; *b*) monthly year-to-date costs: presented as medium-size blue and red vertical bars, behind monthly absolute costs; *c*) annual cost restriction: presented as large light-blue vertical bars, behind previous costs; *d*) annual additional needed funding: presented as large light-red vertical bars, also behind previous costs; and *e*) monthly overall controlled risk value: presented as a green line. Our chart has two vertical axes: a cost value, applied to all bars related to cost variables; and a risk value, applied only to the green line. A horizontal axis represents time, in months. Figure 3(a) illustrates a chart for OPEX resources.

Each year has also an associated slider, which is a grey control in the form of a rounded rectangle. Its vertical position defines the cost restriction for its respective year. As a slider, users may drag it vertically, thus changing its value, which may break the



(a) Chart with an unfeasible portfolio.



(b) By changing second year restrictions, we attain portfolio feasibility.

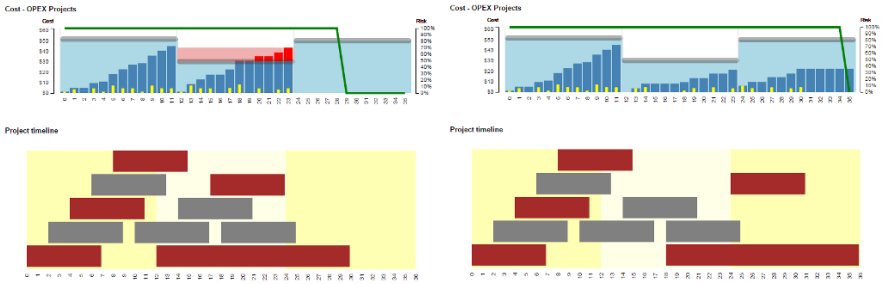
Fig. 3. Example of cost and risk chart for a 3-year portfolio.

portfolio feasibility, *i.e.*, its annual cost restrictions. We use colors to provide insights about portfolio feasibility and broken restrictions. The annual additional needed funding bar represents the amount of resources that is in excess of its given annual cost restriction. Blue and red colors of annual absolute cost bars indicate the amount of resources that obeys or breaks cost restrictions, respectively. Colors are updated instantaneously when a slider is dragged. This mapping enables a fast perception of portfolio feasibility, given that any red region in the chart signals infeasibility for the current portfolio. Besides, the value represented by each slider is shown above it during a drag action. Figure 3(b) shows how to achieve portfolio feasibility when increasing OPEX resources for the second year. Note that there is no red bar in this chart.

A second interactive feature of our chart is a filter that can be used for showing or hiding values of the following time-dependent variables: monthly absolute costs, monthly year-to-date costs, annual absolute costs, and risk values (grey boxes at Fig. 3). Besides, we present a detail window when the mouse pointer hovers over a bar.

It is worth noting that each chart has its importance when used alone, but the power of both charts in helping users make decisions is enhanced when they are presented together and interactively connected to each other. We adopt a coordinated approach in which actions in the portfolio timeline affect the cost and risk charts. That is, when a user moves a project along the timeline, the absolute monthly costs of this project are also moved accordingly. During this action, the portfolio's absolute monthly costs must be recalculated. Besides, this also affects the monthly year-to-date costs. Consequently, all kinds of bars in the cost and risk charts must be updated. Given that terminating the execution of a set of projects affects when the associated risk values are reduced, moving a project may also change values along the risk line, which must then be updated too.

Figure 4 illustrates this coordination. In Fig. 4(a) we present both charts, with a cost and risk chart for OPEX resources at the top, and the portfolio timeline filtered by



(a) (b)

Fig. 4. (a) Coordinated charts with an infeasible portfolio. (b) A feasible portfolio, after reallocating two projects with OPEX resources.

OPEX resources at the bottom. This figure has red bars in the second year, so this is an infeasible portfolio. In order to make it feasible, a user may try moving projects around. This action is illustrated in Fig. 4(b), in which two projects are postponed to months 18 and 24. Note that this action moved costs from year 2 to year 3. Consequently, less resources are necessary for year 2, and a feasible portfolio is reached. However, observe that all risks are deemed controlled only by month 35, whereas Fig. 4(a) shows that all risks were controlled by month 29 instead.

4 Results and Discussion

In this section we discuss how our approach helps users answer questions *Q1* to *Q4*. We discuss these questions and their respective insights based on synthetic scenarios. Besides, we describe preliminary client feedback about our prototype when operating on real data. When using the synthetic scenarios, already presented in Figs. 1 – 4, we observed that our approach may help users answer the following questions:

Q1 *What happens if I change a project scheduled start time? Is the new portfolio still feasible? If not, what restrictions did I break?* Looking at the scenario presented in Figs. 4(a) and 4(b), we note that portfolio feasibility was reached when the user reallocated 2 projects. After this action, the red regions in the cost and risk chart of Fig. 4(a) disappeared; see Fig. 4(b). Obviously, the inverse movement would render the portfolio infeasible again.

Q2 *How do the budget restrictions interfere with project allocation? Are there unused financial resources?* In Figs. 3(a) and 3(b) we observe that the user changed the amount of OPEX resources in year two, rendering the portfolio feasible. In Fig. 4(a), the first and third years have surplus resources, since no red regions appear in the cost and risk chart, and their sliders do not touch any bar in these two years. But year two does not have any surplus resources. The costs presented are from OPEX resources. In the same figure, OPEX projects (selected) are in brown. Postponing two projects was enough to make the portfolio feasible (Fig. 4(b)).

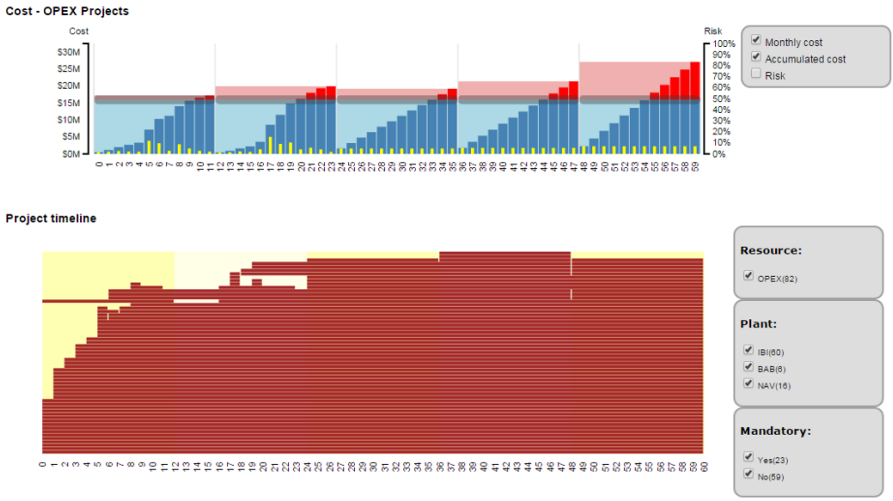


Fig. 5. A real world scenario.

Q3 *How fast is exposure to risk controlled by a given portfolio?* We note that this value is suddenly zeroed in Figs. 4(a) and 4(b), but on distinct months.

Q4 *Are there too many, or too few, projects associated to a given power generation plant in a certain time interval?* In Fig. 1(a), the user selected only projects from plant "BAB". The user can see that all five projects of this plant are allocated on the first year, highlighting a possibly inappropriate distribution.

Regarding data of types *D1* to *D6*, mentioned in the Methodology section, we incorporated most of them into our coordinated charts.

We present data originating from a large power generation company, in a real world scenario. It comprises a real dataset of projects previously allocated in time, and with suggested predefined monthly execution costs for all projects. The entire dataset has 1,412 projects and 434 associated warning points. In this example, we considered cost limits of $16 million per year for illustration purposes. These values can be changed by the user in the interactive phases. Figure 5 presents our coordinated charts for this scenario, in which we selected 82 projects to be scheduled in 5 years. Given that this dataset has many simultaneous, 4-year-long projects, the height of each rectangle was 1 pixel or less, which hampers user interaction for reallocating projects. This is a limitation of our proposal, which will be the focus of subsequent research.

This version of our prototype with coordinated charts was recently presented to decision makers in a meeting, when we collected user feedback in an informal way. We observed that they understood our proposal, and that they reinforced the need of showing mandatory projects. Decision makers also pointed out that they may have interest on moving around these projects. According to them, this would be useful when they perceive that there are insufficient available resources in a given year, and that modifying a mandatory project start time would help to make the portfolio feasible. This

confirms that our tool may help users since it enables them to refine the portfolio data instance which is given as input to the optimization algorithm.

5 Conclusion

This paper presented a visualization-based approach for helping decision makers to solve project portfolio selection problems defined as a single-criteria decision making problem. Our interactive timeline enables users to express their preferences about project starting times. At the same time, our coordinated cost and risk charts are instrumental to help them analyze the impact of these preferences on yearly costs, and consequently on portfolio feasibility. Future work will focus on data scalability for user interaction in scenarios with huge amounts of concomitant projects, and on revealing the impact of moving a given project on the risk of the portfolio.

We thank ANEEL and AES for their financial support to our research.

References

1. Argyris, N., Figueira, J.R., Morton, A.: Interactive multicriteria methods in portfolio decision analysis. In: Salo, A., Keisler, J., Morton, A. (eds.) Portfolio Decision Analysis, Int. Series in Operations Research & Management Science, vol. 162, pp. 107–130. Springer (2011)
2. Bandyopadhyay, S., Saha, S.: Unsupervised Classification – Similarity Measures, Classical and Metaheuristic Approaches, and Applications. Springer (2013)
3. Fisher, M.: Interactive optimization. Annals of Operations Research 5(3), 539–556 (1985)
4. Kiesling, E., Gettinger, J., Stummer, C., Vetschera, R.: An experimental comparison of two interactive visualization methods for multicriteria portfolio selection. In: Salo, A., Keisler, J., Morton, A. (eds.) Portfolio Decision Analysis, Int. Series in Operations Research & Management Science, vol. 162, pp. 187–209. Springer (2011)
5. Kulyk, O., Kosara, R., Urquiza, J., Wassink, I.: Human-centered aspects. In: Kerren, A., Ebert, A., Meyer, J. (eds.) Human-Centered Visualization Environments, LNCS, vol. 4417, pp. 13–75. Springer (2007)
6. Lotov, A.V., Miettinen, K.: Visualizing the pareto frontier. In: Branke, J., Deb, K., Miettinen, K., Slowinski, R. (eds.) Multiobjective Optimization. LNCS, vol. 5252, pp. 213–243. Springer (2008)
7. Miettinen, K.: Introduction to multiobjective optimization: Noninteractive approaches. In: Branke, J., Deb, K., Miettinen, K., Slowinski, R. (eds.) Multiobjective Optimization. LNCS, vol. 5252, pp. 1–26. Springer (2008)
8. Miettinen, K., Ruiz, F., Wierzbicki, A.P.: Introduction to multiobjective optimization: Interactive approaches. In: Branke, J., Deb, K., Miettinen, K., Slowinski, R. (eds.) Multiobjective Optimization. LNCS, vol. 5252, pp. 27–57. Springer (2008)
9. Nowak, M.: Project portfolio selection using interactive approach. Procedia Engineering 57, 814–822 (2013)
10. Salo, A., Keisler, J., Morton, A.: An invitation to portfolio decision analysis. In: Salo, A., Keisler, J., Morton, A. (eds.) Portfolio Decision Analysis, Int. Series in Operations Research & Management Science, vol. 162, pp. 3–27. Springer (2011)
11. Shneiderman, B.: Direct manipulation: A step beyond programming languages. IEEE Computer 16(8), 57–69 (1983)
12. Wills, G.: Visualizing Time – Designing Graphical Representations for Statistical Data. Springer (2012)

A Personal Assistant for Health Care Professionals based on Clinical Protocols

Tiago Oliveira[1], António Silva[2], José Neves[1], and Paulo Novais[1]

Algoritmi Research Centre/Department of Informatics, University of Minho
Braga, Portugal
[1]{toliveira,pjon,jneves}@di.uminho.pt
[2]pg25307@alunos.uminho.pt

Abstract. Current tools to operationalize Computer-Interpretable Guidelines focus mainly on displaying recommendations rather than assisting health care professionals in their daily activities. Furthermore, their underlying models have limitations at the level of temporal representation that hinder the accurate depiction of clinical protocols in a few specific situations. This work identifies such situations and proposes a comprehensive temporal model based on Ontology Web Language (OWL), along with a web-based tool that provides an alternative way to deploy and view clinical protocols. This is evaluated through a case study featuring a clinical protocol for the treatment of colon cancer. It was possible to observe that the model was able to represent the majority of temporal patterns, specially those with periodic events and temporal restrictions about the state of a patient.

1 Introduction

Keeping track of their patients is a laborious task for health care professionals, not only because of the number of patients they tend to, but also due to the complexity of the procedures they have to apply. Clinical Decision Support Systems (CDSSs) that provide patient-specific recommendations may help to ease the burden on health care professionals, but they lack functionalities that would allow them to become more prominent in daily clinical practice, namely those that enable: patient tracking, patient follow-up, scheduling of procedures, and monitoring of procedure constraints [5]. Systems that implement them are available, yet there is an absence of integrated solutions that combine these functionalities with traditional CDSS tasks such as diagnosis and treatment recommendation.

The present work discloses one such solution, the CompGuide web application, based on digital versions of clinical protocols for automatic interpretation, also known as Computer-Interpretable Guidelines (CIGs) [4,7]. The underlying model for CIGs used in this work explores Ontology Web Language (OWL) as the support for the definition of representation primitives and the procedural logic of clinical protocols. The application performs the role of a personal assistant for health care professionals that provides decision support and treatment

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_80

recommendations, reminders for the timely execution of clinical tasks, and notifications about starting time, ending time, and expected outcomes of tasks. To do so, the temporal representation of clinical tasks is the main aspect to take into account and the main subject of this work.

The present article is organized as follows. Section 2 provides related work about the temporal representation of tasks in CIG models. The underlying CIG model and the temporal representation are disclosed in section 3. Section 4 describes a case-study used to assess the expressiveness of the model and the approach followed to make protocols represented according to it available for execution. Finally, section 5 presents conclusions about the work developed so far and future work considerations.

2 Temporal Representation of Clinical Protocols

From the analysis of the main CIG models [9,10,3,1,8], it was possible to divide temporal constraints of clinical protocols into two groups: temporal constraints placed on the execution of clinical tasks and temporal constraints on conditions about the state of a patient. The analysed models, except for Arden Syntax [8], follow a Task Network Model (TNM) in which every clinical recommendation is considered a task. The first group includes temporal patterns that determine how tasks should be executed, namely: durations, which express how long a task should last; repetitions, the number of times a clinical task should be performed over time; periodicities, which express that a task should be performed from time to time, as a succession of several events; waiting times, delays in the execution of tasks; and repetition conditions, conditions about the state of a patient that determine whether a task should be repeated or not. The second group consists of temporal constraints that reflect changes occurred, or expected to occur, in the state of a patient. It is possible to observe in Table 1 that each model shows at least one limitation in one type of temporal constraint. While the duration and waiting time patterns are present in most models, it is only possible to define an important pattern such as periodicities in three of them, and the same goes for repetition conditions. That being said, the GLARE [1] model is specialized in the representation of periodic procedures and is the most comprehensive of the lot. Another drawback of current CIG models is they do not provide adequate representation primitives for temporal constraints regarding conditions about the state of a patient.

In order to become operational, CIGs need an execution engine to interpret the protocol and a tool through which recommendations are conveyed to health care professionals and information is fed to the engine. Tools such as the Guideline Execution Engine (GLEE), SAGEDesktop, or the execution engine of GLARE [4], to name a few, are used to interact with medical personnel. However, they usually do so by displaying protocols as oriented graphs, with no intelligent integration of the recommendations provided by the protocol in the daily schedule of health care professionals.

Table 1. Assessment of CIG models. The symbol ✓indicates the model fully represents the temporal constraint and the ✗ indicates the model does not represent it or has limitations regarding it.

CIG Model	Temporal restrictions about the execution of tasks					Temporal restrictions about the state of a patient
	Durations	Repetitions	Periodicities	Waiting Times	Repetition Conditions	
Arden Syntax [8]	✓	✗	✗	✓	✗	✗
GLIF3 [3]	✓	✗	✗	✗	✗	✓
Asbru [9]	✓	✓	✓	✓	✗	✗
PROforma [10]	✓	✓	✗	✓	✓	✗
GLARE [1]	✓	✓	✓	✓	✓	✗

3 Proposed Temporal Model

Following the limitations identified in section 2, one proposes a comprehensive temporal model. The definition of temporal representation primitives follows the guiding principles of the CompGuide ontology for clinical protocols [6]. This model is based on OWL and provides representation primitives for *Plans*, *Actions*, *Questions*, and *Decisions*. Typically, *Actions* describe tasks that should be carried out by the health care professional, such as exams, observations and so forth. *Questions* are used to feed information about clinical parameters to the execution engine and derive new task recommendations. *Decisions* use that information to perform diagnosis or update the state of the patient. Finally, *Plans* contain instances of any other type of task and are defined to achieve specific goals. CompGuide also provides representation primitives to define different types of conditions, including trigger conditions to select one amongst alternative tasks, pre-conditions to execute tasks, and expected outcomes from tasks. The *Condition* class allows the representation of these conditions with specific properties for clinical parameters and their values. The classes of the temporal model are shown in Figure 1. The main classes are represented as subclasses of *TemporalElement*. One of those subclasses is *TemporalUnit* which represents the different units in which a temporal constraint may be expressed. It is an enumerated class including the instances *second*, *minute*, *hour*, *day*, *week*, *month*, and *year*.

3.1 Temporal Constraints on the Execution of Tasks

The tasks for which it is possible to express durations are *Actions* and *Plans*, since they are the only ones that may unfold over time. The attributes characterizing the *Duration* class are encoded as necessary conditions in OWL (as it is the case with all the other classes). As such, to define a duration, one should choose either to define a maximal and minimal duration, trough the *maxDurationValue* and *minDurationValue* data properties, or to define an exact value for

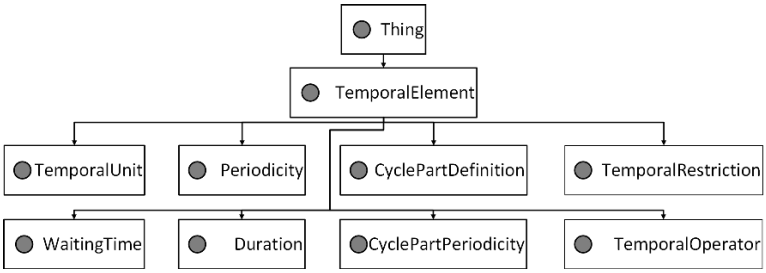


Fig. 1. Classes of the model for the representation of temporal constraints in the CompGuide ontology.

the duration, through the *exactDurationValue* data property. The range of these data properties is defined as a decimal numerical value. Regardless of the type of value one defines, it is always necessary to define a temporal granularity for a decision, which is done through the *hasTemporalUnit* object property connecting instances of *Duration* to instances of *TemporalUnit*.

One can express delays between tasks, motivated for instance by the need to observe the effect a task has on the state of a patient, with the *WaitingTime* class. The waiting time values are defined much like in *Duration*, as intervals (with the *maxWaitingTime* and *minWaitingTime* data properties) or exact values (with the *exactWaitingTime* data property). The *hasTemporalUnit* property is used again to specify the units.

The representation of periodic tasks is the most complex pattern. They are represented with the class *Periodicity*. A periodicity can be defined for any type of task, *Plans*, *Actions*, *Questions* or *Decisions*. However, the periodic event is bound by either a duration, a repetition constraint or a stop condition about the state of the patient. The duration is defined through the reuse of the *Duration* class. As such, an instance of *Periodicity* can also be connected to an instance of *Duration* through the *hasDuration* object property, thus determining for how long a periodic task should take place. On the other hand, if one wants to state the number of times the event should be carried out (the same is to say the number of cycles of the periodic task), it is necessary to formulate a repetition constraint, which is possible through the *repetitionValue* data property, with a range of integer numerical values. Alternatively, it could be the case the periodic task should only occur until a condition about the state of a patient is met. To express this, one uses the *hasStopCondition* object property to connect an instance of periodicity to instances of the class *Condition*. While it is possible for a periodicity to have a duration and a stop condition, a repetition value and a stop condition, or just a stop condition, it is not possible to have both a duration and a repetition value because it is considered to be redundant information. With a duration and a frequency it is already possible to calculate the number of repetitions of a task and vice versa. The stop condition takes precedence over the other temporal restrictions, so, if the condition is met, the task is immediately stopped.The frequency of the periodicity and the temporal granularity are

defined in the data property *periodicityValue* and through the *hasTemporalUnit* object property respectively.

A periodic task unfolds in a series of executions which are handled by the execution engine as events. Each event may have itself an associated periodicity or duration, which means that it may be necessary to define nested temporal patterns. The object property *hasCyclePartDefinition* is used to specify the duration or the periodicity of an event. It connects instances of *Periodicity* to instances of *CyclePartDefinition*. Instances of this class may have the *hasDuration* property connecting them to instances of *Duration* or the *hasCyclePartPeriodicity* property connecting them to instances of *CyclePartPeriodicity*. The latter is similar to *Periodicity* in all but the possibility to define another periodicity or duration within it. One can argue it would be simpler to reuse the *Periodicity* class rather than defining another class for the periodicity of each event, but by doing so it would be possible to nest periodicities inside one another infinitely, which would be difficult to handle computationally.

3.2 Temporal Constraints on the State of a Patient

In CompGuide, a temporal constraint for conditions about the state of a patient is represented by an instance of the *TemporalRestriction* class. To connect the constraint to an instance representing a condition, it is necessary to use the *hasTemporalRestriction* property, which, although non-mandatory, can be defined for any of the above-mentioned conditions.

For each instance of *TemporalRestriction* it is necessary to specify a temporal operator through the *hasTemporalOperator* object property. This object property points to instances belonging to *TemporalOperator*. This is an enumerated class that can only have a limited number of instances, namely *within_the_last* and *within_the_following*. The temporal operators represent the reach of a temporal constraint and are used together with temporal units, defined through the *hasTemporalUnit* object property, and temporal restriction values. The latter are expressed through data properties such as *maxTemporalRestrictionValue* and *minTemporalRestrictionValue* for an interval, or *temporalRestrictionValue* for an exact value, with a range of decimal numerical values.

Each operator conveys a different meaning.The operator *within_the_last* is used when one wants to express that a condition must have held true at least once, within a period of time just before execution time. The execution engine interprets this operator by checking if, in the state of the patient, there is a record regarding the parameter in the condition, registered within the specified time frame, and if its value validates the condition. This temporal operator can be defined for temporal restrictions of simple conditions in *Decision* tasks, trigger conditions and pre-conditions, ant it is used to reason about past events. However, in an expected outcome of a task, it is necessary to express a condition about the future, in which one aims to observe the effect a clinical task has after being applied to a patient. The *within_the_following* operator conveys this meaning to the execution engine which, in turn, checks if the condition holds true after the specified time.

4 Discussion and Implementation

The CompGuide temporal model was validated with a case-study featuring a National Comprehensive Cancer Network (NCCN) protocol for the treatment of colon cancer [2]. This protocol includes procedures that unfold over different phases of treatment, from cancer staging to follow-up, and presents a wide variety of temporal patterns. The representation of the clinical protocol in the model was carried out using Protégé[1], an ontology editor for OWL.

4.1 Analysis of a Case-study in Colon Cancer Treatment

The representation of the NCCN protocol resulted in an *owl* file containing 223 task instances, of which: 190 were *Action* tasks, 21 were *Question* tasks, 1 was a *Decision* task and 11 were *Plans*. Out of the 223 tasks, a total of 95 had temporal constraints. The set included: 7 with *Durations*, 2 with *WaitingTimes*, 79 with *Periodicities*, and 7 with nested *Periodicities*. *Periodicities* were the most abundant pattern, mainly because of the rich description of chemotherapy regimens made in the document. Most *Periodicity* instances were limited by a *Duration*.

The proposed temporal constructors were effective in the representation of the different temporal patterns, specially in the tasks having a *Duration* or a *Waiting Time*. In fact, the information about the duration of tasks was mostly conveyed using exact values or intervals, like what happens in the natural language expression "perform neoadjuvant therapy for 2-3 months", extracted from the protocol [2], in which there is an *Action* consisting in therapy before treatment with a *Duration* expressed using the *minDurationValue* 2.0, the *maxDurationValue* 3.0, and the *TemporalUnit month*. The same is true for waiting times, as seen in the example "reevaluation for colon surgery 2 months after the end of chemotherapy" [2] in which there are clearly two *Actions*, the first is chemotherapy and the second is re-evaluation, with the latter having a delay expressed with the *exactWaitingTime* 2.0, and the *TemporalUnit month*. This temporal model follows a simpler scheme than Asbru which provides a plethora of temporal annotations such as earliest and latest, starting and ending, shifts for tasks [9]. Yet, the CompGuide temporal elements were sufficient to represent all the durations and waiting times of such a complex protocol.

Regarding periodic tasks, as mentioned above, most of them were bounded by a *Duration*. The constraints followed a structure similar to the one in the recommendation "complete physical exam every 6 months for 2 years" [2]. In the example, it is possible to identify the *Action* complete physical exam, the *periodicityValue* 6.0, the *TemporalUnit* for the *Periodicity month*, the *exactDurationValue* 2.0, and the *TemporalUnit* for the *Duration year*. In this case, the execution engine would recommend the execution of the task with the specified frequency during the 2 years. Periodic tasks bounded by the number of repetitions were not that common in the protocol, but their interpretation logic follows

[1] Available at `http://protege.stanford.edu/`.

the same principles as periodic tasks with durations, the execution engine would count the number of times the periodic event was executed and would recommend the task the number of times still left to complete execution. The periodic tasks that had stop conditions usually had a duration limiting their execution. The pattern followed a structure identical to the example "perform colonoscopy every 3 months for 2 years and stop if signs of adenoma are found" [2]. The *Periodicity* identified in the example has the *periodicityValue* 3.0, the *TemporalUnit month*, a *Duration* with the *exactDurationValue* 2.0, and the *TemporalUnit year*. It also has the *Condition* signs of adenoma. After each event of the periodic task, the execution engine should ask the user if the stop condition holds, and, if so, the task is stopped and the execution engine moves on to the following tasks.

The only examples of nested periodicities referred to the description of how the different chemotherapy schemes should be applied. For instance, the expression "CapeOx should be applied every 3 months, with the administration of capecitabine every 12 hours for 14 days" describes an *Action* consisting in applying the CapeOx chemo, that has a *Periodicity* with the *periodicityValue* 3.0, and the *TemporalUnit month*, with a *CyclePartDefinition* which, in turn, has a *CyclePartPeriodicity*. This instance of *CyclePartPeriodicity* has the *periodicityValue* 12.0, and the *TemporalUnit hour*, along with the *Duration* 14 days. This type of constraint tells the execution engine that the event of the task occurring every 3 months should, itself, be performed every 12 hours during 14 days. Once the event is over, it should only be performed again after 3 months.

In the protocol there were 6 occurrences of temporal constraints on conditions about the state of the patient. Most of them expressed the expected outcomes of chemotherapy, as in the expression "the tumor should become operable after 6 months of FOLFOX or CapeOx chemotherapy". Here, an outcome is expressed in the form of the *Condition* the tumor becomes operable, and a *TemporalRestriction* is defined for that condition with the *TemporalOperator within_the_following*, the *temporalRestrictionValue* 6.0, and the *TemporalUnit month*. The execution engine interprets the restriction by checking, after the specified time, whether the outcome was validated and notifies the user of the result. Another common situation was the verification of incompatibilities of chemotherapy regimens. An example of such a situation is the recommendation "for therapy after third progression consider experimental chemotherapy, if the regorafenib regimen has been applied within the last 12 months" which describes the *Action* apply experimental chemotherapy, associated to a trigger condition that determines its selection. The *Condition* is regorafenib having been applied, and there is a *TemporalRestriction* that goes with it, defined with the *TemporalOperator within_the_last*, the *temporalRestrictionValue* 12.0, and the *TemporalUnit month*.

With the examples provided above, it is possible to conclude that the CompGuide temporal model is more encompassing than the existing approaches. When it comes to durations, waiting times, and periodicities, it performs at the level of GLARE [1]. When comparing with the approaches mentioned in Table 1, the examples having periodicities would not have been represented in at least three

of the models. Additionally, the CompGuide model provides a set of primitives for the representation of constraints on conditions about the state of the patient, which are absent from the current approaches, except for one. However, there are some limitations, namely the level of nesting of periodicities and the expression of alternative temporal constraints, related with the freedom of speech allowed in guidelines. For instance, a recommendation may specify that an action should be executed a certain number of times or during a certain period, but, in the model, it is not possible to represent this alternative.

4.2 Protocol Execution and Visualization

The system set up to execute clinical protocols is depicted in Fig. 2. It consists of a *Core Server* that has four distinct components: the *Authentication* component, responsible for authenticating the user into the system; the *Database Handler* to manage the access to the *Database* containing information about physician and patient profiles, patient states, and protocol executions; the *GuidelineHandler* which manages the access to recommendations of clinical protocols in a *Guideline Repository* consisting of a collection of *owl* files; and the *Guideline Execution Engine* which interprets the clinical protocol, analyses the state of the patient, and provides recommendations in the form of tasks. The constraints, including temporal constraints, are defined directly in the ontology, and Semantic Web Rule Language (SWRL) is not used for this specification due to the flexibility and complexity required for temporal constraints.These features are made available by the *Core Server* as RESTful web services in order to ensure they can be easily integrated into any type of application. The Core Server is implemented in Java, using the RESTEasy API over a WildFly Application Server.

The personal assistant, which uses the web services available in the *Core Server*, was developed as a web application following the Model-View-Control (MVC) paradigm using Java Server Faces (JSF). The main interfaces are shown in Fig. 3. The personal assistant provides tasks based on the automated validation of conditions regarding the state of the patient and builds a schedule for the health care professional. As seen in Fig. 3 a), it provides a calendar view of the clinical tasks with different granularities (day, week and month), which can be transformed into a temporal axis view, as seen in Fig. 3 b). The former is intended to provide an overall picture of the tasks that lie ahead, while the latter allows the health care professional to focus on a smaller set of tasks at a time. The application also provides notifications about the different temporal constraints of tasks, alerting the user to when he should execute them, when they should start, when they are due, and the results of expected outcomes. These notifications are shown as side messages, as displayed in Fig. 3 a), and are gathered in a notification stack. By clicking on a task, a panel is shown with task details, namely its description, remaining time and remaining repetitions.

5 Conclusions and Future Work

By building a system that revolves around the temporal model and integrates recommendations into the daily practice of health care professionals, it is pos-

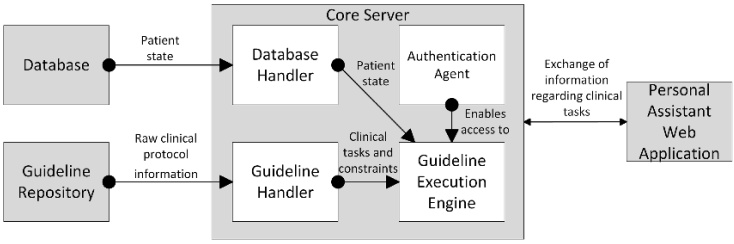


Fig. 2. Architecture of the system for the temporal execution of clinical protocols.

sible to build a schedule for them to follow, endowed with notification features about the correct time to enact clinical tasks. The system displayed herein is innovative in the sense that it is unlike other CIG execution tools. It maps clinical protocols, as they are being applied, onto an agenda. The impact of this is that it enables medical personnel to keep a better track of the clinical processes they are managing. This work aims to disclose the innovative view CompGuide brings to the execution of CIGs its technical feasibility. Additional experiments are in development to evaluate the expressiveness of the model with a wide variety of clinical protocols and a thorough comparison with the other models. In terms of additional features, by accessing other calendar services, it would be possible to fit these tasks into the other activities of the health care professinal's life and possibly sort out schedule conflicts.

Acknowledgements

This work has been supported by FCT Fundação para a Ciência e Tecnologia within the Project Scope UID/CEC/00319/2013. The work of Tiago Oliveira is supported by a FCT grant with the reference SFRH/BD/85291/ 2012.

References

1. Anselma, L., Terenziani, P., Montani, S., Bottrighi, A.: Towards a Comprehensive Treatment of Repetitions, Periodicity and Temporal Constraints in Clinical Guidelines. Artificial Intelligence in Medicine 38(2), 171–195 (2006)
2. Benson, A., Bekaii-Saab, T., Chan, E., Chen, Y.J., Choti, M., Cooper, H., Engstrom, P.: NCCN Clinical Practice Guideline in Oncology Colon Cancer. Tech. rep., National Comprehensive Cancer Network (2013), `http://www.nccn.org/professionals/physician_gls/f_guidelines.asp`
3. Boxwala, A.a., Peleg, M., Tu, S., Ogunyemi, O., Zeng, Q.T., Wang, D., Patel, V.L., Greenes, R.a., Shortliffe, E.H.: GLIF3: A Representation Format for Sharable Computer-Interpretable Clinical Practice Guidelines. Journal of Biomedical Informatics 37(3), 147–61 (Jun 2004)
4. Isern, D., Moreno, A.: Computer-based Execution of Clinical Guidelines: a Review. International Journal of Medical Informatics 77(12), 787–808 (2008)
5. Musen, M.A., Shahar, Y., Shortliffe, E.H.: Clinical decision-support systems. In: Shortliffe, E., Cimino, J. (eds.) Biomedical Informatics, pp. 698–736. Health Informatics, Springer New York (2006)

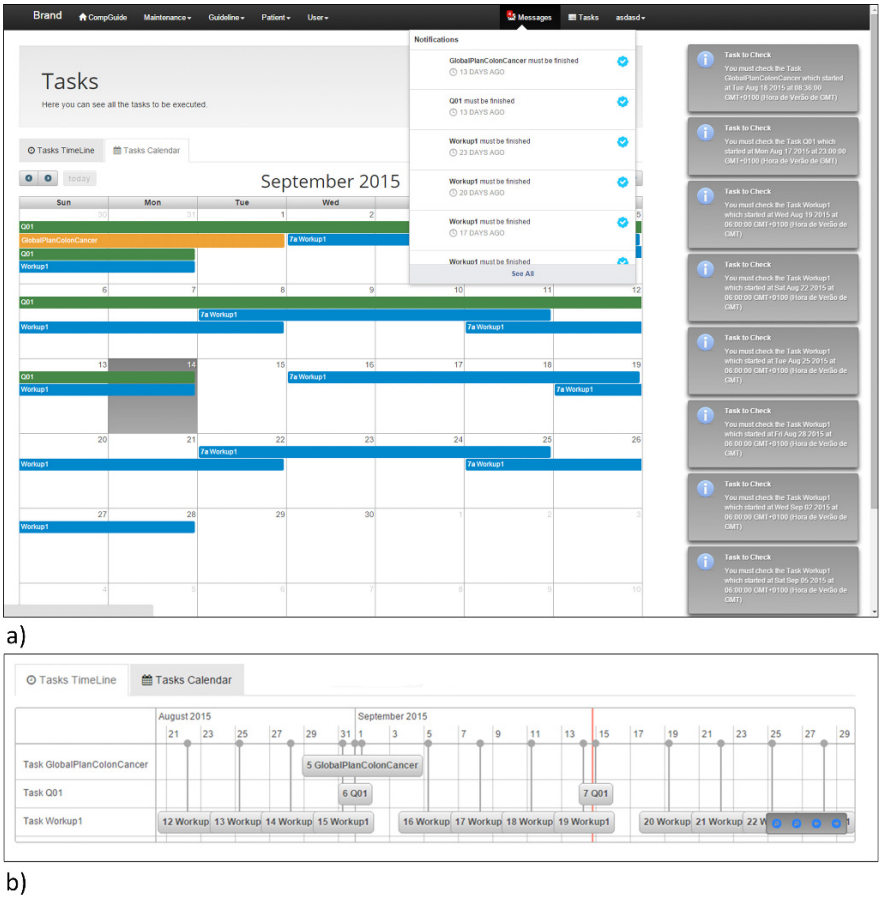


Fig. 3. Clinical task visualization: a) calendar view, notification messages and notification stack; b) temporal axis view.

6. Oliveira, T., Novais, P., Neves, J.: Representation of Clinical Practice Guideline Components in OWL. In: Trends in Practical Applications of Agents and Multiagent Systems SE - 10, Advances in Intelligent Systems and Computing, vol. 221, pp. 77–85. Springer International Publishing (2013)
7. Peleg, M.: Computer-interpretable Clinical Guidelines: A Methodological Review. Journal of Biomedical Informatics 46(4), 744–63 (2013)
8. Samwald, M., Fehre, K., de Bruin, J., Adlassnig, K.P.: The Arden Syntax standard for clinical decision support: Experiences and directions. Journal of biomedical informatics (2012)
9. Shahar, Y., Miksch, S., Johnson, P.: The Asgaard Project: A Task-specific Framework for the Application and Critiquing of Time-oriented Clinical Guidelines. Artificial intelligence in Medicine 14(1-2), 29–51 (1998)
10. Vollebregt, A., ten Teije, A., van Harmelen, F., van der Lei, J., Mosseveld, M.: A study of PROforma, a development methodology for clinical procedures. Artificial Intelligence in Medicine 17(2), 195–221 (1999)

A proposal for automatic evaluation by symbolic regression in virtual learning environments

Adriano Lino[1], Álvaro Rocha[1], Amanda Sizo[2]

[1]Department of Informatics Engineering
Center for Informatics and Systems
University of Coimbra
Coimbra, Portugal
{Adlino, Amrocha}@dei.uc.pt
[2] Center of Information and Communication Technology
Federal University of Pará
Amandasizo@ufpa.br

Abstract. Empirically, symbolic regression tries to identify, through genetic programming and within the sphere of mathematical expressions, a model which best explains the relationship between variables in a given set of data, in terms of precision and simplicity. Virtual learning environments focused on evaluation have been previously investigated, as they offer teachers an effective teaching and learning tool and the student the possibility of computer-assisted evaluation and customized learning. Within this context, the present paper introduces an alternative approach to automatic evaluation in virtual learning environments, which offers the following improvements when compared to other methods, as superior accuracy when compared with the linear regression method, simplicity of implementation and context adaptive. To this extent, it presents the benefits of symbolic regression through genetic programming, emphasizing its efficiency and simplicity of implementation.

Keywords: Symbolic regression; genetic programming; virtual learning environments; automatic evaluation.

1 Introduction

Artificial intelligence (AI) offers automatic computer-based solutions to problems through machine learning, automated reasoning and knowledge representation [18]. In AI, genetic programming (GP) is an evolutionary computation (EC) technique which automatically solves problems without requiring the form or structure of the solution from the user in advance. In its most abstract level, GP constitutes a systematic, domain-independent automatic solving method from a high level problem statement [16].

John Koza introduced a concept of GP where individuals are represented by computer programs, such as mathematical expressions, logical expressions, amongst

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_81

others. This way, instead of researching a set of solutions, programs are automatically generated to solve the problem without a previous knowledge of the structure of the solution [16] and [8].

Symbolic regression is a GP which manipulates mathematical expressions in order to find the equation which best explains the relationship between the variables of a given set of data, adopting a measure that minimizes error, for instance, the square root of the sum of the squares of the differences [8].

In virtual learning environments, one difficulty involves finding a function that expresses the student's performance from the associating a set of data available in such environments. A number of researchers have solved this problem via linear regression, whose prerequisites include knowledge of statistics and a series of tests to validate the identified function. However, addressing the same problem via symbolic regression renders the process simpler, as the goal of the GP is to find the solution without requiring previous knowledge of statistics, it can may provide more accurate results.

In the present investigation work we propose a symbolic function to be applied in virtual learning environments in the context of evaluation, which will be extended in future work.

Therefore, what is herein proposed is an alternative approach to automatic evaluation in virtual learning environments, which can offers a number of improvements when compared with other methods: a) superior accuracy when compared with the conventional regression method; b) simplicity of implementation; c) the possible deduction of final student grades; and d) context adaptive.

Beyond this introduction, the paper is organized in the following sections: 2 Symbolic Regression, 2.1) Gene Expression Programming, 3 Evaluation in Virtual Learning Environments, 3.1) Symbolic Predictor Function of SQL Complexity for LabSQL, 4) Conclusions.

2 Symbolic Regression

In statistics, regression is used to find the coefficients of a predefined function that are best suited for certain data. One of the problems surrounding regression analyses is that, when the fitness is not good, the analyst has to keep trying different functions by hand until a good model is found for the available data. This requires a lot of work and the results of the analysis are highly dependent on the skills and creativity of the analyst. Moreover, even the most experienced user is strongly biased when selecting the functions to be suited. For instance, in many application fields there is a strong tendency towards the adoption of linear or quadratic models, even when a more complex model offers a better adjustment to the available data.

Symbolic regression goes beyond this aspect. It finds a function which adjusts data points without making any assumptions about the structure of this function. GP does not make any such assumption, and suits this type of task perfectly.

It was introduced by Koza [8] as an extension of genetic algorithms (GAs). The main difference between GP and GAs lies in the representation of the solution. GP solutions are computer programs, while GA solutions are created as number

sequences [8]. GP works with randomly generated populations of individuals (computer programs). Each program represents a possible solution for a certain problem. The classic GP technique is also known as a tree based GP pattern [7] and [5]. A program developed by classic GP constitutes a hierarchically structured tree with functions and terminals. Functions and terminals are randomly selected and built together to form a computer model of a tree structure with a root point where branches grow from each function and end in a terminal [7] and [5].

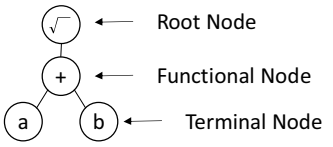


Fig. 1. Tree representation of a GP model $\sqrt{(a+b)}$.

Genetic expression programming is a linear GP variant. Individuals created through linear GP variants are represented as linear chains, which are decoded and expressed as nonlinear entities (trees) [14] and [4].

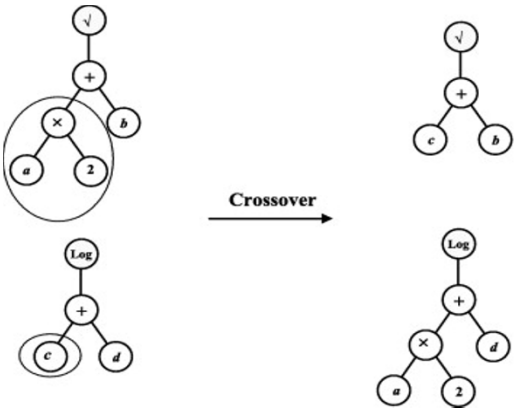


Fig. 2. Typical GP crossover operation.

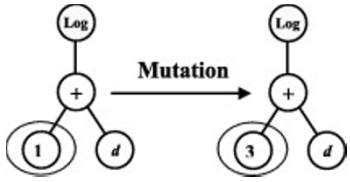


Fig. 3. Typical GP mutation operation.

Once a population of models is randomly created, the GP algorithm evaluates individuals, selecting them for reproduction and generating new individuals and ultimately creating a new generation from all interactions [13] and [8]. New individuals are created through mutation, crossover and direct reproduction. Figure 2 shows a typical GP crossover operation. In the course of this operation, a point on a branch of each program is randomly selected and the set of terminals and / or functions of each program is then exchanged to create two new programs. During the

mutation process, a function or terminal from a model is, occasionally, randomly selected and mutated (see Figure 3). The best program obtained in any generation defines the output of the GP algorithm [13] and [8].

2.1 Genetic Expression Programming

Genetic expression programming (GEP) was developed by Ferreira [1]. Most of the genetic operators used in GAs can be implemented in GEP with minor modifications. GEP consists of five main components, including: (1) set of functions, (2) terminal set, (3) fitness function, (4) control parameters, and (5) stopping criterion. GEP uses a fixed length of strings to represent solutions for problems, which are subsequently expressed as trees of analysis with different sizes and shapes [3] and [5]. These trees are known as expression trees (ETs).

A technical advantage of GEP is that the creation of genetic diversity is rendered extremely simple when genetic operators work on a chromosome level. Another strong point of GEP concerns its unique multigene nature, which allows for the evolution of more complex programs comprised by several subprograms [3] and [5]. Each GEP gene contains a list of symbols with a fixed length, which can be any element of a function defined as $\{+, -, x\}$ and a terminal defined as $\{a, b, c, 1\}$. The set of functions and the set of terminals should display the closure property: each function should be capable of assuming any data type value, which can be returned by a function or assumed by a terminal [3] and [5]. A typical GEP gene with data sets and a terminal function can be:

$$+ \cdot \times \cdot b \cdot a \cdot - \cdot + \cdot \times \cdot c \cdot 1 \cdot b \cdot c \quad (\mathbf{1})$$

where a, b and c are variables and 1 is a constant; "·" is an element of separation that is easy to read. The expression above is known as the Karva notation or K-expression [1]. The K-expression can be represented by a diagram representing an ET. For instance, the gene previously offered as an example can be represented as shown in

Figure 4.

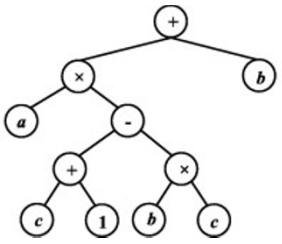


Fig. 4. Typical representation of expression trees (ETs).

The conversion starts from the first position in the K-expression, which corresponds to the ET root, and is read one by one along the chain. The previously offered GEP gene can also be expressed mathematically, as:

$$a((c + 1) - (b \times c)) + b \quad (\mathbf{2})$$

Inversely, an ET can be converted into a K-expression recording nodes from left to right in each layer of the ET, from the root node to the deepest level of the tree, forming a chain. As was already mentioned, the GEP genes have a fixed length, which is predetermined for a given problem. Therefore, what varies in GEP is not the length of the genes, but the size of the corresponding ETs. This means that there is a specific number of redundant elements, which are not useful when mapping the genome. Thus, the valid length of K-expression can be equal or inferior to the length of the GEP gene.

To ensure the validity of a randomly selected genome, GEP applies the head-tail method. Each GEP gene is composed by a head and a tail. The head can hold both the function and terminal symbols, while the tail can only hold terminal symbols [1], [3] and [5]. A basic representation of the GEP algorithm is shown in Figure 5. In GEP, individuals are selected and copied into the next generation according to aptitude via elitist roulette sampling. This ensures the survival and cloning of the best individual for the next generation. Variation of population is introduced by carrying out unique or multiple genetic operators selected in chromosomes, which include crossover, mutation and rotation. The rotation operator is used to rotate two subparts of a genome element sequence in relation to a randomly selected point. It can also drastically reformulate the ETs [3] and [5].

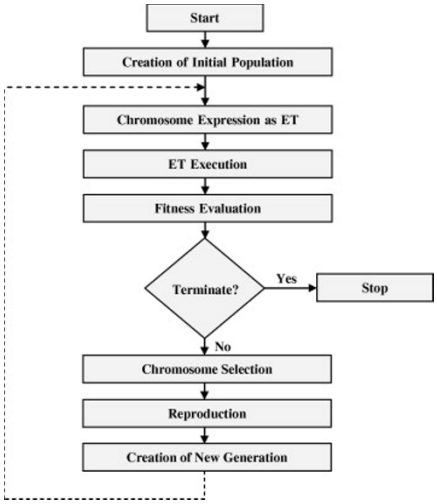


Fig. 5. Basic representation of a GEP algorithm [5].

This type of regression finds the forming equation behind the set of mapped data in an input/output relationship. GP is a commonly used evolutionary technique in this type of regression. Several tools, such as GPTIPS [17], JGAP framework [11] and EpochX [15], GeneXProtools [1], have been proposed to minimize implementation difficulties, and they offer a set of features which are visually easy to adapt in GP and allow for a speedy evaluation of generated models. The GeneXPro tool was adopted here because it implements GEP, it is a reference in scientific works, it offers the most satisfactory results in terms of accuracy, it encompasses features which allow for a

more detailed analysis, which have been maintained from its inception to the present days [2]. Additionally, this tool can be used in Windows, 32 and 64 bit versions [2].

The parameters to be defined in these systems form part of the preparatory steps for the application of GP in problem solving, which involve the identification: a) the set of terminals; b) the set of functions; c) the fitness measure; d) the parameters and variables which control execution; e) the result definition method and stopping criterion.

In (a) the set of terminals is identified. In this problem, the information that will be processed by the mathematical expression corresponds to the value of the independent variable x. Thus, the set of terminals, known as T, is $T = \{2\}$.

In (b) the set of functions used to generate mathematical expressions is defined, in an attempt to adjust the set of given points. For instance, linear regression functions are comprised by addition and multiplication operations, and in GP this set of functions would be enough to solve the problem. A more general choice could include subtraction and division functions. Besides, in order to solve a greater variety of problems, it would be advisable to include sine, cosine, exponential and logarithm functions. Therefore, for this problem the set of functions, represented by F, is: $F = \{+, -, *, \%, sin, cos, exp, rlog, ceil, mod, avg, min, tan\}$.

In (c) the fitness measure is determined. The direct fitness for this problem is the sum, taken from the fitness cases, of the absolute value of the difference between the value obtained with the symbolic expression and the correct value. The lower this difference, the better the individual program. In this case, standardized fitness equals direct fitness. The adjustment measure counts the number of fitness cases where numeric values returned by the symbolic expression display a small tolerance, known as the adjustment criterion, in relation to the correct value. As an example, we can define the adjustment criterion as 0,01, that is, the difference between the estimated and the correct value should the inferior to 0,01 in module. The adjustment measurement is more intuitive than fitness, hence its usefulness when the user observes the evolution of GP generations.

In (d) the parameters and variables that control the expression are determined, restricted to a population size of 500 individuals and a number of generations equal to 51, with a random initial generation and 50 more for evolution. These numbers were proposed by Koza [8] when applying genetic programming to problems in general, including symbolic regression.

In (e) for each execution, the relative frequency per generation of individuals that met the predicate for success is observed, and the cumulative probability is obtained.

A common method of representing computer programs in GP is through syntax trees which can be easily transformed into known programming languages. The adopted programming language in the original implementation GP's List Processing (LISP) [8].

3 Evaluation in Virtual Learning Environments

The main goal of educational evaluation is to determine if the students know, understand and are able to perform [6]. The subdivision of evaluation into three

different classes is widely used and accepted, namely: a) diagnostic – before the learning process begins, this is used to determine the level of pre-required knowledge and skills and previous knowledge of the contents to be addressed (for instance, reading readiness test); b) formative – in the course of a unit and within a class cycle, used to measure progress (for instance, practical student problems, weekly evaluation tests) and; c) summative – in the end of a unit or year, used to measure growth and formal accomplishment (for instance, final evaluation).

In the context of virtual learning environments (VLE), diagnostic, formative and summative assessments can be used to ensure the quality of teaching. In this sense, in terms of validity and reliability, besides minimizing subjectivity, standardized tests are frequently adopted and grades assigned, following a process where test results are converted in grades. Grades are then recognized as student learning measurements [6].

The following subsection describes the LabSQL environment, the primary case study of the present investigation work, which automatically evaluates SQL questions and assigns a final grade that can be used in formative, diagnostic and summative assessment.

The next subsection describes the LabSQL environment, an initial study of research work, which automatically evaluates SQL questions and assigns a final grade that can be used in formative, diagnostic and summative assessment.

3.1 Symbolic Predictor Function of SQL complexity for LabSQL

LabSQL, developed in 2005, is an interactive environment that helps students learn the database Structured Query Language (SQL) and can be used as a support tool for teachers, which automatically evaluates laboratory activities. For students involved in online e-courses, this tool can help assess learning levels, helping them regulate their study and learning path. In his environment evaluation, Lino [10] observed that 96,67% of the students considered that LabSQL increased their learning when compared with the traditional teaching-learning process.

However, Lino [10] proposed a solution to automatically evaluate open-ended and closed-ended questions in SQL, based in software engineering (SE) metrics and multiple linear regression [9]. In [12] different qualitative aspects of evaluation are covered through tips and feedback, encouraging students to find better solutions.

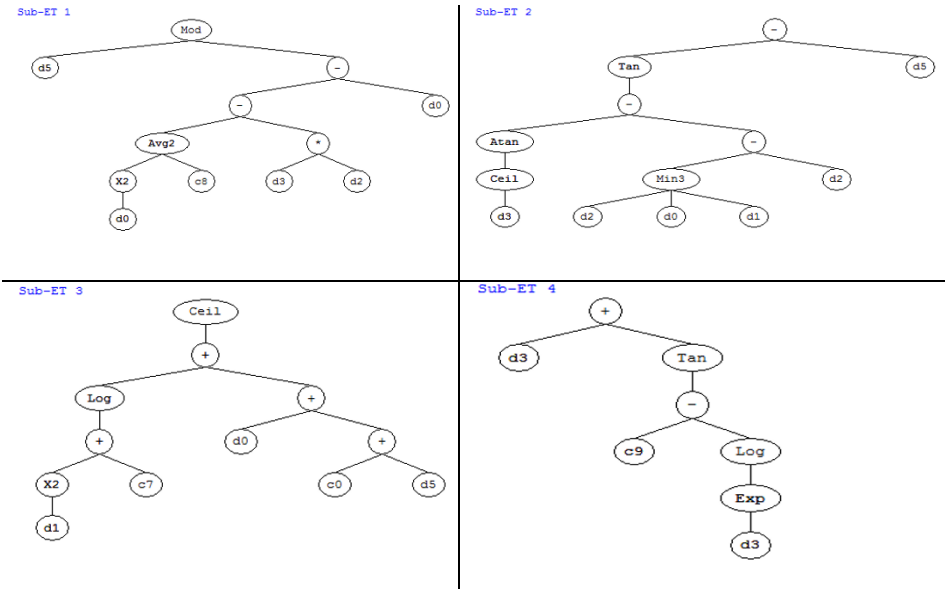


Fig. 6. Symbolic expression trees (Sub-ETs).

The primary case study adopts SE and database (DB) metrics, defined in [9] to obtain ET via PEG with software [1], and confronts the results obtained in the first investigation work [10] against the GEP model, based on accuracy and simplicity of implementation. The symbolic GEP based function predicts the SQL complexity through SE and DB metrics, and the best obtained function is shown in Figure 6, assuming the format of four sub trees (Sub-ETs). The elements represented by the letter "d" in each Sub-ET correspond to metrics SE and DB. The constants are represented by the letter "c" (c0, c7 to c9). The basic arithmetic operators and functions used to generate this model were described in the previous section.

The first goal, that is, selecting the simplest model, can be controlled by the user through the definition of parameters (for instance, the size or the number of genes). For other goals, the following objective function (OBJ) is adopted as a measure of the extent to which the output of the predicted model complies with the experimentally measured output. The best GEP model selection is deduced by minimizing function [11].

A comparison between the symbolic function model and the value predicted by the GEP is shown in Figure 7. The model reveals a mean percentage error below 1,5, which in the graphic is translated in the short distance observed between the generated model and the CX values for each observation.

The CX (y) classification is shown in Figure 8, with a square error of 0,9877 and a growing angular line. In this graphic we can clearly observe that the conceived model, represented by the straight line, displays a small margin of error in CX classifications, revealing a good square error adjustment.

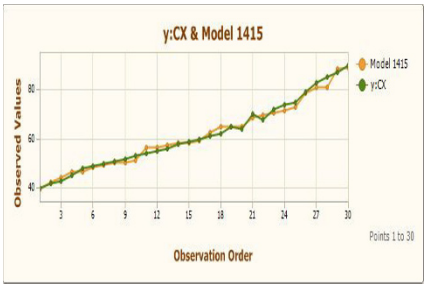


Fig. 7. Comparison between the symbolic function model and the GEP predicted values.

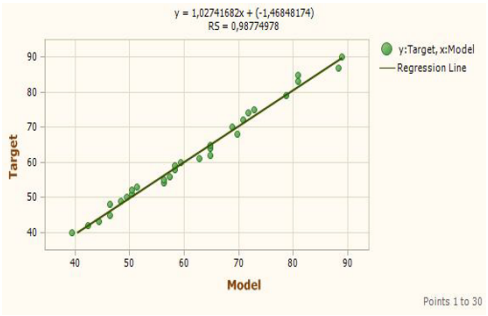


Fig. 8. Regression model classification graphic.

4 Conclusions

This study addressed a GP variant, that is, a GEP used to assess the complexity of an SQL code. We obtained a symbolic model, through empirical means, in order to predict the SQL complexity from a database of results obtained in complexity tests and develop a predictive model. The validity of the model was tested using part of the trials and the trial database. This validation stage confirms the general efficiency in the application of the model when estimating the complexity of the SQL code. Moreover, the GEP predictor model effectively meets the conditions of different criteria adopted for its external validation.

The proposed model was assessed against the linear regression model and significantly surpassed the later in terms of statistical analysis for using nonlinear functions. Owing to the nonlinearity of its behavior, GEP leads to better results when compared to regression based models. Its concept also proved to be superior, owing to its simplicity of implementation, in measurement results, besides being adaptable to a different evaluation system, such as open-ended questions or conceptual maps.

Additionally, we can easily calculate the complexity of the model from SE and DB metrics. Therefore, this model doesn't require validation tests by DB experts. Similarly, as the creation of other models for different evaluations requires a minimum of metrics, for example, to evaluate open-ended questions coefficients would be based in n-grams. The model can thus be safely adapted and implemented for other evaluation and pre-practical purposes to the extent that it derives from tests with a wide variety of metrics, and this can be considered the main advantage of the GEP model.

Acknowledgement

This work was conduct out with CNPq support, National Council for Scientific and Technological Development - Brazil. We also appreciate the financial support of AISTI (Iberian Association for Information Systems and Technologies), which permitted the registration in the WorldCIST'16 (4th World Conference on Information Systems and Technologies), held in Recife, Brazil, 22 - 24 March 2016, and consequently this publication.

References

1. Ferreira, C.: Gene expression programming in problem solving. In: Soft Computing and Industry. pp. 635–653 Springer (2002).
2. Ferreira, C.: Gene Expression Programming Tools (GeneXproTools v 5.0) http://www.gepsoft.com/, http://www.gepsoft.com/, (2015).
3. Gandomi, A. et al.: Nonlinear Genetic-Based Models for Prediction of Flow Number of Asphalt Mixtures. J. Mater. Civ. Eng. 23, 3, 248–263 (2011).
4. Gandomi, A.H. et al.: A Discussion on "Genetic programming for retrieving missing information in wave records along the west coast of India"[Applied Ocean Research 2007; 29 (3): 99–111]. Appl. Ocean Res. 30, 4, 338–339 (2008).
5. Gandomi, A.H. et al.: A new prediction model for the load capacity of castellated steel beams. J. Constr. Steel Res. 67, 7, 1096–1105 (2011).
6. Hill, P., Barber, M.: Preparing for a Renaissance in Assessment London: Pearson. (2014).
7. Hossein Alavi, A., Hossein Gandomi, A.: A robust data mining approach for formulation of geotechnical engineering systems. Eng. Comput. 28, 3, 242–274 (2011).
8. Koza, J.R.: Genetic programming: on the programming of computers by means of natural selection. MIT press (1992).
9. Lino, A.D.P. et al.: Avaliação automática de consultas SQL em ambiente virtual de ensino aprendizagem, (2007).
10. Lino, A.D.P.: LABSQL: laboratório de ensino de SQL. Mestrado, Universidade Federal do Pará (2007).
11. Meffert, K. et al.: JGAP - Java Genetic Algorithms and Genetic Programming Package. http://jgap.sf.net. (2008).
12. Melo, B.M. et al.: Assessment module automatic SQL code with feedback in the form of tips in the virtual learning environment LabSQL. In: Information Systems and Technologies (CISTI), 2013 8th Iberian Conference on. pp. 1–7 CISTI (2013).
13. Mousavi, S.M. et al.: Modeling of compressive strength of HPC mixes using a combined algorithm of genetic programming and orthogonal least squares. Struct Eng Mech. 36, 2, 225–241 (2010).
14. Oltean, M., Grosan, C.: A comparison of several linear genetic programming techniques. Complex Syst. 14, 4, 285–314 (2003).

15. Otero, F. et al.: Epochx: Genetic programming in java with statistics and event monitoring. In: Proceedings of the 14th annual conference companion on Genetic and evolutionary computation. pp. 93–100 ACM (2012).
16. Poli, R. et al.: A field guide to genetic programming. Lulu. com (2008).
17. Searson, D.P. et al.: GPTIPS: an open source genetic programming toolbox for multigene symbolic regression. In: Proceedings of the International multiconference of engineers and computer scientists. pp. 77–80 Citeseer (2010).
18. Turing, A.M.: Intelligent machinery. report for national physical laboratory. reprinted in ince, dc (editor). 1992. mechanical intelligence: Collected works of am turing, (1948).

Part V
Multimedia Systems and Applications

TweeProfiles3: visualization of spatio-temporal patterns on Twitter

André Maia[1], Tiago Cunha[1], Carlos Soares[1], and Pedro Henriques Abreu[2]

[1] Faculdade de Engenharia da Universidade do Porto, Porto, Portugal
{ee08163,tiagodscunha,csoares}@fe.up.pt
[2] Departamento de Engenharia Informática da Universidade de Coimbra
Coimbra, Portugal
pha@dei.uc.pt

Abstract. With the advent of social networking, a lot of user-specific, voluntarily provided data has been generated. Researchers and companies noticed the value that lied within those enormous amounts of data and developed algorithms and tools to extract patterns in order to act on them. TweeProfiles is an offline clustering tool that analyses tweets over multiple dimensions: spatial, temporal, content and social. This project was extended in TweeProfiles2 by enabling the processing of real-time data. In this work, we developed a visualization tool suitable for data streaming, using multiple widgets to better represent all the information. The usefulness of the developed tool for journalism was evaluated based on a usability test, which despite its reduced number of participants yielded good results.

Keywords: Clustering, Information Visualization, Stream processing

1 Introduction

Online social networks present a variety of social media services which have achieved a huge importance in social life as well as in marketing strategies as they "have been regarded as a timely and cost-effective source of spatio-temporal information" [10]. One business which has been significantly affected is journalism. Social networks can be used to change the way journalists are able to take the pulse of the trending topics. Twitter is one of the top social networks, both in popularity and monthly active users (around 250 million). It is a starting point for our ongoing work because it is the most widely used microblogging application.

The first version of TweeProfiles [6] is focused on identifying profiles on data collected from Twitter. The data is processed over 4 dimensions (spatial, temporal, social and content) using Data Mining techniques. The tool enables the visualization of the results of the clustering algorithm. Since it lacked the ability to produce real-time visualizations of the evolution of the data stream, one extensions was developed: TweeProfiles2 [14]. It replaced the original batch clustering algorithm with a stream clustering algorithm, enabling the use of real-time

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_82

data. However, the system was not fully implemented and still used static data to perform clustering.

Until now, all work performed was essentially technical and scientific, in order to design and prototype solutions to the challenges involved. For this reason, it has not yet been possible to evaluate the visualization platform in a real-world application. Our motivation for this work lies with the design of an extension for TweeProfiles2. Our most important contribution is the development of a visualization system with an interactive representation of the profiles. In addition, we also included connections to other platforms in order to enrich the profiles and ease the access to relevant information. We used services provided by SAPO Labs[3], which devote themselves to the extraction and analysis of several online data sources related to the Portuguese community. We also aim to evaluate this tool in a real-world application, as well as to integrate the previous process with a real-time data extraction platform named SocialBus[4] [3]. We discuss this tool in more detail in Section 3.

This paper is organized as follow: Section 2 contains the State of the Art for the research areas of clustering and information visualization. Section 3 presents the developed system with the concepts and decisions for the data mining process and the visualization tool. Section 4 presents some results obtained from our analysis of this project. Finally, Section 5 lists our conclusions and tasks for future work.

2 State of The Art

2.1 Clustering

Data mining is the process of exploring large amounts of data with the goal of finding potentially interesting patterns [9]. One of its most well-known tasks is Clustering and it is defined as the process of grouping a set of data objects into multiple groups or clusters so that objects within a cluster have high similarity, but are very dissimilar to objects in other clusters [9]. Over the years, cluster techniques have been applied in multiple domains, e.g. profiling breast cancer patients to predict overall survival [1], helping to choose the best strategy to defeat a soccer opponent [2] among others. Since this project follows the work done in TweeProfiles2, one of its main tasks is to perform clustering on data collected from Twitter, specifically using Stream Clustering approaches. Stream Clustering is a research area that recently emerged to discover knowledge from large amounts of continuously generated data. In this context, several algorithms have been proposed to perform unsupervised learning [15]. Since this project is more focused on Information Visualization than Stream Clustering, further details regarding this topic will not be presented. However, a detailed survey can be found elsewhere [15].

[3] http://labs.sapo.pt
[4] https://reaction.fe.up.pt/socialbus

2.2 Information Visualization

An important step in the data mining process is the interpretation of the results. It is often based on tools to visualize both the data and the knowledge extracted. The main properties that must be verified by these tools are: the displaying of the data and temporal behaviour; showing properties of the entire displayed scene and support interaction [8]. Visualization tools in a large multidisciplinary initiative require a pragmatic yet somewhat critical review of the ways visualization can be used to represent and to analyse data. In this project, the review of related work is focused on was done based on systems that collect data from Twitter.

For clustering visualization, one of the most common representations are graphs. The objects in each cluster are presented and the goal of assigning similar objects the shortest distance between clusters is maintained. Another option involves assigning different colors and objects to different concepts. For instance, overlapping ellipses over the most representative objects are displayed to represent similar objects. This approach was applied to study geographical lexical variation [7] and to classify events [4]. More recently, different clustering visualization methods were designed based on a different technique. For instance, clusters can be displayed in a more innovative and interactive way, enabling the user to easily identify content in each cluster [12].

Regarding visual representations on Twitter data, there are several approaches reported in the literature. TweetPos [17] is a web service that is intended to facilitate the analytical study of geographic tendencies in Twitter data feeds. In order to improve the user's experience with the tool, TweetPos relies on visual data structures such as heat maps and charts to represent the geo-spatial sources of tweets.

SensePlace2 [13] presents a geovisual analytics approach to support situational awareness for crisis events using Twitter. It focuses on leveraging explicit and implicit geographical information for tweets and on providing visual interface methods to enable understanding of place, time, and theme components of evolving situations.

TweetDrops [16] is a computer-based visualization tool designed for people who have not paid attention to sustainability in their life before. It opens up an opportunity for them to learn about energy conservation. It has two main visual components: the background rain drops, which represent the accumulation of energy related tweets collected from Twitter and the other is clickable foreground tweets with detailed content.

Earthquake [5] is a visualization tool that uses Twitter posts regarding the earthquake which occurred on the East Coast of the United States on August 23, 2011. It gathers information based on hashtags and displays the locations of different tweets in different time periods. It displays information as heat maps as well as graphs.

3 TweeProfiles3

In order to obtain data from Twitter in real time, we integrated TweeProfiles2 in SocialBus. SocialBus is a platform that allows users to gather and store data from Twitter. Integrating SocialBus in TweeProfiles2 is a big improvement, due to the fact that we may restrict SocialBus to save only tweets with the required information for the task. Also, not only it allows TweeProfiles2 to be performed directly on the Twitter stream in real time, but also allows the information to be saved, in order to apply clustering to the same data. This is an important feature for evaluation of stream clustering algorithms.

3.1 System Architecture

TweeProfiles3 combines SocialBus' extraction and pre-processing methods to gather data from Twitter and the multidimensional stream clustering strategy from TweeProfiles2. The system architecture for TweeProfiles3 involves several modules, namely: Data Handling, Clustering, Data Mapping and Search.

Data Handling The design of the data collection software module separates web-interface logic from the background processes for data collection and storage. This is completely done by SocialBus who uses the open-source Twitter4J library for connection to the Streaming API and stores received tweets in MongoDB. The data collected suffers pre-processing tasks, namely time conversion and geo-data filtering.

Clustering As the data is retrieved from MongoDB it is fed to the clustering algorithms used in TweeProfiles2: DenStream and DBSCAN. DenStream is responsible for the creation of micro-cluster that are then used as input to DBSCAN in order to create the macro-clusters.

Data mapping This module is responsible for data visualization. It displays the results of the clustering algorithms and of spatial, temporal and textual queries to the end users. The Google Maps[5] and Leaflet[6] Javascript APIs are used to display retrieved tweets and resulting clusters on a map.

Search Full-text search is incorporated in our systems to assist end users with textual analysis, speed-up queries on a large data-set and to produce a broader set of search results for each keyword specified by the user. Specifically, the system performs a match of the desired word to both tweets and set of words in all clusters. The system also incorporates a full spatial search enabling the users the define a specific region to analyse, as well as a temporal search so that the user can define a certain weekday to display all tweets and clusters and a timeline to go back in time 7 days.

[5] http://maps.google.com
[6] http://leaftletjs.com

3.2 Visualization System

TweeProfiles3 exposes its functionality to end users through a php web application framework, entitled Codeigniter[7]. It also provides a simple web based data collection and retrieval interface, which is shown in Figure 1. All widgets are related in the sense that when selecting an element in the map, all other widgets update accordingly.

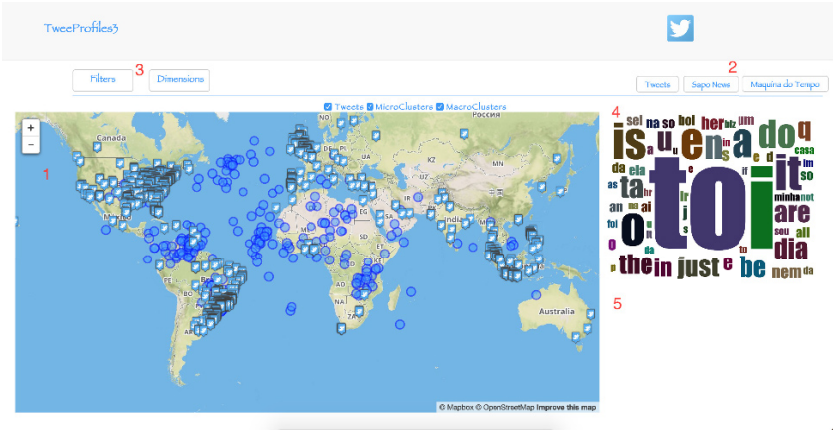


Fig. 1. TweeProfiles3's web interface.

The system interface includes 5 core components: 1) Tweet and cluster map; 2) tweet, news and entities list; 3) display/dimension controls; 4) wordcloud and 5) time graphics.

Tweet and Cluster map The map supports simultaneous tweets and clustering distribution overview. In one platform, a heatmap provides the overview for tweets and the clusters are displayed using simple markers. In a second platform, tweets' positions are displayed using markers and clusters with circles. Here we can get detailed information such as the number of words in the cluster, the creation time and position.

Tweet, News and Entities list The tweet list depicts the 1000 newest tweets for any query. The entity list displays any personality found in the processed tweets and the news list display the 20 more recent news. These were achieved by acessing public APIs from Labs Sapo: *Verbetes* to detect entities from the tweets and *Máquina do Tempo*, which provides the news per entity.

[7] http://www.codeigniter.com

Display/Dimension controls These controls support query filtering with region selection, time range sliders (either choosing weekday or going back in time) and a minimalistic interface to specify terms for text-based queries. These controls also include a filter to specify the desired dimensions.

Wordcloud Displays the most frequent words in all clusters. The size of the words is equivalent to its frequency in tweets. The higher the frequency of said word, the bigger the word's size is. Clicking any word in the cloud performs a search for news related to that word in *Sapo.pt*.

Time graphics In this dimension we have two types of graphs. The first ones display the hour and weekday of the creation of all clusters (see Figure 2). They are represented by a circle with a center on the average time of all tweets and its size is directly dependent on the duration of the cluster. The second graph is inspired on a timeline using horizontal bars to characterize each cluster. The length of the bar is given by the earliest and latest timestamps of that cluster (see Figure 3).

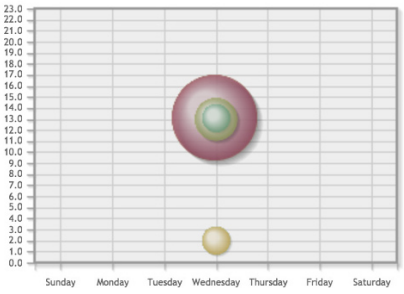


Fig. 2. Temporal visualization - $x - y$ graph.

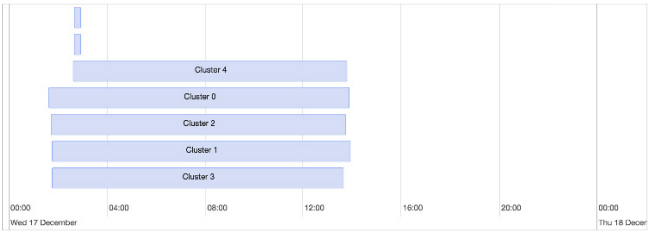


Fig. 3. Temporal visualization - timeline.

The chosen visualization strategy for the system assumes a spatio-temporal representation as the basis. This decision was taken based on the fact that time

and space dimensions are the most intuitive and easily representable and interpretable. This representation approach was based on the methodology used by [7] but with two differences: the colors to represent each cluster and the shape of the clusters. One disadvantage of this type of representation is the overlapping markers and circles when zoomed out. The only solution for this problem is zooming in a specific region and/or using the available filters.

4 Results

The system was tested with a large scale data over a period of 30 days. The data collection, for testing purposes, was focused on tweets labelled in Portuguese, English, French and Spanish. All these tweets were retrieved without using any specific query method, besides the language filtering. The clustering algorithm parameters established are the same used in TweeProfiles2. Since the distance function weighting was not performed correctly in TweeProfiles2, we do not consider dimensional weighting in TweeProfiles3. Our goal is to provide a suitable interface for TweeProfiles2 multidimensional clustering process, and therefore we do not present the clustering results. A more extensive explanations of these results can be found elsewhere [14]. Furthermore, since we still lack an evaluation methodology suitable for the multidimensional nature of TweeProfiles, the results shown would have to be only examples of application and not a full-fledged evaluation. Therefore, we devote ourselves to the presentation of the user study used to validate our system and, in particular, the visualization tool.

4.1 Usability Tests

To understand if TweeProfiles3 met the desired features and design of end users, we performed an usability test. We asked the participants to use the tool to extract information from tweets, news and clusters, evaluating the time and detail of the result. These tests were made with JPN[8] journalists, but unfortunately only 3 were available at the time of this publication.

The participants were asked to complete a form, for us to understand how they felt about the implemented features and the general use of TweeProfiles3. This survey was created based on [11] and people were able to evaluate, from 1-5, different features and aspects of the system (1 being that they disagreed with the statement and 5 that they fully agreed). Table 1 presents the questionnaire used for this user study, alongside the answer given by the three journalists.

We were able to understand that the users easily and effectively extracted information from both tweets and all news features. The ability to apply different filters to the data was highly appreciated and used, being the content filtering the one that got the most attention. All data shown on the map seemed to be useful for the tasks. An example given for the usage of tweet's details was the terrorist attack on Charlie Hebdo. The users stated that TweeProfiles3 would be

[8] http://jpn.up.pt/

Table 1. User study questionnaire

Question	Journalist 1	Journalist 2	Journalist 3
Age	25	23	27
Academic background	Bachelor	Bachelor	Masters
Current position	Journalist	Journalist	Editor
Years of experience in journalism	3	3	4
System simplicity	4	4	4
System efficiency for journalism?	4	4	4
System understandability	4	3	4
Information easily accessible	5	3	4
System layout	5	5	5
Tools available in the system	4	3	4
General feedback	4	4	4
Most important features?	Map, News	Map, News	Map, News
Which tool would you remove?	n/a	Máquina do Tempo	n/a
Which feature needs improvement?	n/a	Graphics	n/a
Are the connections to Sapo tools useful?	Yes	Yes	Yes
Most relevant Sapo tool used?	News	News	News
Do you consider the wordcloud useful?	Yes	Needs improvement	Yes
Which is the most efficient method: the tool (TP3) or traditional methods?	n/a	TP3	TP3

perfect to support an article regarding what happened, since they could not only gather information from the news, but also from what people were saying, giving the possibility to use such information in the article. Regarding the same topic, one aspect considered missing were hashtags and images. These two features are removed from the analysis and since the biggest trend from the attack included images and hashtags, a lot of information was lost. Improving the algorithm to use this would be a big step to TweeProfiles3.

One other aspect considered important by the journalists was the integration of Sapo platforms in TweeProfiles3. Even though the news list was more analysed than *Máquina do Tempo*, both were acknowledge as a plus.

At first people evaluated how simple the usage of the system was. All answers point to the fact that TweeProfiles3 is a simple system to use. This was our biggest concern when designing the application, to create a simple system with all the desired information. The users also agreed (with the same evaluation) that they were able to complete work effectively using TweeProfiles3. Regarding the usability of our system, one participant evaluated with a 4, and one of them with a 3, on our 1-5 scale, how easy it was to understand. When it comes to the information we present, all respondents answered with 5 on how clear the information was organized on the screen, but regarding how easy it was to find the information they were searching, one person evaluated with a 3, while others still evaluated with a 5.

One other question all participants came to agreement was regarding the implemented features. All said that the most important were the map with all tweets/clusters and the news. However, they also considered that the time graphs and the wordcloud require improvement. When asked if they agreed with the integration of the platform from Sapo, all participants answered positively and also, all agreed that the news list was more relevant than *Máquina do Tempo*.

When finally asking the participants if they were satisfied with the outcome of TweeProfiles3, the answers were positive, all rating 4, which means our system proved to be to the liking of all people who tested it. Even though there are some improvements to be made and some features to be added, and the number of journalists we had to test our application was fairly low, it was easy to understand how all participants considered TweeProfiles3 faster, more efficient and detailed than any other traditional method for gathering information. Platforms like this are seen as useful and necessary for the journalism community, and overall, TweeProfiles3 went in the right way, satisfying all participants.

5 Conclusions

In this project we developed an integration of a multidimensional Stream Clustering algorithm from TweeProfiles2 and SocialBus to create a visualization system capable of displaying the profiles found in all different dimensions. We also related these profiles with different news and entities from Sapo Labs and made the first attempt to evaluate the tool as a real-world application. The visualization tool made use of different visual patterns associated with all dimensions. Specifically, a map with information regarding both tweets and clusters, a timeline and a graph with timestamp details and a wordcloud with the most common words in all clusters. These widgets enable a simultaneous representation of the same information in different dimensions. Lastly, we performed a usability test with journalists to understand the efficiency, usability and overall performance of the platform. Despite the reduced number of interviewees, the results are promising. We have planned to tackle several problems in the future work: improve the data filtering and cleaning strategies, implement other widgets or filters that may lead to a more detailed analysis of the data, connect to external tools to support more languages and increase the amount of the journalists invited to the user study in order to provide our tests with statistical significance.

Acknowledgments. This work was partially supported by projects REACTION (Retrieval, Extraction and Aggregation Computing Technology for Integrating and Organizing News - UTA-Est/MAI/0006/2009), POPSTAR (Public Opinion and Sentiment Tracking, Analysis, and Research - PTDC/CPJ-CPO/116888/2010) and Sapo Labs. It was also financed by the ERDF – European Regional Development Fund through the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020 Programme, and by National Funds through the FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within project POCI-01-0145-FEDER-006961.

References

1. Abreu, P.H., Amaro, H., Silva, D.C., Machado, P., Abreu, M.H.: Personalizing breast cancer patients with heterogeneous data. In: Proceedings of the 2013 IFMBE International Conference on Health Informatics, 2013. pp. 39–42 (2013)

2. Abreu, P.H., Silva, D.C., Almeida, F., Mendes-Moreira, J.: Improving a Simulated Soccer Team's Performance Through a Memory-Based Collaborative Filtering Approach. Applied Soft Computing 23, 180–193 (2014)
3. Boanjak, M., Oliveira, E., Martins, J., Mendes Rodrigues, E., Sarmento, L.: Twitterecho: a distributed focused crawler to support open research with twitter data. In: Proceedings of the 21st international conference companion on World Wide Web. pp. 1233–1240. ACM (2012)
4. Boettcher, A., Lee, D.: Eventradar: A real-time local event detection scheme using twitter stream. In: Green Computing and Communications (GreenCom), 2012 IEEE International Conference on. pp. 358–367. IEEE (2012)
5. Crooks, A., Croitoru, A., Stefanidis, A., Radzikowski, J.: # earthquake: Twitter as a distributed sensor system. Transactions in GIS 17(1), 124–147 (2013)
6. Cunha, T., Soares, C., Mendes Rodrigues, E.: Tweeprofiles: Detection of spatio-temporal patterns on twitter. In: Luo, X., Yu, J., Li, Z. (eds.) Advanced Data Mining and Applications, Lecture Notes in Computer Science, vol. 8933, pp. 123–136. Springer International Publishing (2014), http://dx.doi.org/10.1007/978-3-319-14717-8_10
7. Eisenstein, J., O'Connor, B., Smith, N.A., Xing, E.P.: A latent variable model for geographic lexical variation. In: Proceedings of the 2010 Conference on Empirical Methods in Natural Language Processing. pp. 1277–1287. Association for Computational Linguistics (2010)
8. Gahegan, M.: 11 visual exploration and explanation in geography analysis with light. Geographic Data Mining and Knowledge Discovery p. 291 (2009)
9. Jiawei, H., Kamber, M.: Data mining: concepts and techniques. San Francisco, CA, itd: Morgan Kaufmann 5 (2001)
10. Lee, C.H., Yang, H.C., Chien, T.F., Wen, W.S.: A novel approach for event detection by mining spatio-temporal information on microblogs. In: Advances in Social Networks Analysis and Mining (ASONAM), 2011 International Conference on. pp. 254–259. IEEE (2011)
11. Lewis, J.R.: Ibm computer usability satisfaction questionnaires: psychometric evaluation and instructions for use. International Journal of Human-Computer Interaction 7(1), 57–78 (1995)
12. Liu, X., Hu, Y., North, S., Shen, H.W.: Compactmap: A mental map preserving visual interface for streaming text data. In: Big Data, 2013 IEEE International Conference on. pp. 48–55. IEEE (2013)
13. MacEachren, A.M., Jaiswal, A., Robinson, A.C., Pezanowski, S., Savelyev, A., Mitra, P., Zhang, X., Blanford, J.: Senseplace2: Geotwitter analytics support for situational awareness. In: Visual Analytics Science and Technology (VAST), 2011 IEEE Conference on. pp. 181–190. IEEE (2011)
14. Pereira, J.: TweeProfiles2: real-time detection of spatio-temporal patterns in Twitter. Master's thesis, Faculdade de Engenharia da Universidade do Porto (2014)
15. Silva, J.A., Faria, E.R., Barros, R.C., Hruschka, E.R., de Carvalho, A.C., Gama, J.: Data stream clustering: A survey. ACM Computing Surveys (CSUR) 46(1), 13 (2013)
16. Wang, X., Cosley, D.: Tweetdrops: a visualization to foster awareness and collective learning of sustainability. In: Proceedings of the companion publication of the 17th ACM conference on Computer supported cooperative work & social computing. pp. 33–36. ACM (2014)
17. Wijnants, M., Blazejczak, A., Quax, P., Lamotte, W.: Tweetpos: A tool to study the geographic evolution of twitter topics. In: International Conference on Web Information Systems and Technologies. pp. 257–266 (2014)

RetweetPatterns: detection of spatio-temporal patterns of retweets

Tomy Rodrigues[1], Tiago Cunha[1], Dino Ienco[2], Pascal Poncelet[3], and Carlos Soares[1]

[1] Faculdade de Engenharia da Universidade do Porto, Porto, Portugal
{ei08159,tiagodscunha,csoares}@fe.up.pt
[2] IRSTEA - Institut National de recherche en sciences et technologies pour l'environment et l'agriculture, Montpellier, France
dino.ienco@teledetection.fr
[3] LIRMM - Laboratoire d'Informatique, de Robotique et de Microélectronique de Montpellier , Montpellier, France
pascal.poncelet@lirmm.fr

Abstract. Social media is strongly present in people's everyday life and Twitter is one example that stands out. The data within these types of services can be analyzed in order to discover useful knowledge. One interesting approach is to use data mining techniques to perceive hidden behaviours and patterns. The primary focus of this paper is the identification of patterns of retweets and to understand how information spreads over time in Twitter. The aim of this work lies in the adaptation of the GetMove tool, that is capable of extracting spatio-temporal pattern trajectories, and TweeProfiles, that identifies tweet profiles regarding several dimensions: spatial, temporal, social and content. We hope that the more flexible clustering strategy from TweeProfiles will enhance the results extracted by GetMove. We study the application of said mechanism to one case study and developed a visualization tool to interpret the results.

Keywords: Pattern Mining, Spatio-temporal, Clustering

1 Introduction

The proliferation of social media services, like Twitter for instance, has contributed to an increase of public available data. Since this data has the potential of holding interesting hidden patterns, many researchers have attempted to aggregate and organize it, in order to try to find relationships, relevant changes and anomalies [1, 2].

In this work, we aim to integrate two data mining tools (TweeProfiles [3] and GetMove [10]) and apply the resulting process to a dataset built about the manifestations in Brazil during the period of June to July 2013. TweeProfiles allows the extraction of tweet profiles by taking into account several dimensions: social, temporal, spatial and content. On the other hand, GetMove attempts to extract trajectories from spatio-temporal data. Therefore, our motivation lies

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_83

with assessing if by considering the social, temporal, spatial and content dimensions of tweets we can obtain an enhancement on the GetMove results for our problem. The process consists in exchanging the standard clustering stage in GetMove with a multidimensional clustering process provided by TweeProfiles. Since the data required and the results can be easily adapted to GetMove, the only difference is that we hope that the results provided by TweeProfiles will empower the clustering with greater detail by taking advantage of the complex relationships in the data. Another goal for our work is the development of a visualization tool capable of displaying the multidimensional trajectory patterns extracted by the previous data mining tool. It is important to find suitable ways of displaying how information propagates, while paying particular attention to the social, temporal, spatial and content dimensions.

This paper is organized as follows: Section 2 discusses the related work on the relevant scientific areas, while Section 3 presents our proposal to integrate TweeProfiles with GetMove in order to apply it to the retweet pattern problem. Section 4 presents our visualization tool and in Section 5 its application to a case study. Lastly, in Section 6, we present our conclusions and future work tasks.

2 Related Work

2.1 Twitter

Twitter[4] is a social network that allows to publish instant messages with the maximum number of 140 characters (also known as a tweet). Within Twitter, social relationships are represented in at least two ways: a user is following someone and can be followed by other users. These relationships allow the propagation of tweets throughout the platform. There are several tools to aid the communication among users in Twitter, namely mentions (identify a specific user), replies (answer to previous tweet), hashtags (keywords that describe the topic of the tweet) and retweets (share another user's tweet). Although all of these tools promote data propagation, we focus our study in the retweet actions since we consider them the most unbiased data propagation tool. We justify this decision arguing that by performing a retweet we want to show a specific tweet only to our followers. In fact, in a retweet the content remains unchanged and there is no explicit contact with other users. We believe this means that the tweet contains an important message (at least considering the user's interest) and then the analysis of this specific data propagation tool has potential interest.

2.2 TwitterEcho and TweeProfiles

The TwitterEcho project [1] is a research platform for extracting, storing and analysing the Portuguese Twittosphere for research and journalistic purposes. It collects data using the Twitter API. This platform accesses the Twitter Streaming API to obtain real time tweets through the crawler clients. These tweets

[4] https://twitter.com/

are sent to a message broker and processed on two components: stream processing and pre-processing. After the information is stored, it is subjected to batch processing in order to mine different kinds of knowledge. This knowledge is available through analysis modules which include text mining, opinion mining, sentiment analysis and social network analysis. A more recent version of this project is called SocialBus[5] and it has several improvements regarding query control, monitorization and interoperability with other systems.

The main goal of TweeProfiles [4] is to analyze Twitter's spatio-temporal data in several dimensions and display the information retrieved with appropriate visual representations. It contains a multidimensional clustering strategy that considers spatial, temporal, content and social dimensions in an unified fashion. The process consists in the manipulation of dissimilarity matrices for the several dimensions using appropriate distance measures to perform clustering. It creates a dissimilarity matrix per dimension using appropriate distance functions: Haversine for spatial, time difference for temporal, TF-IDF representation with cosine similarity for content and geodesic distance in social graph for the social dimension. After each matrix is created, a min-max normalization process is executed and the final combination process delivers the resulting matrix for clustering. The combination formula to obtain the final dissimilarity matrix D^{4D} is a linear combination of the spatial (D^{Sp}), temporal (D^{T}), content (D^{C}) and social (D^{So}) dissimilarity matrices with the respective pre-defined weights w_{Sp}, w_{T}, w_{C} and w_{So}:

$$D^{4D} = w_{Sp}D^{Sp} + w_{T}D^{T} + w_{C}D^{C} + w_{So}D^{So} \tag{1}$$

Afterwards, the final dissimilarity matrix is fed to the DBSCAN clustering algorithm [5] and the results stored. These are accessible by a visualization tool that displays the multidimensional patterns using a spatio-temporal approach. It allows users to choose different weights for the dimensions considered and provides a wide range of usability features to better analyse the results. The visualization tool is available online[6].

2.3 GetMove

The main objective of the GetMove tool [10] is to extract different kinds of moving object patterns, exploiting techniques coming from the field of frequent closed itemset mining. These patterns can be classified as Swarm, Closed Swarm, Convoy, Moving Clusters and Group Patterns. Before dwelling in the patterns, let us introduce appropriate notations. Considering that we have a group of objects defined as $O = \{o_1, o_2, o_3 ... o_n\}$ and a set of timestamps $T = \{t_1, t_2, t_3 ... t_n\}$ associated with each object, each pattern is represented by $(\{O_k\}, \{t_l\})$, where $O_k \subset O$ and $t_l \subset T$. We consider that the objects at each timestamp t_l are a cluster.

[5] http://reaction.fe.up.pt/socialbus/
[6] http://reaction.fe.up.pt/tweeprofiles/tweeprofiles.html

A Swarm [7] is a group of objects that contains at least ε objects during a minimum time min_t. The pair $(\{O_k\}, \{t_l\})$ is a swarm if there is at least one cluster containing all the objects at each timestamp t_l. A Swarm can be defined as a Closed Swarm [9] only if the objects remain unchanged for a minimum number of (possibly non-consecutive) timestamps min_t. A Convoy is a group of objects that contains at least ε objects for a minimum number of timestamps min_t. The difference to a Closed Swarm is that the timestamps must be consecutive. Moving clusters can be seen as special cases of convoys with the additional condition that they need to share some objects between two consecutive timestamps. A Group Pattern is the combination of the two patterns defined previously. In other words, it is a group of objects that remain unchanged for a minimum number of consecutive timestamps min_t and after an indefinite period reappear once again for a minimum number of consecutive timestamps min_t.

The GetMove algorithm has several steps, being the first one the extraction of clusters of objects for each timestamp. To achieve this, the GetMove framework uses a cluster matrix representation where each row represents an item and each column a cluster. The weighting scheme is binary based and similar to the bag-of-words representation: when a cell has the value 1 means that a given item is in the corresponding cluster. Afterwards, it uses the LCM algorithm to extract frequent closed itemsets. It iteratively finds the transitions in which the objects are present and also extracts the common elements for these transitions. The process is repeated for each combination of object subsets possible and the results stored if they fulfill all the conditions required by each pattern.

2.4 Visualizing Twitter Data

There are several approaches to represent Twitter data or information extracted from such data in the literature. It depends not only on the data, but also on the scope of the problem. Silicon Graphics International [6] has partnered with researchers from the University of Illinois in order to perform Sentiment Analysis on tweets. They use a visualization tool to represent the extracted patterns by considering several representations: a map with various geo-referenced tweets, where each tweet is represented according to the feelings expressed with a red (negative feelings) or blue dot (positive feelings). On top of this representation, they use heatmaps that illustrate the feelings of people on Twitter during Hurricane Sandy and the presidential elections of 2012.

Another visualization tool that takes advantage of tweets was developed in order to detect the birth and death of rumors on Twitter: Riots [11]. The tool developed was designed to visualize the evolution of tweets related to a particular rumor. The authors decided to represent said rumors in the form of tweets grouped into larger circles, where each circle consists of a set of retweets of a given tweet. In this way, circles represent clusters that define a group of the same or similar elements gathered or occurring closely together. It is also possible to view the progress and associated sentiment of the tweets and retweets clusters over time. The influence and importance of each cluster in the social network is

represented by the size of the circle. The tool also features a timeline with the most relevant tweets over time.

Mentionmapp [8] is a web application that uses data from Twitter and allows us to see tweet themes of a user and the people who follow him. The tool shows the connections with different friends and followers of each user in the social network, as well as relevant hashtags employed by different users. By selecting a friendship connection, customized information is displayed. There are several types of nodes depending on the geographical distance between users, where closest nodes identify nearby users. Finally, links between nodes also reflect the frequency with which a user makes reference to another user. The thickness of the line represents the amount of information exchanged between the two users.

3 RetweetPatterns

The main focus of this paper is to find retweet patterns using multidimensional clustering. In order to achieve this goal, we use the GetMove tool to extract moving object patterns applied to retweet data. Although the original purpose of the tool is not the retweet patterns, by having access to spatio-temporal data and a data propagation mechanism such as retweets, we can make the required adaptation. Therefore, we use GetMove to extract frequent itemsets. But, unlike in the original implementation, we wish to apply TweeProfiles clustering strategy to find the clusters. We argue that since its process is oriented to spatio-temporal data, it may improve the clustering results, while providing a greater control over the clustering process.

After collecting geo-referenced data from Twitter, we need to process it to fit our problem. The first problem at hand is the different notion of timestamp in the tweet data and in the GetMove tool. The problem is that if we consider t_i to be the timestamp of a retweet, then it will be very hard to find t_i in more than one retweet. Therefore, we solve the problem by using sequences instead, where t_i is the order of the timestamp in the set of retweets. The next step is to separate all extracted retweets with identical content in order to obtain sets of retweets. Afterwards, to obtain the various timestamps $t_i...t_n$, we sorted them in chronological order.

After defining the timestamps, the next step is to perform clustering for each timestamp. We filter the tweets related to each timestamp and apply the TweeProfiles clustering strategy. This step will create more clusters per each timestamp with regards to the spatial, temporal, content and social dimensions. After individually performing the clustering process, we can then build a cluster matrix to be used in GetMove. This way we can apply the GetMove algorithm to analyze the evolution of the clusters over time. We can thus extract Closed Swarms, Convoys, Moving Cluster and Group Patterns.

It is important to understand beforehand the meaning of each moving objects pattern when we apply the GetMove tool to retweet data. Since Closed Swarm extracts patterns involving groups of objects that can be together in non-consecutive timestamps, this means that this pattern tries to find sets of retweets

that are recurrent over time. On the other hand, Convoy extracts groups of objects that need to be together in consecutive timestamps. In our scenario this means that we find sets of retweets that have consecutive timestamps. With regarding to Moving Cluster, such a pattern can be seen as a special case of convoys with the additional condition that they need to share some retweets between two consecutive timestamps. Finally, the Group Pattern means that we have found disconnected convoys, i.e. sets of retweets having consecutive timestamps which exist up to a certain point and reappear some time later again.

4 Visualization tool

After obtaining the result from GetMove it is important to display the extracted patterns in an intuitive and explicit fashion. The RetweetPattern tool was designed to present the results extracted from the GetMove algorithm using one component for each one of the 4 dimensions. The first component is a map that represents the spatial patterns found with GetMove (see Figure 1). The user can observe several patterns: Closed Swarms, Convoys, Moving Clusters and Group Patterns. The choice of patterns affects the data represented in the map and, by extension, in the remaining visualization components.

Fig. 1: Map close-up with moving patterns represented.

The map displays each pattern by a line that indicates the propagation of tweets (or clusters of tweets) over time. When a point refers to a cluster instead of a single point, its location is averaged from all tweets in the respective cluster. By clicking on the line that represents a pattern we can see the various retweets constituting the pattern. Each point on that line represents a timestamp for the GetMove algorithm. Clicking on a point we can view the users who retweet and when they do it. Figure 2 shows the respective visualization.

The tool displays the content and the social dimensions using a wordcloud and a social graph, respectively. The wordcloud is simply built using all the text from the retweets, but due to its characteristics enables a clear visualization of the most important topics. The social graph is more complex, since the patterns are represented with the same colors used on the map, but the improvement

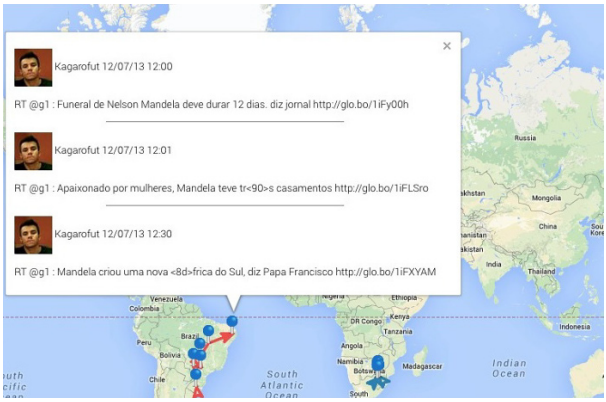


Fig. 2: Detailed information after clicking on a point.

is that you can quickly view how many paths of retweets are present in each pattern. Each node in the graph represents a user, which represents a point on the map. It is also possible to visualize the social relationship of each user by analysing the graph edges. The thickness of the edge between two nodes is directly proportional to the number of retweets in common. It is also possible to show the name of the user hovering the mouse on top of the node. Due to space constraints, we only present the complete tool layout in Figure 5.

Finally, the temporal dimension is presented by a timeline with all retweets extracted from the algorithm. Figure 3 shows the timeline widget. The retweets here are presented in chronological order and the timeline gives the user the possibility to interact with the person that posted the retweet or with whoever made the initial tweet. By simply pressing its name, the tools present the selected user's Twitter timeline. Furthermore, if the retweet contains URLs, it is possible to view the content in another browser tab. Our tool is available online[7] for further inspection.

5 Validation and Results Illustration

In this section we will look at a case study referring to a set of retweets extracted at the time of the protests in Brazil. The dataset ranges from June 2013 and July 2013 and consists of a total of 17083 tweets extracted from Twitter during a protests period in Brazil. We performed the pre-processing tasks defined in Section 3 and ended up with 260 different retweets. The timestamps for GetMove were defined by sorting the tweets chronologically, considering that each retweet is part of a tweet sequence.

Afterwards, we applied TweeProfiles' DBSCAN clustering algorithm with the following parameters: the minimum number of points always set as 2 and

[7] http://trodrigues37.github.io/RetweetPattern/

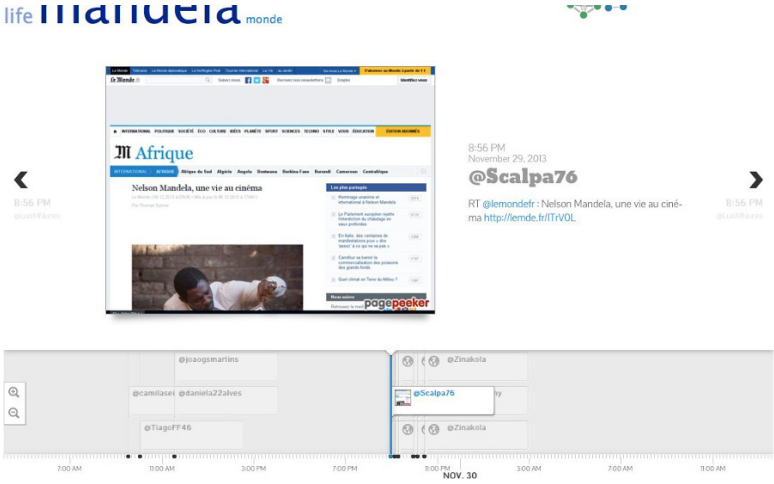


Fig. 3: Timeline with extracted patterns.

the maximum radius value which we defined as 10%. The minimum number of points was always set as 2, which means that if at least 2 retweets are reachable within the circle radius, they belong to the same cluster. As for the circle radius, it depends directly on the dissimilarity matrix. After executing tests upon all combinations, we concluded that the best value possible is 10% over the maximum value in the matrix. This is a critical value, since if it is too small the result may not return any clusters. On the other hand, if the value is too high, it will return a single cluster with all items, being therefore not representative.

Fig. 4: Closed Swarm patterns found.

The next step involves applying the GetMove algorithm and extracting the moving object patterns. We found 18 closed swarms, 5 convoys, 5 moving clusters and no Group Pattern. Due to space restrictions, we are limited to displaying

Fig. 5: Timeline and wordcloud for the Closed Swarm patterns found.

one example here, while the remaining results are available elsewhere[8]. Figure 4 shows the 18 paths of Closed Swarm found which are composed by 84 retweets. We can see that the majority of paths found are located in Rio de Janeiro and São Paulo. This reflects the importance of the protests in these cities. The most frequent words are "protestos" and "vemprarua" which mean protests and "come to street" (see Figure 5).

6 Conclusion

The goals of the work are the extraction of spatio-temporal patterns of retweets in various dimensions and create a visual platform to represent and enable the analysis of the information retrieved. The purpose of using different dimensions was to enable their combination and to validate if the results obtained would successfully return interesting patterns. To accomplish such goals, a data mining process was developed combining Tweeprofiles and GetMove with different stages: data preparation, dissimilarity matrices computation, matrices normalization and combination, clustering and lastly, application of the GetMove algorithm. The visualization tool uses visual patterns associated with all dimensions. Namely a map, a timeline, a social graph and a wordcloud. These widgets allowed the simultaneous representation of information in different dimensions and to interact with them in order to enable a deeper exploration of the results presented. From the results obtained we can argue that the inclusion of TweeProfiles as the clustering stage in the GetMove has been succesfull and that it has improved the quality of results as well as provided greater control over the clustering process. We plan to explore more advanced visualization strategies to enable a deeper usability of our tool and also to propose and implement a proper evaluation strategy.

[8] http://trodrigues37.github.io/RetweetPattern/RetweetPattern3.html

Acknowledgments. This work was partially supported by projects REACTION (Retrieval, Extraction and Aggregation Computing Technology for Integrating and Organizing News - UTA-Est/MAI/0006/2009), POPSTAR (Public Opinion and Sentiment Tracking, Analysis, and Research - PTDC/CPJ-CPO/116888/2010) and Sapo Labs. It was also financed by the ERDF – European Regional Development Fund through the Operational Programme for Competitiveness and Internationalisation - COMPETE 2020 Programme, and by National Funds through the FCT – Fundação para a Ciência e a Tecnologia (Portuguese Foundation for Science and Technology) within project POCI-01-0145-FEDER-006961.

References

1. Boanjak, M., Oliveira, E., Martins, J., Mendes Rodrigues, E., Sarmento, L.: TwitterEcho: A Distributed Focused Crawler to Support Open Research with Twitter Data. In: Proceedings of the 21st International Conference Companion on World Wide Web. pp. 1233–1240. ACM, New York, NY, USA (2012)
2. Byun, C., Kim, Y., Lee, H., Kim, K.K.: Automated Twitter Data Collecting Tool and Case Study with Rule-based Analysis. In: Proceedings of the 14th International Conference on Information Integration and Web-based Applications and Services. pp. 196–204. IIWAS '12, ACM, New York, NY, USA (2012)
3. Cunha, T., Soares, C., Mendes Rodrigues, E.: TweeProfiles: deteção de padrões espácio-temporais no Twitter (2013), http://hdl.handle.net/10216/68545
4. Cunha, T., Soares, C., Mendes Rodrigues, E.: TweeProfiles: Detection of Spatio-temporal Patterns on Twitter. In: Advanced Data Mining and Applications, pp. 123–136 (2014)
5. Ester, M., Kriegel, H., Sander, J., Xu, X.: A density-based algorithm for discovering clusters in large spatial databases with noise. In Proceedings of the 2nd International Conference on Knowledge Discovery and Data Mining pp. 226–231 (1996)
6. Fitzgerald, B.: SGI Twitter Heat Map: Supercomputer Shows Where Angriest Tweeters Live. http://www.huffingtonpost.com/2012/11/19/sgi-twitter-heat-map_n_2138726.html (2012)
7. Li, Z., Ding, B., Han, J., Kays, R.: Swarm: Mining Relaxed Temporal Moving Object Clusters. Proc. VLDB Endow. 3(1-2), 723–734 (2010)
8. Mentionmapp: Mentionmapp. http://mentionmapp.com/ (2013)
9. Nhat Hai, P., Ienco, D., Poncelet, P., Teisseire, M.: Extracting Trajectories through an Efficient and Unifying Spatio-temporal Pattern Mining System. In: Proceedings of the European Conference on Machine Learning and Principles and Practice of Knowledge Discovery in Databases. pp. 820–823. Lecture Notes in Computer Science (2012)
10. Nhat Hai, P., Poncelet, P., Teisseire, M.: GeT Move: An Efficient and Unifying Spatio-temporal Pattern Mining Algorithm for Moving Objects. In: Hollmén, J., Klawonn, F., Tucker, A. (eds.) In Proceedings of the Eleventh International Symposium on Intelligent Data Analysis, Lecture Notes in Computer Science, vol. 7619, pp. 276–288. Springer Berlin Heidelberg (2012)
11. Richards, J., Lewis, P.: How Twitter was used to spread – and knock down – rumours during the riots. http://www.theguardian.com/uk/2011/dec/07/how-twitter-spread-rumours-riots (2011)

Adaptive Filtering Techniques for Improving Hyperspectral Image Classification

Paulo Amorim[1], Thiago Moraes[1], Jorge Silva[1], and Helio Pedrini[2]

[1] Tridimensional Technology Division
Center for Information Technology Renato Archer
Campinas-SP, Brazil, 13069-901

[2] Institute of Computing, University of Campinas
Campinas-SP, Brazil, 13083-852

Abstract. Hyperspectral imaging sensors have been used to collect data for various applications, such as medicine, physics, archaeology, remote sensing, astronomy, geosciences, surveillance, among others. This work investigates the use of several local filtering techniques for improving the classification of hyperspectral images. Spectral-spatial features are extracted from the pixel values present in the image bands. A classifier is applied to each pixel of the image to determine its class. Experiments on hyperspectral images are conducted to show the effectiveness of the proposed method.

Keywords: hyperspectral data, image classification, spatial and spectral features, entropy information

1 Introduction

Advances in image acquisition techniques over the past decades have allowed the extraction of large volumes of data with high spectral resolution. Such data, called hyperspectral, are composed of various spectral bands representing observations collected simultaneously.

Hyperspectral imaging has applications in several knowledge domains, such as agriculture, medicine, astronomy, physics, geosciences, and surveillance. The analysis of hyperspectral data [7, 21] has received attention of the scientific community, since they have spectral attributes with high discriminative power. However, an inherent difficulty in the analysis of these data is their high dimensionality.

Hyperspectral image classification aims at categorizing data pixels into one of multiple land cover classes based on their properties. Land cover can be described as the physical state of the earth's surface according to its natural environment (such as soil, vegetation, water) and man-made structures (such as roads, buildings). Thematic maps can be generated by categorizing all pixels present in an image into themes or classes in terms of spectral and spatial information.

This work investigates the use of several different local filtering techniques for improving the classification process of hyperspectral images. The main purpose is to employ spatial weighted kernels to calculate image values for the classification. Although

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_84

the filtering process is simple, it reduces spectral variations and noise effect, producing better classification results. The effectiveness of the proposed methodology is evaluated on a set of hyperspectral images.

The remainder of the text is organized as follows. Section 2 gives a brief description of concepts related to the topic under investigation. The proposed methodology is presented in Section 3. Experimental results obtained from the application of the methodology are described and evaluated in Section 4. Section 5 presents the conclusions and directions for future work.

2 Background

Hyperspectral imaging sensors acquire information as a collection of images, where each image represents a wavelength range of the electromagnetic spectrum. The combination of the images forms a three-dimensional representation, called hyperspectral data cube (x, y, λ), where x and y represent the spatial dimensions, whereas λ represents the spectral dimension.

The main techniques for acquiring the hyperspectral cube are spatial scanning, spectral scanning, snapshot imaging, and spatio-spectral scanning [6, 16, 21]. Each approach has its intrinsic characteristics and the choice of the technique is dependent on the specific application.

The analysis of hyperspectral data is complex due to its high dimensionality and high redundancy present in the adjacent bands. Despite such difficulties, several techniques have been proposed in the literature to perform automatic extraction and classification of relevant information [2, 12, 27].

The main steps for hyperspectral image analysis usually include data acquisition, preprocessing, feature extraction and selection, and classification.

Hyperspectral data can be acquired from aircrafts or satellite sensors, which extract spectral signatures for objects and materials. The acquired images usually contain hundreds of spectral bands.

The preprocessing involves data filtering to reduce noise effect and smooth spectral information, data normalization to adjust values measured on different scales to a specific range, and data registration to transform different sets of data into a common coordinate system.

Feature extraction and selection aim at obtaining the most discriminative information from the data and convert it in a more succinct representation of the data, called feature vector, which stores the most representative attributes of the images. The number of attributes or characteristics determines the dimension of the feature vector and usually depends on the application area and the properties that need to be discriminated. Due to the high dimensionality [17] of the feature vector that represents the spectral and spatial information contained in hyperspectral images, feature selection techniques [10] are usually applied as preprocessing to the data classification. A widely used technique for data compression and dimensionality reduction is the Principal Component Analysis (PCA) [18].

Several classification methods have been proposed in the literature for labeling the image pixels according to specific classes, including Bayesian networks [1], support

vector machines (SVM) [24], neural networks [22], nearest neighbors [4], clustering algorithms [35], decision trees [14], among others.

Most pixelwise classification approaches [36] consider only spectral information of the pixels. Other methods take spatial information present in the image into account [13, 26]. Some strategies for including spatial information in the classification are watershed [34], minimum spanning forests [2], graph cuts [37], shortest paths [23], random walks [15], and Markov random fields [33].

3 Methodology

The main stages of the proposed methodology for improving the hyperspectral image classification based on adaptive filtering are illustrated in Figure 1.

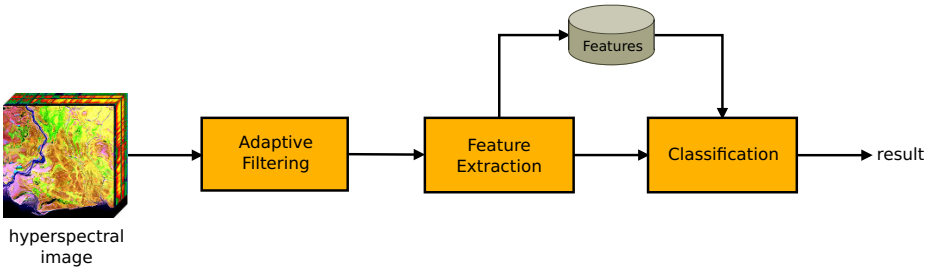


Fig. 1: Main steps of the proposed methodology.

A hyperspectral image can be considered as a three-dimensional volume formed by spatial resolution (two dimensions) and a third dimension represented by several contiguous spectral bands. Therefore, a hyperspectral image pixel is a column vector with same dimensions as the number of spectral bands. For a given vector of hyperspectral pixels $\mathbf{p} = (p_1, ..., p_m)^T$, each component p_k represents a pixel in the band B_k.

The set of n samples labeled as $\{\mathbf{x}_i, y_i\}$, $i = 1, \ldots, n$, where $\mathbf{x}_i \in \Re^m$ represents the m-dimensional feature vector for the i-th pixel with label $y_i \in \Omega$. The value m is the number of bands and Ω is the set of possible labeled classes of the image.

Local filtering techniques can be implemented by spatial convolution with block processing, where the filter replaces the intensity value of each image pixel with a new value that captures a specific local image property around the pixel. Different types of filters can be proposed for extracting spectral-spatial features from the images. For instance, Camps-Valls et al. [5] presented a framework of composite kernel machines for image classification, combining spatial and spectral information.

In our work, the following filters are applied to each spectral channel of the hyperspectral images using:

(a) Mean: filters the image such that each output pixel contains the mean value of an $m \times m$ neighborhood around the corresponding pixel in the input image.

(b) Standard Deviation: filters the image such that each output pixel contains the standard deviation value of an $m \times m$ neighborhood around the corresponding pixel in the input image.
(c) Median: filters the image such that each output pixel contains the median of an $m \times m$ neighborhood around the corresponding pixel in the input image.
(d) Minimum: filters the image such that each output pixel contains the minimum value of an $m \times m$ neighborhood around the corresponding pixel in the input image.
(e) Maximum: filters the image such that each output pixel contains the maximum value of an $m \times m$ neighborhood around the corresponding pixel in the input image.
(f) Range: filters the image such that each output pixel contains the range value (difference between maximum and minimum value) of an $m \times m$ neighborhood around the corresponding pixel in the input image.
(g) Entropy: returns the entropy value of an $m \times m$ neighborhood around the corresponding pixel in the input image.
(h) Gaussian: filters the image with a 2-D Gaussian smoothing kernel with standard deviation σ.
(i) Edge-preserved smoothing: filters the image through an edge-preserving operator based on weighted least squares [11].

For the training set, 20% of the pixels are randomly selected from the ground truth for each class. Such samples are used to train the classifier, which is applied to the remaining 80% of the pixels that form the test set.

It is important to mention that, differently from several works found in the literature, our approach employs all the classes present in the hyperspectral images, without removing certain classes that contain only few samples.

The overall accuracy corresponds to the percentage of samples classified correctly, expressed as

$$A = \frac{\sum_{i=1}^{\Omega} x_{ii}}{\sum_{i,j=1}^{\Omega} x_{ij}} 100\% \tag{1}$$

where element x_{ij} of the confusion matrix corresponds to the number of samples for class i classified as class j.

Cohen's kappa coefficient [9] is defined as

$$\kappa = \frac{n \sum_{i=1}^{\Omega} x_{ii} - \sum_{i=1}^{\Omega} (x_{i+}\, x_{+i})}{n^2 - \sum_{i=1}^{\Omega} (x_{i+}\, x_{+i})} \tag{2}$$

where n is the total number of samples in the matrix, x_{ii} is the number of samples in the row i and in the column i, x_{+i} is the total value for the row i, whereas x_{i+} is the value for the column i.

4 Results

Experiments were conducted on six benchmark datasets [3]. The main characteristics (image dimensions, number of bands, number of classes) of each tested dataset are summarized in Table 1.

Table 1: Summary of the main hyperspectral image characteristics.

Dataset	Rows	Columns	Bands	Classes
Indian Pines	145	145	200	16
Pavia Centre	1096	715	102	9
Pavia University	610	340	103	9
Salinas	512	217	204	16
Salinas-A	83	86	204	6
Kennedy Space Center	512	614	176	13

The experiments conducted on all datasets employed 20% of the image pixels as training samples, whereas the remaining pixels were used as test samples. Two different classifiers were used to evaluate the performance of the classification process, K-Nearest Neighbor (KNN) and Support Vector Machines (SVM). We used a cross-validation step to search for the optimal parameters. The background is only used to identify samples that are not labeled, that is, it is not considered in the classification process.

Each local filtering technique was applied to all datasets. The filters are denoted as mean (MEA), standard deviation (STD), median (MED), minimum (MIN), maximum (MAX), range (RNG), entropy (ENT), Gaussian (GAU), edge-preserving (EDP). The filter denoted as ESP returns the spectral pixel values directly, that is, without calculating any statistic around the pixel. A 9×9 neighborhood was used in all filters. The value of σ was 3 for the Gaussian filter.

Tables 2 and 3 show the results for accuracy and kappa measures, respectively, for each dataset. Due to space limitations, only results for SVM classifier are shown, which achieved better performance than K-NN. From these tables, it is possible to observe that the local filtering techniques are effective to improve the classification when compared to only using spectral information of the images. In particular, filters based on entropy and Gaussian smoothing produced high accuracy rates.

Figures 2 and 3 show a visual comparison of the best classification results produced by SVM. The images depict only the classes, that is, the respective background is removed and shown in black.

Table 4 shows a comparison of the classification results for the Indian Pines dataset, which is considered as a benchmark for testing supervised classification algorithms. Despite their simplicity, the local filtering techniques are able to achieve very competitive accuracy rates compared to other approaches available in the literature.

Table 2: Results of overall accuracy (in percentage) for each dataset through SVM classifier.

Dataset	Filter									
	ESP	MEA	STD	MED	MIN	MAX	RNG	ENT	GAU	EDP
Indian Pines	56.92	96.35	94.59	92.94	76.27	93.07	91.95	97.41	98.81	95.59
Pavia Centre	58.78	95.92	93.12	92.34	77.12	92.01	90.65	95.26	96.22	94.23
Pavia University	60.11	97.23	93.93	93.26	82.92	94.82	92.11	98.12	98.97	96.72
Salinas	68.23	87.21	88.96	89.02	82.11	91.56	89.13	93.87	95.23	89.63
Salinas-A	70.15	89.33	90.80	90.94	83.09	93.10	90.01	95.60	96.60	90.15
Kennedy Space Center	66.39	86.33	86.22	87.23	81.03	89.53	87.64	91.66	93.56	86.34

Table 3: Results of kappa coefficient for each dataset through SVM classifier.

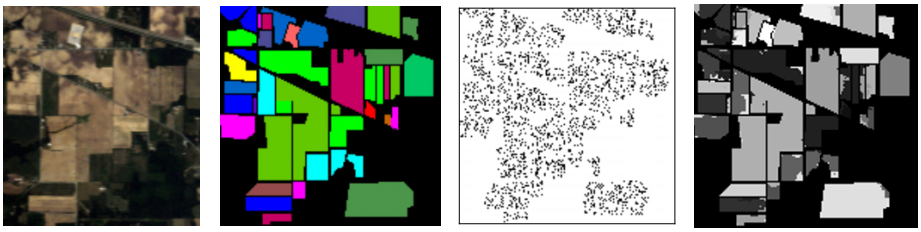
Dataset	Filter									
	ESP	MEA	STD	MED	MIN	MAX	RNG	ENT	GAU	EDP
Indian Pines	0.503	0.958	0.938	0.919	0.728	0.921	0.908	0.970	0.986	0.949
Pavia Centre	0.573	0.943	0.918	0.912	0.768	0.911	0.893	0.943	0.953	0.932
Pavia University	0.592	0.962	0.924	0.923	0.809	0.933	0.912	0.973	0.979	0.953
Salinas	0.674	0.864	0.873	0.883	0.813	0.905	0.886	0.923	0.945	0.882
Salinas-A	0.626	0.866	0.884	0.886	0.786	0.913	0.875	0.944	0.957	0.897
Kennedy Space Center	0.654	0.853	0.848	0.863	0.797	0.874	0.853	0.901	0.923	0.853

Table 4: Comparison of the results (overall accuracy) for different classification methods applied to Indian Pines dataset.

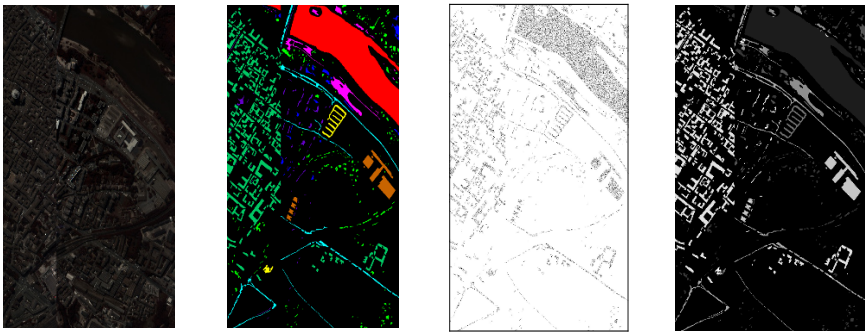
Classification Method	Accuracy (%)
ECHO [19]	82.64
SVM [8]	84.52
WH+MV [29]	86.63
CaHO-SAM [31]	88.87
CaHO-MSE [31]	89.15
SVM-PLR [20]	89.34
SVM-FSR [32]	91.10
SP-S [8]	91.16
SVMMSF+MV [28]	91.80
SVM-MRF [30]	92.95
SVM-CK [5]	94.53
SVM-CK [25]	94.86
SOMP [25]	95.34
LSGM [25]	96.07

5 Conclusions

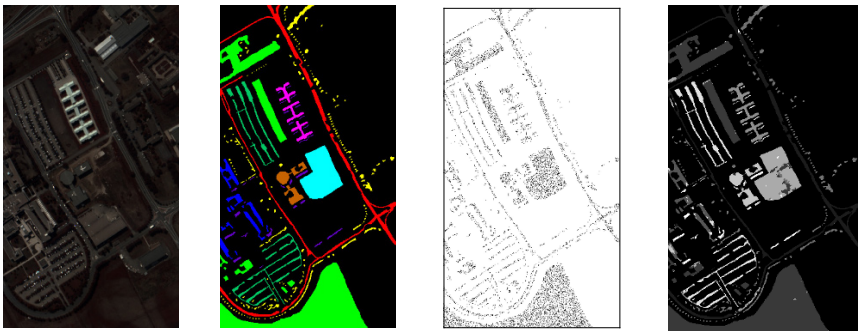
This work proposed and evaluated the use of different local filters for improving the classification process of hyperspectral images. Each filter was applied to a set of hyperspectral images and each pixel was classified to determine its class.



(a) Indian Pines



(b) Pavia Centre

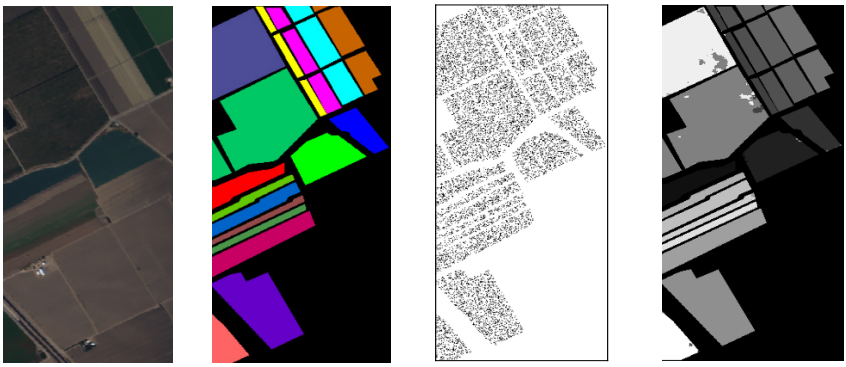


(c) Pavia University

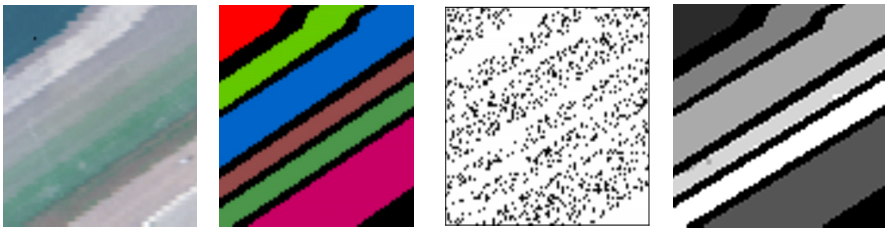
Fig. 2: Visual comparison of the classification results. (i) first column: original hyperspectral image; (ii) second column: ground truth; (iii) third column: test mask; (iv) fourth column: classification.

Experiments demonstrated that the adaptive filters were capable of enhancing the classification when compared to the direct use of spectral information present in the images.

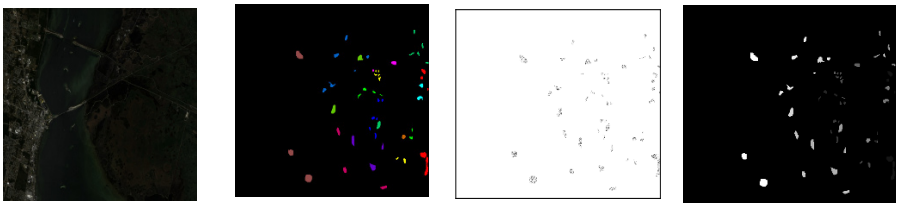
As directions for future work, we intend to evaluate other region filtering techniques, as well as combine the most representative features in order to obtain a more robust classifier.



(a) Salinas



(b) Salinas-A



(c) Kennedy Space Center

Fig. 3: Visual comparison of the classification results. (i) first column: original hyperspectral image; (ii) second column: ground truth; (iii) third columns: test mask; (iv) fourth column: classification.

Acknowledgements

The authors are grateful to FAPESP, CNPq and CAPES for their financial support.

References

1. Bali, N., Mohammad-Djafari, A.: Bayesian Approach with Hidden Markov Modeling and Mean Field Approximation for Hyperspectral Data Analysis. IEEE Transactions on Image Processing 17(2), 217–225 (Feb 2008)

2. Bernard, K., Tarabalka, Y., Angulo, J., Chanussot, J., Benediktsson, J.: Spectral-Spatial Classification of Hyperspectral Data Based on a Stochastic Minimum Spanning Forest Approach. IEEE Transactions on Image Processing 21(4), 2008–2021 (Apr 2012)
3. Biehl, L.L.: Hyperspectral Images (2014), https://engineering.purdue.edu/~biehl/MultiSpec/hyperspectral.html
4. Blanzieri, E., Melgani, F.: Nearest Neighbor Classification of Remote Sensing Images with the Maximal Margin Principle. IEEE Transactions on Geoscience and Remote Sensing 46(6), 1804–1811 (2008)
5. Camps-Valls, G., Gomez-Chova, L., Muñoz-Marí, J., Vila-Francés, J., Calpe-Maravilla, J.: Composite Kernels for Hyperspectral Image Classification. Geoscience and Remote Sensing Letters, IEEE 3(1), 93–97 (2006)
6. Chang, C.I.: Hyperspectral Imaging: Techniques for Spectral Detection and Classification, vol. 1. Springer Science & Business Media (2003)
7. Chang, C.I.: Hyperspectral Data Processing: Algorithm Design and Analysis. John Wiley & Sons, Inc., Hoboken, NJ, first edition edn. (2013)
8. Chen, Y., Nasrabadi, N.M., Tran, T.D.: Hyperspectral image classification using dictionary-based sparse representation. IEEE Transactions on Geoscience and Remote Sensing 49(10), 3973–3985 (2011)
9. Cohen, J.: A Coefficient of Agreement for Nominal Scales. Educational and Psychological Measurement 20(1), 37–46 (1960)
10. Deng, S., Xu, Y., Li, L., Li, X., He, Y.: A Feature-Selection Algorithm based on Support Vector Machine-Multiclass for Hyperspectral Visible Spectral Analysis. Journal of Food Engineering 119(1), 159–166 (2013)
11. Farbman, Z., Fattal, R., Lischinski, D., Szeliski, R.: Edge-Preserving Decompositions for Multi-Scale Tone and Detail Manipulation. In: ACM Transactions on Graphics. vol. 27, p. 67. ACM (2008)
12. Fauvel, M., Chanussot, J., Benediktsson, J.A., Sveinsson, J.R.: Spectral and Spatial Classification of Hyperspectral Data using SVMs and Morphological Profiles. IEEE Transactions on Geoscience and Remote Sensing 46(10), 3804–3814 (Oct 2008)
13. Fauvel, M., Tarabalka, Y., Benediktsson, J.A., Chanussot, J., Tilton, J.C.: Advances in Spectral-Spatial Classification of Hyperspectral Images. Proceedings of the IEEE 101(3), 652–675 (2013)
14. Goel, P.K., Prasher, S.O., Patel, R., Landry, J., Bonnell, R., Viau, A.: Classification of Hyperspectral Data by Decision Trees and Artificial Neural Networks to Identify Weed Stress and Nitrogen Status of Corn. Computers and Electronics in Agriculture 39, 67–93 (2003)
15. Grady, L.: Random Walks for Image Segmentation. IEEE Transactions on Pattern Analysis and Machine Intelligence 28(11), 1768–1783 (Nov 2006)
16. Grahn, H., Geladi, P.: Techniques and Applications of Hyperspectral Image Analysis. John Wiley & Sons (2007)
17. Harsanyi, J., Chang, C.I.: Hyperspectral Image Classification and Dimensionality Reduction: An Orthogonal Subspace Projection Approach. IEEE Transactions on Geoscience and Remote Sensing 32(4), 779–785 (Jul 1994)
18. Jolliffe, I.: Principal Component Analysis. Springer-Verlag, New York, NY, second edition edn. (2002)
19. Kettig, R.L., Landgrebe, D.: Classification of Multispectral Image Data by Extraction and Classification of Homogeneous Objects. IEEE Transactions on Geoscience Electronics 14(1), 19–26 (1976)
20. Khodadadzadeh, M., Ghassemian, H.: Contextual Classification of Hyperspectral Remote Sensing Images Using SVM-PLR. Australian Journal of Basic and Applied Sciences 5(8), 374–382 (2011)

21. Lu, G., Fei, B.: Medical Hyperspectral Imaging: A Review. Journal of Biomedical Optics 19(1), 010901 (2014)
22. Merényi, E., Farrand, W.H., Taranik, J.V., Minor, T.B.: Classification of Hyperspectral Imagery with Neural Networks: Comparison to Conventional Tools. EURASIP Journal on Advances in Signal Processing 2014(1), 1–19 (2014)
23. de Mesquita Sá Junior, J.J., Backes, A.R., Cortez, P.C.: Texture Analysis and Classification using Shortest Paths in Graphs. Pattern Recognition Letters 34(11), 1314–1319 (2013)
24. Mountrakis, G., Im, J., Ogole, C.: Support Vector Machines in Remote Sensing: A Review. ISPRS Journal of Photogrammetry and Remote Sensing 66(3), 247–259 (2011)
25. Srinivas, U., Chen, Y., Monga, V., Nasrabadi, N.M., Tran, T.D.: Exploiting Sparsity in Hyperspectral Image Classification via Graphical Models. Geoscience and Remote Sensing Letters, IEEE 10(3), 505–509 (2013)
26. Takayama, T., Iwasaki, A., Kashimura, O.: Optimal Segmentation of Classification and Prediction Maps for Monitoring Forest Condition with Spectral and Spatial Information from Hyperspectral Data. In: IEEE International Geoscience and Remote Sensing Symposium. pp. 3498–3501 (2014)
27. Tarabalka, Y., Benediktsson, J., Chanussot, J.: Spectral-Spatial Classification of Hyperspectral Imagery based on Partitional Clustering Techniques. IEEE Transactions on Geoscience and Remote Sensing 47(8), 2973–2987 (Aug 2009)
28. Tarabalka, Y., Chanussot, J., Benediktsson, J.A.: Segmentation and Classification of Hyperspectral Images using Minimum Spanning Forest Grown from Automatically Selected Markers. IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics 40(5), 1267–1279 (2010)
29. Tarabalka, Y., Chanussot, J., Benediktsson, J.A., Angulo, J., Fauvel, M.: Segmentation and Classification of Hyperspectral Data using Watershed. In: IEEE International Geoscience and Remote Sensing Symposium. vol. 3, pp. III–652. IEEE (2008)
30. Tarabalka, Y., Fauvel, M., Chanussot, J., Benediktsson, J.A.: SVM-and MRF-based Method for Accurate Classification of Hyperspectral Images. Geoscience and Remote Sensing Letters, IEEE 7(4), 736–740 (2010)
31. Tarabalka, Y., Tilton, J.C.: Spectral-Spatial Classification of Hyperspectral Images using Hierarchical Optimization. In: 3rd Workshop on Hyperspectral Image and Signal Processing: Evolution in Remote Sensing. pp. 1–4. IEEE (2011)
32. Villa, A., Chanussot, J., Benediktsson, J.A., Jutten, C.: Spectral Unmixing for the Classification of Hyperspectral Images at a Finer Spatial Resolution. IEEE Journal of Selected Topics in Signal Processing 5(3), 521–533 (2011)
33. Xu, Y., Wu, Z., Wei, Z.: Markov Random Field with Homogeneous Areas Priors for Hyperspectral Image Classification. In: IEEE International Geoscience and Remote Sensing Symposium. pp. 3426–3429 (Jul 2014)
34. Yang, Y., Cao, G.: Combining Watersheds and Conditional Random Fields for Image Classification. In: 10th International Conference on Fuzzy Systems and Knowledge Discovery. pp. 805–810 (2013)
35. Zhang, B., Li, S., Wu, C., Gao, L., Zhang, W., Peng, M.: A Neighbourhood-Constrained k-means Approach to Classify Very High Spatial Resolution Hyperspectral Imagery. Remote Sensing Letters 4(2), 161–170 (2013)
36. Zhang, L., Zhang, L., Tao, D., Huang, X.: On Combining Multiple Features for Hyperspectral Remote Sensing Image Classification. IEEE Transactions on Geoscience and Remote Sensing 50(3), 879–893 (Mar 2012)
37. Zhou, H., Zheng, J., Wei, L.: Texture Aware Image Segmentation using Graph Cuts and Active Contours. Pattern Recognition 46(6), 1719–1733 (Jun 2013)

Part VI
Computer Networks, Mobility and Pervasive Systems

Managing Enterprise Network Resilience through the Mimicking of Bio-Organisms

Sami Habib and Paulvanna N. Marimuthu
Computer Engineering Department
Kuwait University
P. O. Box 5969 Safat 13060 Kuwait
sami.habib@ku.edu.kw

Abstract. The success of an enterprise network (EN), serving business applications, relays on its sustainability against the dynamic business environment. The enterprise network sustainability can be achieved through its resilience to disorders, such as the failures and operational overload. We view EN resilience as its ability to endure and manage the uncertain workload, as the evolution of business applications flooding EN with unprecedented volume of data. In this paper, we have proposed an integrated framework to improvise the ability of EN to manage against varying workloads through the mimicking of resilient behavior of bio-organisms against the environmental changes. We have formulated the resilience management problem as an optimization problem with an objective function to maximize EN resilience, where the proposed framework unifies the existing EN clusters into one; and redesigns EN infrastructure within ant colony optimization (ACO). The simulation results have showed that the resilience improved by 20%.

Keywords: Ant Colony Optimization, Capacity Planning, Clustering, Enterprise Network, Redesign, Resilience.

1 Introduction

The living organism is viewed as an "open system," which has the capability to evolve and to adapt continuously through the changing environmental conditions. The ability to accommodate changes, without modifying the structure is the resilience according to Folke et al., [1]; and the living organisms are resilience by nature. The resilience can be described by three characteristics according to Carpenter et al. [2]: i) the amount of disruption a system can absorb without changing its present state, ii) the degree to which it can self-organize, and iii) the ability to evolve towards adaptation. Living organisms, like ants, have the ability to handle obstacles and difficulties such as rebuilding their colonies under a sudden rain attack [3].

Enterprise networks are often subject to uncertain workload (an extra traffic was not considered in the initial design stage) and component failures, leveraging to abnormal behavior with inconsequence outcomes. Further, dynamic business environment and social networks have increased the volume of traffic, by increasing the number of users. The excess workload leads to over-exploitation of available EN resources, thereby decreases the quality-of-service. In general, the enterprise network associated with external business communications has three states based on its capacity utilization:

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_85

i) normal with acceptable quality-of-service (QoS), ii) under-utilized, and iii) over-utilized. In the latter state, QoS is low in over-utilized EN, whereas under-utilized EN leads to wastage of resources. Thus, EN is forced to employ some strategies to recover and adapt from disruptions for ensuring acceptable QoS to its customers. One of the strategy is that the enterprise network may be embedded with resilience characteristics in order to cope up with the uncertainty in workload, which may be achieved through by evolving EN infrastructure throughout incremental changes, without adding or deleting the resources.

In this paper, we have defined and formulated the resilience management problem as an optimization problem, whereby the existing EN clusters are redesigned to generate an alternative infrastructure to resist the changes in workload and to sustain its normal operations with the available resources. We have proposed an integrated framework to evolve the existing EN infrastructure with greater resilience through redesign. The redesign process is embedded with a hybrid algorithm, combining ant colony optimization (ACO) and a local search to aid in the evolution of EN infrastructure with near optimum resilience. The redesign process unifies all nodes into one cluster and determines the best possible partition for the nodes to increase EN resilience. The redesign process evolves EN continuously until the point at which the resilience started decreasing on further clustering; this is due to the increase in number of clusters, which increases the inter-cluster traffic through the backbone and overloading the backbone. The simulation results of the proposed framework on an enterprise with 100 clients demonstrated that the resilience capacity of EN is increased by 20% by cluster-redesign within ACO with acceptable QoS.

The rest of the paper is organized into five sections, where Section 2 details the related work. Section 3 describes the mathematical model in formulating EN resilience, and Section 4 details the proposed framework for resilience management. Section 5 discusses about the outcomes of the experiments, and Section 6 concludes the paper.

2. Related Work

Researchers analyzed the importance of resilience and its challenges under various networking environments. The resilience and the behavior of large scale systems are discussed by Gunderson and Pritchard [4], where they analyzed resilience of large system to understand its behavior near known stable state. The challenges of designing a resilient and sustainable systems under economic and environmental threats were presented by Fiksel [5]. The author discussed about the challenges behind increased complexity towards achieving sustainability and also, he elaborated the importance of resilience in bringing adaptability for sustaining operations. Moreover, Immers et al., [6] studied the possibility of utilizing resilience as a factor to achieve robustness in platforms other than EN, such as the transportation networks.

Konak and Bartolacci utilized a hybrid Genetic Algorithm based approach to include resilience as a factor in network design [7], where the network traffic efficiency and nodal failures are measured to compute network resilience. Menth et al. [8] presented the resilient analysis of communication networks, where, the authors claimed that the proposed framework was able to detect the weak points in the network to protect from link failures and congestion. A survey of existing resilience measurement

techniques were presented by Erol et al. [9], where the authors proposed three metrics: recovery time, level of recovery and level of vulnerability to potential disruptions.

Zhao et al. [10] studied the resilience of a supply network under random and known disruptions. The authors presented a degree and locality based attachment model to generate a new topology to sustain under disruptions. Wodczak [11] presented the service resilience of autonomous and cooperative communications under cloud computing environment. A fuzzy architecture for assessing the resilience of critical infrastructure is proposed by Muller et al. [12], where redundancy and adaptability were considered to be the primary components of infrastructure resilience. Schaeffer-Filho et al. [13] proposed a framework for management of network resilience in offline and also during a runtime. The authors defined reusable patterns of mechanisms for resilience management. Lopes et al. [14] presented an integrated management approach, employing automatic node's configuration replication and redeployment framework, to improvise service resilience in computer network. Ali et al. [15] discussed a proposal in combination of policy-based management and fuzzy based self-evolving technique to provide adaptive resilience in computer networks. Hilten et al. [16] demonstrated how the use of systems thinking principles and thinking method contributed to the development of resilience, where they have utilized the behavior of human body towards the achievement of resilience. In addition, resilience is utilized to achieve robustness in storage clouds [17], and electric distribution system [18].

In our earlier work [19], we have proposed a bio-inspired scheme to provide sustainable operations under varying traffic load, where an iterative search algorithms, such as Tabu search and Simulated Annealing were employed to evolve the network to sustain its operations. In this paper, we have proposed an integrated framework, embedded with ACO and a local search algorithm to enhance the resilience of existing enterprise network under uncertain clients' demands.

3. Problem Formulation

We have considered an enterprise network, $\Omega = \{g_1, g_2, g_3, ..., g_k\}$, as k clusters, where each cluster g_i in Ω comprises of subset of nodes. Thus, two constraints should be validated when EN's clusters were formed, such as constraints 1 and 2 respectively. Constraint (1) confirms that the union of nodes present in all the clusters at any time is equal to V, which is the set of all nodes in EN. Constraint (2) is added to ensure that no node is presented in more than one cluster.

$$g_1 \cup g_2 \cup g_3 \cup g_4 \cdots \cup g_k = V \tag{1}$$

$$g_1 \cap g_2 \cap g_3 \cap g_4 \cdots \cap g_k = 0 \tag{2}$$

We have defined a number of attributes for each g_i, such as

i) A cluster center (v_i^c), a node in g_i should be selected as cluster center for the cluster g_i, as defined in constraint (3)

$$v_i^c \in g_i \tag{3}$$

ii) the selected cluster center (v_i^c) should have both the incoming and outgoing links ***(e_{out}, e_{in})***, as illustrated in constraint (4)

$$\forall v_i^c \in g_i, v_i^c(e_{in}, e_{out}) = true \tag{4}$$

iii) the number of nodes in any g_i should be bounded as in constraint (5).

$$2 \le |g_i| \le \frac{|V|}{2} \tag{5}$$

We are dealing with a two-level EN, where the first-level represents the local area network within each cluster g_i ; and the second-level represents the backbone, where all the inter-communications among the clusters should go through the backbone. The goal is to determine the value of k (number of clusters) and the contents of each cluster with a maximum resilience, for a given EN. We have defined and formulated the resilience management problem as an optimization problem with the objective function is to maximize the resilience of EN as illustrated in Equation (6); where the maximum capacity of the backbone network with acceptable QoS (quality-of-service) is taken as C_{max}. The term $\sum_j C_{req}$ represents the total capacity needed by the EN at a time instance to manage the traffic demand at the backbone, generated from the existing j clusters. The 'min' term in Equation (6) is to force our algorithm to cluster the nodes in a way to minimize the $\sum_j C_{req}$ at the backbone. The number of clusters are bounded between 2 to k.

$$\max R = \min \left| \frac{C_{\max} - \sum_j C_{req}}{C_{\max}} \right|, \text{ where } 2 \le j \le k \tag{6}$$

4. Proposed Bio-Inspired Framework

The proposed integrated framework is illustrated in Figure 1; and it's operation comprises of three folds: i) evolve EN infrastructure with incremented clusters ii) generate a pool of alternate EN infrastructures at each point of evolution utilizing ant colony optimization (ACO), and iii) apply local search algorithm to select the best alternative infrastructure having higher resilience from the generated solutions.

The existing EN is a clustered network, where the inter-cluster communications are through the backbone. The over-utilization of resources in EN at any point of time initiates the redesign operations. The framework unifies all nodes distributed within the clusters to form a single cluster and the evolution of enterprise network is started with two clusters. Then, the number of clusters are incremented and the enterprise network resilience is measured at each time. The cluster evolution continues until the resilience

of EN started decreasing on further clustering, where the inter-cluster resource utilizations are greater than the intra-cluster resource utilizations. The framework utilizes ACO to generate a better combination of nodes to form clusters with an increased resilience. The local search algorithm embedded on top of ACO chooses the best infrastructure with an optimum resilience. The proposed framework should be embedded within EN; and it is part of the EN protocol to terminate the framework.

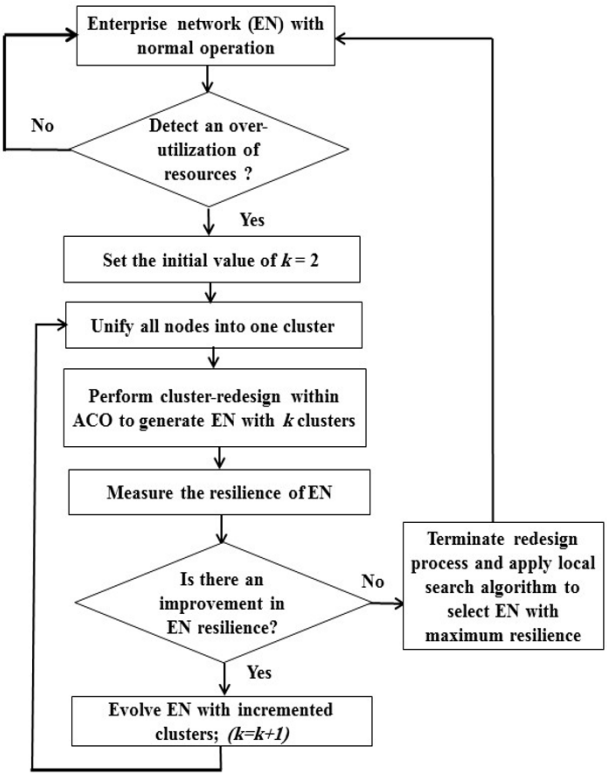


Fig. 1. A generic view of proposed framework to be embedded within a network administration protocol.

4.1 Redesign Process Utilizing Ant Colony Optimization

ACO is a meta-heuristic, population based construction algorithm, which builds the solutions based on the behavior of ants searching for the food source. ACO is illustrated in Figure 2, where the ants communicate according to the density of pheromones deposited during the movement of ant from the nest to the food source [20] and the pheromone is a chemical substance. At the beginning of the food searching process, the ants started moving randomly. Once a food source is discovered, ants returned back to the nest in various paths; and the returned ants deposit pheromones on their path. After a

period of time, the shortest path will be traversed by more ants and the increased deposition of pheromones will attract more ants to the popular path, which is the shortest path to the food source.

```
1 Ant Colony Optimization ( )
2    begin
3     search for food source randomly;
4     if food source discovers, then return to nest;
5     select return path randomly;
6     lay pheromone and create a trial;
7     while (pheromone found with increased proba
       bility)
8     follow the pheromone trail;
9    end
```

Fig. 2. Ant colony optimization (ACO) according to [20].

During the evolution of EN clusters, ACO plays a vital role in generating a near optimal solution through redesign, where the randomly selected the set of cluster-center nodes $\bar{k} = \{v_1^c, v_2^c, v_3^c, ..., v_k^c\}$ to integrate the remaining nodes to form k clusters. Thus, the inter-cluster traffic routed through the backbone reduces; and the capacity of the backbone network to handle the incoming demand increases, i.e. the resilience of EN increases. The random selection of cluster centers within ACO, generates a pool of alternate infrastructures with varying resilience.

In ACO, we select $|\bar{k}|$ nodes as cluster-centers, as the food sources for generating clusters. Then, the remaining nodes $V - \bar{k}$ will act as ants seeking to reach the food source (cluster-center). We have defined a link in ACO as the direct connection between two ants; and the path is defined as a group of links connecting an ant to a food source. Constraints are added to ensure that the nodes are sorted according to their outgoing degree (deg) in ascending order, before applying ACO to avoid multiple selections of a single link. The pheromone of each link $(\tau_{i,j})$ is updated locally using Equation (7) whenever an ant traverses the link. The pheromone values of the best path selected is globally updated by additionally incrementing the pheromones using same Equation (7). The best path describes the completely connected path between the node (ant) to the selected cluster-center (food source).

$$\tau_{i,j} = \tau_{i,j} + 0.5 \tag{7}$$

The ant explores the whole network and it tries to associate the selected node to a better food source using the probability rule defined in Equation (8), where $P_{i,j}$ is the probability of selecting node j as a next connecting node for the client i during path construction. The parameters α and β represent the relative importance of pheromone and heuristic value respectively. The parameters $\tau_{i,j}$ and $\eta_{i,j}$ correspond to the pheromone value and the heuristic value in the link *(i, j)*. Hereby, the outgoing traffic link with higher traffic volumes is used as the heuristic information.

$$P_{i,j} = \frac{(\tau_{i,j})^{\alpha} * (\eta_{i,j})^{\beta}}{\sum_{\substack{k \in N \\ except\ i\ and\ j}} (\tau_{i,k})^{\alpha} * (\eta_{i,k})^{\beta}} \quad (8)$$

The probability rule is applied for each neighboring node and the link showing maximum traffic to the cluster center is added to the path. The node distribution within the generated clusters is balanced by limiting the number of nodes within a cluster to certain threshold, which may further avoids overcrowding of clients within few clusters.

5. Results and Discussion

We have considered an EN comprising of 100 clients, and it is capable of handling a heavy backbone traffic of around 7.6 TB during the peak hours, with acceptable quality-of-service. We have coded the resilient management framework with evolving EN clusters using Java platform. We have conducted two sets of experiments on the existing EN: i) cluster-redesign by random, and ii) cluster-redesign within ACO. The first set of experiments generate the specified clusters, by associating the nearby nodes randomly to the selected cluster-centers. The cluster-centers are selected at random. The second set of experiments are performed within ACO.

We have carried out a number of experiments within ACO and at random, to generate various partition of the unified EN. We have terminated the redesign process after generating EN with nine clusters since the value of resilience R started to decrease. The experimental results showing the evolution of clusters from two to nine are plotted in Figure 3. It is observed that during the initial stages of partitioning, the increase in number of clusters, increased the intra-cluster traffic, and thereby decreased the inter-cluster traffic at the backbone. Thus, the resource utilization at the backbone got reduced, which increased EN resilience. For each number of generated clusters, the cluster-redesign within ACO is repeated with randomly varying cluster-centers. Thus, EN with varying infrastructures and varying resilience are generated. The local search algorithm selects a best alternative infrastructure from the pool of redesigned infrastructures.

The bar-graph illustrates in Figure 4 showing the increased capacity of EN on comparison, after redesign process. Here, the increased local traffic within the clusters, increases the capacity of EN at the backbone to handle additional traffic, with acceptable QoS. The local search algorithm considers the point at which the cluster-redesign operation shows a maximum resilience developed at the backbone as illustrated in Figure 3, and the resilience starts decreasing on further clustering.

The simulation results shows that under a similar workload environment, the redesigned EN clusters utilizing ACO enhanced EN resilience, thus, increased its capacity to handle additional traffic demand at backbone. We have observed a maximum of 20% increased in the resilience, when the unified clusters are patitioned into four.

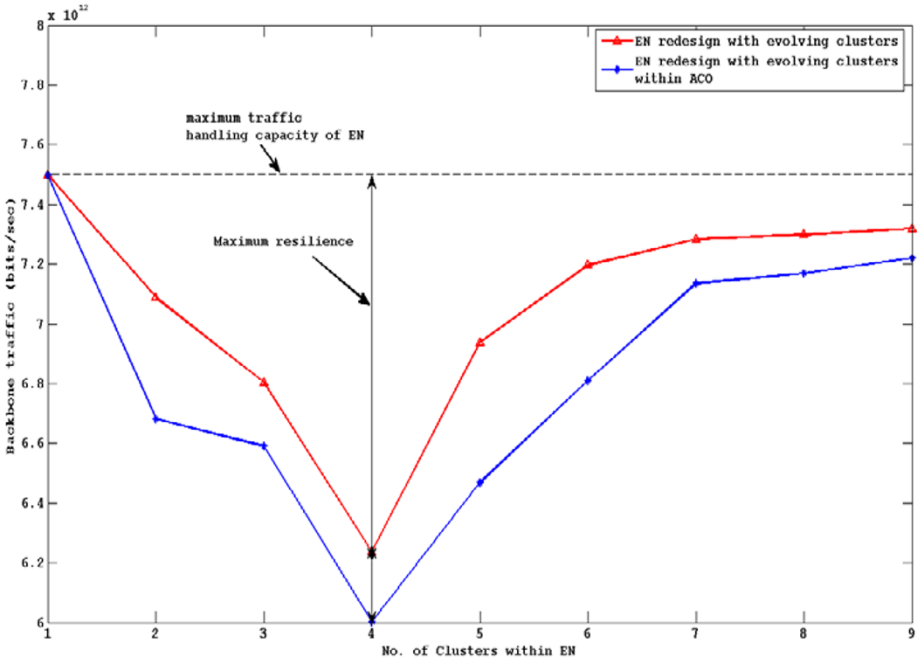


Fig. 3. Traffic demand at the backbone before and after redesign.

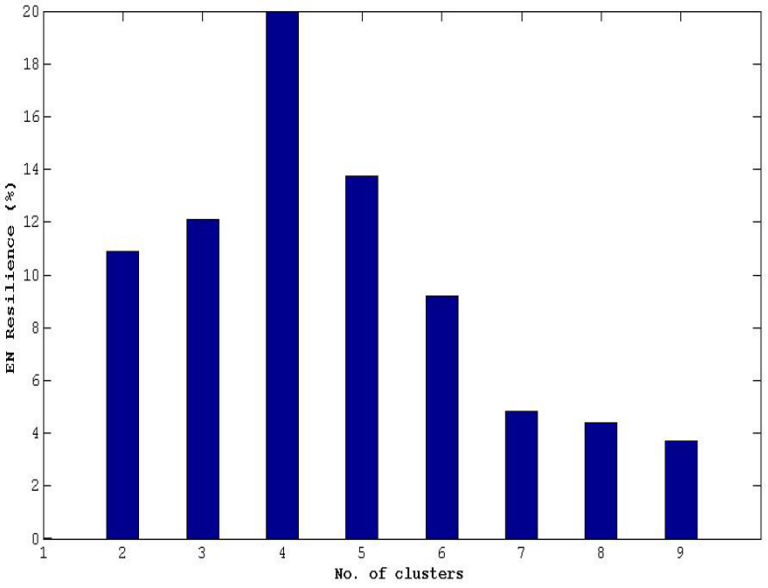


Fig 4. EN resilience with varying cluster-redesign.

6. Conclusion

We have proposed an integrated framework to enhance the resilience of existing enterprise network (EN) through a cluster-redesign within an ant colony optimization (ACO). We have defined resilience as the ability of EN to manage additional traffic within its maximum capacity by redesigning its infrastructure. We have formulated the resilience management problem as an optimization problem, whereby the main objective function is to find the number of clusters and the nodes associated with the clusters, leads to EN with higher resilience. The embedded hybrid algorithm, comprising of ant colony optimization (ACO) and a local search aids in the selection of best alternate infrastructure with near optimum resilience. Hereby, ACO tried to link the nodes sharing heavy traffic volumes with the selected cluster centers, during redesign operations. The evolution of enterprise infrastructure is continued with increased resilience until a saturation point is reached, where the resilience reaches its maximum and on further cluster divisioning, EN resilience started to decrease. The simulation of an enterprise with 100 clients demonstrated the ability of the proposed framework in managing the increased workload by increasing the resilience of EN by 20%.

Acknowledgment

This work was supported by Kuwait University under a research grant no. EO 02/11.

References

1. Folke, C., S. Carpenter, T. Elmqvist, L. Gunderson, C., Holling C.S., and Walker, B.: Resilience and Sustainable Development: Building Adaptive Capacity in a World of Transformations. Ambio: A Journal of Human Environment, vol. 31, pp. 437-440, 2002.
2. Carpenter, S.R., B.H. Walker, J.M. Anderies and N. Abel. From Metaphor to Measurement: Resilience of What to What?, Ecosystems, vol. 4, pp.765–781, 2001.
3. Backen, S.J., Sendova-Franks, A.B., and Franks, N.R.: Testing the Limits of Social Resilience in Ant Colonies. Journal of Behavioral Ecology and Sociobiology, Springer-Verlag, vol. 48, no. 2, pp. 125-131, (2000).
4. Gunderson, L., and Pritchard, L.: Resilience and The Behavior of Large Scale Systems. Island Press, Washington, D.C, USA, 2002.
5. Fiksel, J.: Designing Resilient Sustainable System. Environmental Science and Technology, vol. 37, pp. 5330-5339, 2003.
6. Immers, L., Stada, J., Yperman, I., and Bleuk, A.: Robustness and Resilience of Transportation Networks. In the Proceedings of 9th International Scientific Conference MOBILITA, Bratislava, Slovania, 6-7, May 2004.
7. Konak, A., and Bartolacci, M.R.: Designing Survivable Resilient Networks: A Stochastic Hybrid Genetic Algorithm Approach, Omega, vol. 35, Issue 6, pp. 645-658, 2007.
8. Menth, M., Duelli, M., Martin, R., and Milbrandt, J.: Resilience Analysis of Packet Switched Communication Networks. IEEE/ACM Transactions on Networking, vol. 17, no. 6, pp. 1950-1963, 2009.
9. Erol, O., Henry, D., Sauser, B., and Mansouri, M.: Perspectives on Measuring Enterprise Resilience. In the Proceedings of IEEE Conference on Systems Conference, San Diego, CA, USA, 5-8 April, 2010.

10. Zhao, K., Kumar, A., Harrison, T.P., and Yen, J.: Analysing the Resilience of Complex Supply Network Topologies against Random and Targeted Disruptions. IEEE Systems Journal, vol. 5, no.1, pp. 28-39, 2011.
11. Wodczak, M.. Resilience Aspects of Autonomic Cooperative Communications in Context of Cloud Networking. In the Proceedings of First International Symposium on Network Cloud Computing and Applications, Toulouse, France, 21-23 November, 2011.
12. Muller G. Fuzzy Architecture Assessment for Critical Infrastructure Resilience. Procedia Comput Science, vol.12, pp. 367–72, 2012.
13. Schaeffer-Filho, A., Smith, P., Mauthe, A., Hutchison, D., Yu, Y., and Fry, M.: A Framework for the Design and Evaluation of Network Resilience Management. In the Proceedings of the 13th IEEE/IFIP Network Operations and Management Symposium. Maui, Hawaii, USA, April 2012, pp. 401–408.
14. Lopes, M., Costa, A., and Dias, B.: Improving Network Services Resilience through Automatic Service Node Configuration Generation. In the Proceedings of the 13th IEEE/IFIP Network Operations and Management Symposium, Maui, Hawaii, USA, 16-20 April, 2012.
15. Ali, A., Hutchison, D., Angelov, P., and Smith, P.: Adaptive Resilience for Computer Networks: Using Online Fuzzy Learning. In the Proceedings of Ultra Modern Telecommunications and Control Systems and Workshops, St. Petersburg, Russia, 3-5 October, (2012).
16. Hilton, J., Wright, C., and Kiparoglou, V.: Building Resilience into Systems, In the Proceedings of IEEE Conference on Systems Conference, Vancouver, BC, Canada, 19-22 March 2012, pp.1-8.
17. Jaiswal, V., Sen, A., and Verma, A.: Integrated Resiliency Planning in Storage Clouds. IEEE Transactions on Network and Service Management, vol. 11, no. 1, 2014.
18. Enose, N.: Implementing an Integrated Security Management Framework to Ensure a Secure Smart Grid. In the Proceedings of Intenational Conference on Advances in Computing, Communications and Informatics, Delhi, India, 24-27 Sept. 2014, pp.778-784.
19. Habib, S.J., Marimuthu, P.N., and Hussain, T.S.: Enterprise Network Sustainability through Bio-inspired Scheme. In the Proceedings of 9th International Conference on Bio-inspired Computing: Theories and Applications, Wuhan, China, 16-19 October, 2014.
20. Dorigo, M., Maniezzo, V., and Colorni, A.: Ant System: Optimization by A Colony of Cooperating Agents, IEEE Transactions on Systems, Man, and Cybernetics, Part B: Cybernetics, vol. 26, no. 1, pp. 29 -41, 1996.

Simulation and Test of Communication in Multi-Robot Systems using Co-Simulation

Alisson Brito[1], Thiago Oliveira[1].

[1] Federal University of Paraiba – Center of Informatics , João Pessoa, Paraíba - Brazil
thiago.oliveira@dce.ufpb.br, alissonbrito@ci.ufpb.br

Abstract. Multi-Robot System consisting of multiple interacting robots, each running a specific control strategy. Its development process involves important design decisions, communication between teams, software, sensors and other aspects. All this, when together, should be very well modeled and simulated. Make tools, methodologies and teams can work together is not an easy task to accomplish. Academic and industrial communities have developed standards and tools for this purpose. High Level Architecture was developed to provide a simpler way to connect different simulators in Department of Defense of United States, allowing several simulators and real applications can be simulated together. In this work, we present a project for simulation in MRSs using ROS, co-simulation and network simulation. The goal of this work is make simulations in ROS more realistic, where the data exchange will be performed by using a network simulator, as if we were simulating real robots exchanging data through a network.

Keywords: We would like to encourage you to list your keywords in this section.

1 Introduction

Multi-robot systems (MRS) consist of multiple interacting robots, each executing an application-specific control strategy, which is not centrally steered [3]. The development of robot software is a demanding discipline. Technical challenges arise from the need to develop complex, software-intensive products that take the constraints of the physical world into account [2].

In 2007, a group of scientists, industry and engineers create an open-source robotic framework called Robot Operating System (ROS) [7]. It is a flexible framework for designing robots, providing a collection of tools, libraries, and conventions aiming to simplify the task of creating complex and robust robot behavior across a wide variety of robotic platforms. However, there was the necessity of connect different simulators and real applications to make more complex tests and simulations.

To [6], the co-simulation represents one of the most popular techniques of validation in heterogeneous systems. According [10], the fundamental principle of co-simulation is to provide support to execute different simulators in a cooperative way. It allows the union of heterogeneous simulations with different models of execution.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_86

In 2007, a group of scientists, industry and engineers create an open-source robotic framework called Robot Operating System (ROS) [7]. It is a flexible framework for designing robots, providing a collection of tools, libraries, and conventions aiming to simplify the task of creating complex and robust robot behavior across a wide variety of robotic platforms.

In this way, High Level Architecture (HLA) was developed in order to provide a simpler way to interconnect simulators. It provides a specification of a common architecture to several simulations tools in Department of Defense of United States [4]. It's a pattern described in IEEE 1516-series and has been developed to provide a common architecture to distributed model and simulation [13].

At this point, MRS could be simulated by using ROS and interconnected with others simulators and/or real systems through co-simulation (using HLA, for example). However, there was a need that simulations were closer to reality, as if we were simulating real robots exchanging data via a network. This paper presents a project for simulation of communication in MRS using ROS, co-simulation and network simulation called OMNeT++. The goal of this work is make simulations in ROS more realistic, where the data exchange will be performed by using a network simulator, as if we were simulating real robots exchanging data through a network.

The remaining of this paper is organized as follow. Section 2 presents some related works. The architecture is proposed in Section 3. The initial results are presented in Section 4. Conclusions, discussions and main difficulties can be found in Section 5. Finally, Section 6 is about the future works.

2 Related Works

An operational semantics of co-simulation allows the discrete and continuous models to run on their respective simulators and managed by a coordinating co-simulation engine [5] Some works in literature use the concept of co-simulation to provide a solution in heterogeneous and distributed simulations.

In [15], a co-simulation framework to large-scale wireless network is presented. Similarly, interfaces were defined to enable integration with other simulations.

Another work [1] proposes the development and evaluation of a solution to model and simulate heterogeneous Models of Computation (MoCs) in a distributed way integrating Ptolemy II and High Level Architecture (HLA), creating an environment to run heterogeneous models of large scale in high-performance.

A Multi-System Robot simulator named ARGoS is presented in [8]. It was projected to simulate complex experiments involving large swarms of different robots. According the authors, the simulator is, in same time, efficient and flexible, allowing high level of customization.

In [11] proposed a distributed simulation of traffic using High Level Architecture, where a set of interoperable federations cooperates and communicate through the RTI's HLA. Also, in [9] is developed a framework for rapid integration of different simulators. A car-to-car communication application was presented, where SystemC is used to model the electronic controller of the car, OMNeT++ is responsible simulation of communication and Sumo simulates car traffic.

Other authors integrates the Matlab and DEVSim++ in a unique and distributed simulation environment through High Level Architecture in way to obtain good results with regard to integration of two Models of Computation (MoCs) with hybrid simulators [12].

3 Architecture

Next, is presented the environment to simulate MRS using ROS, co-simulation and network simulation, objective of this paper. The architecture can be seen in Figure 1.

The proposed environment have two parts. The first part composes all the ROS environment, the robots, its interface (interface ROS) and core, responsible for coordinate all the ROS environment in simulation. The second part is the HLA environment, with RTI, the ambassador, responsible for communication with the ROS interface and the OMNeT++ ambassador that communicates with RTI and forward information from OMNeT++ simulator.

The intersection point between the environments is called bridge. It implements a ROS node Interface and RTI ambassador to aim messages from RTI to ROS and vice versa. The bridge checks the ROS variables of all robots (such, speed, position) and send this information to HLA environment. This way, is possible to exist several robots sharing their data with any other simulator, such OMNeT++ or another HLA simulator. The co-simulation environment's flow is present in Figure 1.

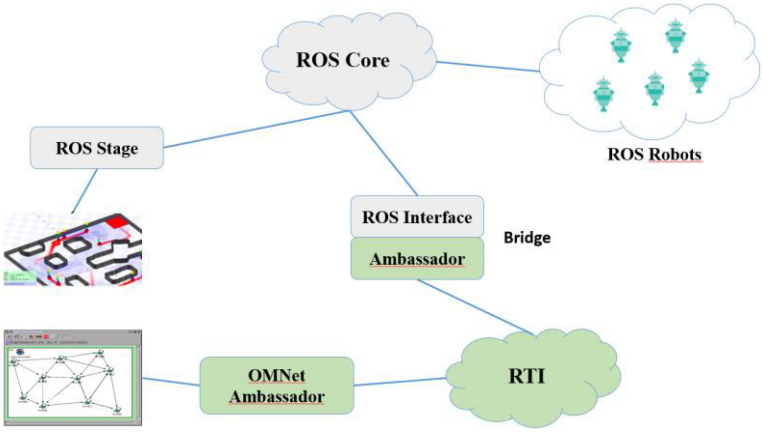


Fig. 1 - Proposed Architecture

The co-simulation environment can be divided in two parts. The first, called Multi-Robot System Environment, and second, Communication. The HLA act integrating this two layers to make possible data exchange. In proposed Architecture, there is a one-to-one relationship for robots in MRS and Communication layers. For each robot existing in ROS, there is a correspondent node in OMNeT++.The MRS Layer is

responsible to simulate several robots in the same environment and use ROS, as stated earlier. It initiates the robot nodes that will transmit data to second layer of co-simulation environment, the Communication layer. The Communication layer uses OMNeT++, responsible for exchange data with ROS Stage. The way is possible to simulate robots interacting in the network and test various situations presents in this type of communication (network protocols, packet loss, and interferences), making simulations even closer to reality.

3.1 Simulations

The idea is simulate scenarios in context of RoboCup using ROS, co-simulation and network simulation. The Robot World Cup Initiative (RoboCup) is an attempt to foster AI and intelligent robotics research by providing a standard problem where wide range of technologies can be integrated and examined [15].

To assess the impact caused by addition of OMNeT++, two types of simulations are created. Simulations have N robots, where one is the Master, responsible to coordinate the other robots, and N-1 Slaves. The Master moves from point x_0y_0 to x_1y_1 and send your position to all slaves, that follow the master from their position to nearby of Master's position. As validation, simulations in our tests were executed for 50, 100, 200 and 400 seconds containing two robots, one master and one slave. In a total, 20 simulations were performed for each type of simulation.

Simulations have a cycle of 1 second that be coordinate by HLA to ensure that the simulators are in same runtime. Every second, the HLA will order that all simulators execute a command called advanceTime, so that simulators can advance their times and, after that, the simulation can proceed. Those who have already advanced their time will wait until all the others have run the advanceTime to be able to continue.

The first type of simulation uses ROS Stage and HLA. This kind of simulation executes in "ideal environment", once that do not exist any interference in communication among robots existing in ROS Stage. The simulation will be the bases to compare that will be made using the second type of simulation.

In the second type of simulation, the OMNeT++ simulator is responsible for exchange messages among the robots present in ROS Stage. The utilization of OMNeT++ allows delays, packet loss and other things, in way to let the simulation even closer to reality. That way, we can compare the executions of the two types of simulation and observe the impacts that simulated network brings to communication among Stage robots. Communication among OMNeT's robots and the router have 59 milliseconds of delay and five different percentages for packet loss (1, 2, 3, 4 e 5) were tested. Once the robot sends a message to another, a counter is initiated and 1200 milliseconds after, if the confirmation message don't have arrived, the same message is sent again. In every cycle of simulation, the communication between the robots occurs like mentioned in Figure 2. In order to make OMNeT++ capable to exchange data with HLA is necessary that exists a node called Federate. His function is exchange information between the network simulator and HLA without interfering network communication, or in other words, does not have latency of communication, packet loss or any other aspect related to network. Next, will see some results about the simulations and discusses futures researches.

4 Partial Results

Until now, two aspects were observed when we compare the two types of simulations: Execution Time and Data Exchanged. The Table 1 shows a big picture of data collected in simulations. From it, we can conclude that the three aspects have a considerable increase after the inclusion of OMNeT++ but we will discuss these aspects separately and in more detail.

Table 1 - Data Simulations Overall. In the Table, orange columns represent data for ROS simulations and green columns, simulations with ROS and OMNeT++.

Simulation Time	Execution Time		Bytes Sent		Bytes Received	
50	50590	64098	10713	32111	25614	87179
100	100379	127960	20436	62671	48943	169036
200	200199	255498	40117	123158	95796	331845
400	399876	511146	79755	245153	189816	659524

About the Execution Time (see Table 01) in OMNeT++, the time is calculated taking into account the Simulation Time, the delay's communication and the time generated for packet losses. That way, the Execution Time tends to increase considerably in cases of high values for packet loss percentages and how higher is the simulation time, once the delay affects every communication between the robots.

The Table 2 shows the packet losses in the simulations performed during the tests using the average of lost packets in simulations. Taking into account that every packet loss increases the Execution Time in 1790 milliseconds (counter + delay), the 21 packets losses in simulations with simulation's time equals to 400, will increase the Execution Time in 37590 milliseconds. The other impact of packet losses is the increase of data exchanged. In this simulations with time equals 400, in average, 400 messages are sent, 354856 bytes are received and 6.6 messages are lost per execution. This way, every message has 887 bytes, what results in 5854 bytes of missing data per execution. The following chart shows the amount of missing data in this simulations. In 10 simulations, 66 packets were lost resulting in 385430 bytes of data missing.

The second aspect observed was data exchanged between the simulators. The following table shows the total of data exchanged in two types of simulations. After the inclusion of OMNeT++, the amount of exchanged data was multiplied by 3,33 (average). This happens because the quantity of data exchanged is proportional to number of federates existing in HLA environment plus the messages generated by own

OMNeT++, once that every message in HLA is received by every Federate, even if this federate will not catch the message. Beyond that, all massages destiny to a robot in ROS must pass through the correspondent robot in OMNeT++. In simulations presents in this paper, the ROS ignore the messages that not come from OMNeT++, not communicating with other federates of HLA. Following are presented some considerations and future works of this research.

Table 2 - Missing Data in Simulations with Time Equals 400 seconds

Bytes Received	Average Data per Message	Packet Losses	Missing Data
354489	886,2	9	7976
354481	886,2	3	2659
354688	886,7	4	3547
354575	886,4	5	4432
355128	887,8	7	6215
355120	887,8	7	6215
355223	888,1	3	2664
355062	887,7	7	6214
354876	887,2	10	8872
354915	887,3	11	9760

5 Final Considerations

Until this point of research, some aspects have been observed. In OMNeT++, for example, the latency and packet loss directly influence the time of simulation as a whole (managed by HLA). At the end of simulations, the time in OMNeT++ is always greater than HLA's time. One possible approach is make the OMNeT++ responsible to manage the time of Simulation Time. In ROS Stage, some configurations influencing the robot's behavior, such as Rate, that defines the frequency of robot's cycles, especially in cases of packet losses. The aspects observed in ROS Stage will be researched in more detail to know how exactly is the impact of them in the simulations and the behavior of the robots.

Since the proposed architecture was executed successfully, the next phase is test scenarios related to RoboCup initiative, analyzing the differences in robot's behavior to each type of simulation. As mentioned before, the main goal of this work is prove that the addition of OMNeT++ will make simulations more realistic, thus the same scenario will be tested in both types of simulation to understand the influence of OMNeT++, especially in robot's behavior, once already demonstrated their impact in terms of time and data.

References

1. Brito, A. V., Negreiros, A. V., Roth, C., Sander, O., & Becker, J. Development and evaluation of distributed simulation of embedded systems using ptolemy and hla. In: Distributed Simulation and Real Time Applications (DS-RT), 2013 IEEE/ACM 17th International Symposium, pp. 189-196. IEEE (2013)
2. Broenink, J. F., Ni, Y., & Groothuis, M. A. On model-driven design of robot software using co-simulation. In: Intl. conf. on simulation, modeling and programming for autonomous robots, pp. 659-668, Darmstadt (Germany) (2010)
3. Caliskanelli, I.; Broecker, B.; Tuyls, K. Multi-Robot Coverage: A Bee Pheromone Signaling Approach. In: Headleand Christopher J., T. W. J. A. C. L. (Ed.). Artificial Life and Intelligent Agents, vol. 519, pp. 124-140. Bangor, UK (2014)
4. Dahmann, Judith S., Richard M. Fujimoto, and Richard M. Weatherly. The department of defense high level architecture. Proceedings of the 29th conference on Winter simulation. IEEE Computer Society, pp. 142-149 (1997)
5. Fitzgerald, J. S., Larsen, P. G., Pierce, K. G., & Verhoef, M. H. G. A formal approach to collaborative modelling and co-simulation for embedded systems. Mathematical Structures in Computer Science, vol. 23, n. 04, pp. 726-750 (2013)
6. Nicolescu, G., Boucheneb, H., Gheorghe, L., & Bouchhima, F. Methodology for efficient design of continuous/discrete-events co-simulation tools. In: High Level Simulation Languages and Applications-HLSLA. SCS, pp. 172-179, San Diego, CA (2007)
7. M. Quigley, K. Conley, B. Gerkey, J. Faust, T. Foote, J. Leibs, R. Wheeler, and A. Y. Ng. Ros: an open-source robot operating system. In: ICRA workshop on open source software, vol. 3, n. 3.2, pp. 5 (2009).
8. Pinciroli, C., Trianni, V., O'Grady, R., Pini, G., Brutschy, A., Brambilla, M., ... & Dorigo, M. ARGoS: a modular, parallel, multi-engine simulator for multi-robot systems. In: Swarm intelligence, vol. 6, n. 4, pp. 271 – 295 (2012)
9. C. Roth, H. Bucher, A. Brito, O. Sander, and J. Becker. A simulation tool chain for investigating future v2x-based automotive e/e architectures. vol. 1, no. 1, pp. 1739–1748 (2014).
10. Straßburger, S., Schulze, T., Klein, U., & Henriksen, J. Internet-based Simulation using off-the-shelf Simulation Tools and HLA. In: Proceedings of the 30th conference on Winter simulation, IEEE Computer Society Press, pp. 1669-1676 (1998)
11. Sung, C. H., Hong, J. H., & Kim, T. G. Interoperation of DEVS models and differential equation models using HLA/RTI: hybrid simulation of engineering and engagement level models. In: Proceedings of the 2009 Spring Simulation Multiconference, Society for Computer Simulation International, pp. 150 (2009)
12. Symington, S.; Morse, K. L.; Petty, K. IEEE Standard for Modeling and Simulation (MS) High Level Architecture (HLA) - Federate Interface Specification (IEEE Std 1516-2000). Institute of Electrical and Electronics Engineers, Inc, (2001)
13. Varga, A. The OMNeT++ discrete event simulation system. In: Proceedings of the European simulation multiconference (ESM'2001), vol. 9, n. 185, pp. 65. (2001)
14. Onoe, Y., Atsumi, Y., Sato, F., & Mizuno, T. Cooperation of multiple simulators for Mobile IP networks. In: Advanced Information Networking and Applications, 17th International Conference, IEEE, pp. 367-372 (2003)
15. Kitano, Hiroaki et al. "Robocup: The robot world cup initiative". Proceedings of the first international conference on Autonomous agents. ACM, 1997. pp. 340-347.

An Evaluation of Distributed Processing Models for Random Walk-based Link Prediction Algorithms over Social Big Data

Alejandro Corbellini[1], Cristian Mateos[1], Daniela Godoy[1], Alejandro Zunino[1], and Silvia Schiaffino[1]

ISISTAN Research Institute. UNICEN University. Campus Universitario, Tandil (B7001BBO), Buenos Aires, Argentina. Tel.: +54 (249) 4385682 ext. 35. Also Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET)

Abstract. The problem of inferring missing relationships between people in online social networks such as Facebook, Google+ and Twitter is currently being given much attention due to its enormous applicability. To this end, link prediction algorithms which operate on graph data have been considered. However, the relentless increase of the size of such networks calls for distributed processing models able to cope with the associated big amounts of data. In this paper, we study the suitability of three models (Fork-Join, Pregel and DPM) for scaling up a common class of such algorithms, i.e. random walk-based. Broadly, Fork-Join and Pregel promote two rather different ways of creating and handling parallel sub-computations, while DPM is a model combining the best of both. Experiments performed with the Twitter graph and two classical random walk-based algorithms named HITS and SALSA show that DPM outperforms Fork-Join and Pregel by [30-40]% and [10-20]% respectively in terms of recommendation time.

Keywords: Online social networks, Big data, link prediction, Fork-Join, Pregel, HITS, SALSA

1 Introduction

The problem of link prediction in complex social networks has attracted much attention lately due to its big potential for real-word applications in today's online social networks (OSNs). More prominently, the problem of friend/followee recommendation can be seen as inferring a non-existent o missing relationship between two persons and has been approached using a variety of link prediction algorithms [13].

Common algorithms for link prediction use node-wise and topology-based similarity metrics to predict the existence of links, being the second the most widely applied in OSNs as in these networks node attributes (user profiles) are often hidden. Metrics based on graph topology can be further classified according to their characteristics into [13]: neighbor-based (e.g. common neighbors), path-based (e.g. Katz index), and random-walk-based. Particularly, random walks provide a simple scheme for unifying the information from ensembles of paths between two nodes, so that the problem of recommending people can be framed as ranking entities in a graph [21]. In this category of link prediction algorithms, HITS [9] and SALSA [12] stand out, being the last one the base of the popular Twitter's Who To Follow (WTF) service [6].

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_87

Graphs underlying real-word social networks are not only huge, but they are continuously evolving, which poses major challenges regarding big social data processing. In spite of this fact, most experimental recommendation algorithms for social networks are implemented as single-machine, single-threaded applications [7,20,4,23,5]. Even the well-known Twitter's WTF algorithm was implemented in a single-machine to reduce architectural complexity [6]. Then, these implementations struggle with scalability issues as the underlying social graph increases in massive real-world applications.

In distributed computing environments, the implementation of link prediction algorithms can be adjusted to different distributed processing models, such as MapReduce [3], BSP [22] or, specifically for graphs, Pregel [16]. Such a processing model prescribes certain primitives that govern how sub-computations are created and coordinated. Moreover, in terms of graph traversing operations, neighbor and path-based algorithms have completely different requirements than random walks-based algorithms. The first ones perform a single graph traversal operation, while the second ones run a successive number of iterations over subgraphs. Hence, choosing the adequate processing model directly impact on the performance of the algorithm when applied to social big data.

Therefore, in this paper, we evaluate different processing models for supporting the distributed computation of random walk-based link prediction algorithms. These algorithms are compute intensive since random walk takes multiple iterations of graph traversal, updating probabilities in each node according to their neighbors. HITS and SALSA, for example, iteratively calculate the hub and authorities scores of nodes to produce a rank. Specifically, Pregel and Fork-Join [17] are contrasted for implementing and running both algorithms, whereas an hybrid model of our own called DPM (Distributed Partitioned Merge) is considered as a more efficient alternative to both.

The remainder of this document is organized as follows. Section 2 presents current approaches to the problem of processing social big data. Section 3 presents the distributed processing models evaluated in this work for random-walk based recommendation algorithms. Section 4 reports the experimental setting and results obtained. Finally, conclusions are stated in Section 5.

2 Related Work

OSNs are one of the more important sources of social big data as these platforms allow individuals to interact with one another and provide information about their preferences and relationships [1]. As an example, Facebook's social network has 801 million daily active users that upload more than 500 TB to Facebook's data stores. Likewise, as of March 2014, Twitter's 240 million active users generated 500 million tweets per day.

Several scalable solutions that handle the bulk of data present on social networks have recently emerged. Particularly, as networks can be represented as graphs, NoSQL graph databases [14] and distributed processing frameworks [16,19,15] have attracted great attention. The former operate at the data storage level, providing means to gather and persist graph data, but do not support modeling generic graph algorithms to process the data. In most cases, graph databases limit graph processing to simple traversal algorithms, i.e. algorithms which follow a path on the graph and collect information. The latter provide models to implement elaborated graph algorithms, but usually operate in-memory, so that graph data is loaded into main memory from a graph database or data-warehouse.

Frameworks supporting graph algorithms in clusters of computers are, for example, jPregel (`http://charlesmunger.github.io/jpregel-aws/`), HipG [10], Piccolo [19]

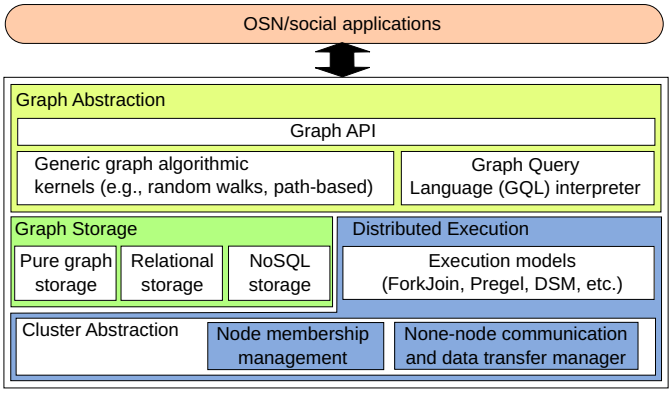


Fig. 1. Graphly layered architecture.

and GraphLab [15]. Many of those efforts are based on the well-known Bulk Synchronous Parallel (BSP) model by [22], which divides the execution of an algorithm in multiple supersteps synchronized by logical barriers in which message passing between subcomputations takes place. In fact, Pregel –implemented by Giraph and GraphLab– is one of the most popular BSP-based computational models for graph processing. Despite not being specially crafted for graph processing, other models for distributed processing such as Fork-Join or MapReduce have also been applied to graph processing [8]. Their usage can be explained by the availability and widespread popularity of open source frameworks such as Hadoop (`https://hadoop.apache.org/`) or GridGain (`http://www.gridgain.com/`). Surprisingly, some of these frameworks [10,15] do not cleanly support permanent graph data distributed storage, which prevents them from efficiently keeping up with the evolving nature of social big data. Moreover, these frameworks center around a single distributed processing model. In contrast, graph algorithms follow different programming styles, such as divide-and-conquer or iterative computing, which might not fit well in a given framework model. Nevertheless, the idea of abstracting away different graph storage backends (e.g. Titan (`http://thinkaurelius.github.io/titan/`)) and graph systems (e.g. TinkerPop (`http://tinkerpop.incubator.apache.org/`)) behind a single API is gradually entering the scene.

3 Evaluated Graph Processing Models

In order to support random walk-based link prediction algorithms, different graph processing models are described and evaluated in this work. Following the idea discussed at the end of the previous section, these models are all integrated into a lightweight distributed execution framework for Java specifically designed for developing recommendation algorithms in online social networks, called Graphly [2] (see Figure 1). Graphly includes a Graph Storage layer, which defines an abstract API for temporarily or persistently store graphs. Several implementations for this API can be chosen, for example one using a purely graph-oriented storage like Neo4J [18] or alternatively a graph store based on relational or NoSQL key-value stores. Graph data can be accessed either via the abstract API or graph query languages. Furthermore, in contrast to general-purpose graph processing frameworks, Graphly abstracts the algorithm developer from the distributed processing model to be used, thus avoiding to entangle the application code with distributed execution concerns.

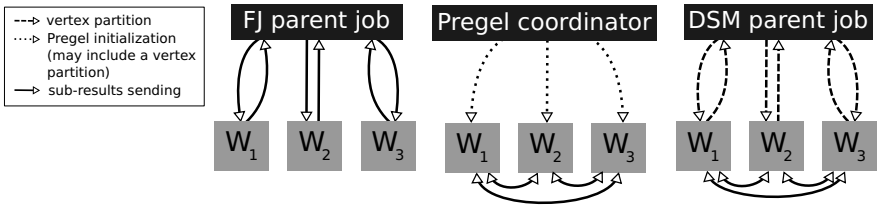


Fig. 2. Fork-Join, Pregel and DPM: Schematic view.

Broadly speaking, the aim of a any processing model is to provide a unified way of developing distributed algorithms and, at the same time, foster an efficient use of distributed computing resources. As explained, there a number of processing models that can be used in graph processing. The models currently supported by Graphly are the Fork-Join (FJ) and the Pregel model as they account for the commonly used approaches for developing graph-based recommendation algorithms: divide-and-conquer traversals and iterative graph computations. A third model of our own, called Distributed Partitioned Merge (DPM), sits between FJ and Pregel, and is evaluated as an alternative which combines ideas from both models. These three processing models are depicted in Figure 2 and described below.

3.1 Fork-Join

Fork-Join (FJ) [17], also known as Split and Merge or Split and Reduce in some frameworks (e.g. Gridgain), is one of the most simple models available for distributed processing. FJ is based on two basic operations: fork and join. The fork operation spawns from a parent job the so-called child jobs or workers, which run in parallel. The parent job usually issues a join operation to wait for the child jobs to finish in order to collect the results of their assigned sub-computations and provide a final result by merging its children results. In the context of distributed systems, the fork operation is responsible for creating jobs to be executed in remote machines. Once child jobs finish their execution, they send their results back to the machine where the parent job runs. Depending on the application, child jobs might be further split, and hence algorithmically FJ resembles the well-known divide-and-conquer programming strategy.

3.2 Pregel

The Bulk Synchronous Parallel (BSP) model by [22] parallelizes the execution of an algorithm in multiple *supersteps*, synchronized by logical barriers managed by a coordinator component in which child jobs interchange sub-results. Pregel [16] is one of the most popular BSP-based computational models for graph processing. Pregel is vertex-centric, since it requires the user to define algorithms through vertex functions, i.e. operations applied to the graph vertices. As in other models, Pregel splits the graph in shards by applying a hash function to the vertex ID. Each child job is, thus, assigned with the computation of a shard and is responsible for applying the vertex function to all or part of the vertices in its assigned shard. To organize the execution of the distributed algorithm, Pregel uses a logical synchronization barrier that establishes the iteration boundaries and avoids reading inconsistent sub-results.

3.3 Distributed Partitioned Merge (DPM)

DPM mitigates the performance bottleneck observed in the FJ model upon merging sub-results while still providing a divide-and-conquer programming style, which is simpler compared to vertex-centric programming. Indeed, the proposed model divides the vertex list to process among child jobs as in FJ, but emits job sub-results as in Pregel. DPM uses the graph sharding provided by the Graph Storage module of Graphly (see Figure 1) to aid the merging of results. Under Graphly, DPM runs on top of FJ.

A list of vertices is provided as an input to DPM. This list is partitioned into different sub-lists using a default splitting strategy and assigned to different DPM child jobs. Basically, each job executes a user-defined function that operates on the provided sub-list of graph vertices. Instead of returning all the sub-results to the parent DPM job, the programmer must call an *emit* operation to produce a sub-result associated to a given vertex in a step. This is, when the child jobs finish their sending stage, only the lists of vertices that where activated, i.e. those that where *emitted*, are sent back to the parent DPM Job. This produces a merge bottleneck that is much smaller than that of FJ because no sub-result must be merged. The DPM job must join the sets of vertices into one final list that is used to collect results from the graph.

As in the Pregel framework, DPM stores the value of the previous result that is going to be used in the current step of a sub-computation and a temporary value for the current sub-results. When a DPM child job completes its execution, the temporary results are committed, overwriting the previous results.

4 Empirical Evaluation

4.1 Experimental Setting

To evaluate the three processing models, we implemented and run two well-known random walk-based graph algorithms, namely HITS [9] and SALSA [12], on top of Graphly. Experiments were performed using a Twitter dataset[1] containing the complete follower-following network as of July 2009, provided by [11]. The dataset contains approximately 1,400 million relationships between more than 41 million users crawled using Twitter's Application Programming Interface (API). Since Twitter data are no longer available to researchers, this remains the largest snapshot of Twitter accessible.

The distribution incoming and outgoing links of real-work social networks posses a challenge to the efficient distribution of graph-parallel computation as most users have relatively few neighbors while a small number of users have many neighbors (e.g. celebrities). In fact, as reported in the study [11], there are only 40 users with more than a million followers, being all of them celebrities (e.g. Ashton Kutcher or Britney Spears) or mass media (e.g. the Ellen DeGeneres Show or CNN Breaking News).

Two groups of users were selected out of the complete dataset with the goal of illustrating the performance of the models when varying user profiles and hence sub-graph structures. The first set consists of the top-10 users ordered by amount of followees, called the "Followees Set". Likewise, the second-set, called the "Followers Set", contains the top-10 users ordered by amount of followers. The former group is mostly composed of information seekers, i.e. people that follow many Twitter accounts to receive their updates, while the later is integrated by very popular Twitter users having many followers.

[1] `http://an.kaist.ac.kr/traces/WWW2010.html`

Table 1. Cluster machines: hardware characteristics.

	First set (5 machines)	Second set (3 machines)
CPU	AMD Phenom II X6 1055T @2.8 Ghz	AMD FX 6100 @3.3 Ghz
# of cores	6	6
Total RAM	8 GB	16 GB
Hard Disk	500 GB - 7200 RPM	500 GB - 7200 RPM

Regarding the distributed environment characteristics, we used an semi-heterogeneous cluster comprising 8 machines classified in two sets, each having identical hardware characteristics. Machines were connected through a 1 Gbps physical network. Table 1 summarizes the most relevant characteristics of each set of machines.

4.2 Results

The experimental results are shown in Figure 3 and Figure 4, for the Followees and the Followers set, respectively. It can be seen that FJ performed poorly, mostly due to the way data is merged and transferred throughout the cluster. Interestingly, although both DPM and Pregel handle the merging of results and data transfer similarly, on most tests, DPM was slightly faster than Pregel. This can be explained by the simplification of the message sending mechanism in DPM. Another reason is the overhead produced by Pregel to manage the currently active vertices and the messages sent to each vertex. Note that in the DPM approach, the parent job manages the list of active vertices by merging all "touched" vertices in previous iterations. Then, the vertex list is partitioned and sent to the workers. The user-defined DPM task receives the partitioned list, instead of a list of messages for each vertex. DPM obtains the previous results stored in the local store (i.e. in the machine where the task is tunning), instead of aggregating a list of messages, as in the Pregel's Vertex Function.

Regarding network usage, FJ transferred more than twice the amount of data than other models, which may also explain its low performance in recommendation time. In this regard, Pregel was the winner with the lowest network consumption. The DPM model followed Pregel w.r.t. network usage. The difference between DPM and Pregel corresponds to the vertex list partitions being transferred from and to the parent DPM job.

Both the Followees and the Followers set exhibited the same patterns of usage, but in different scales. In fact, the Followees set produced higher spikes of network usage and recommendation time. An explanation for this behavior is the fact that although the Followers set is composed of users that have many followers, their followees lists are very short. For example, Fol_1 has $1,843,561$ followers and only 563 followees. However, users in the Followees set have more balanced lists of followees and followers. For example, Fee_1 has $920,556$ followers and $134,788$ followees. The resulting effect is that users in the Followees set generated bigger subgraphs than users in the Followers set.

5 Conclusions and future works

Link prediction in OSNs has attracted much attention due to its suitability for recommendation applications, and particularly for friend recommendation. OSNs can be modeled as

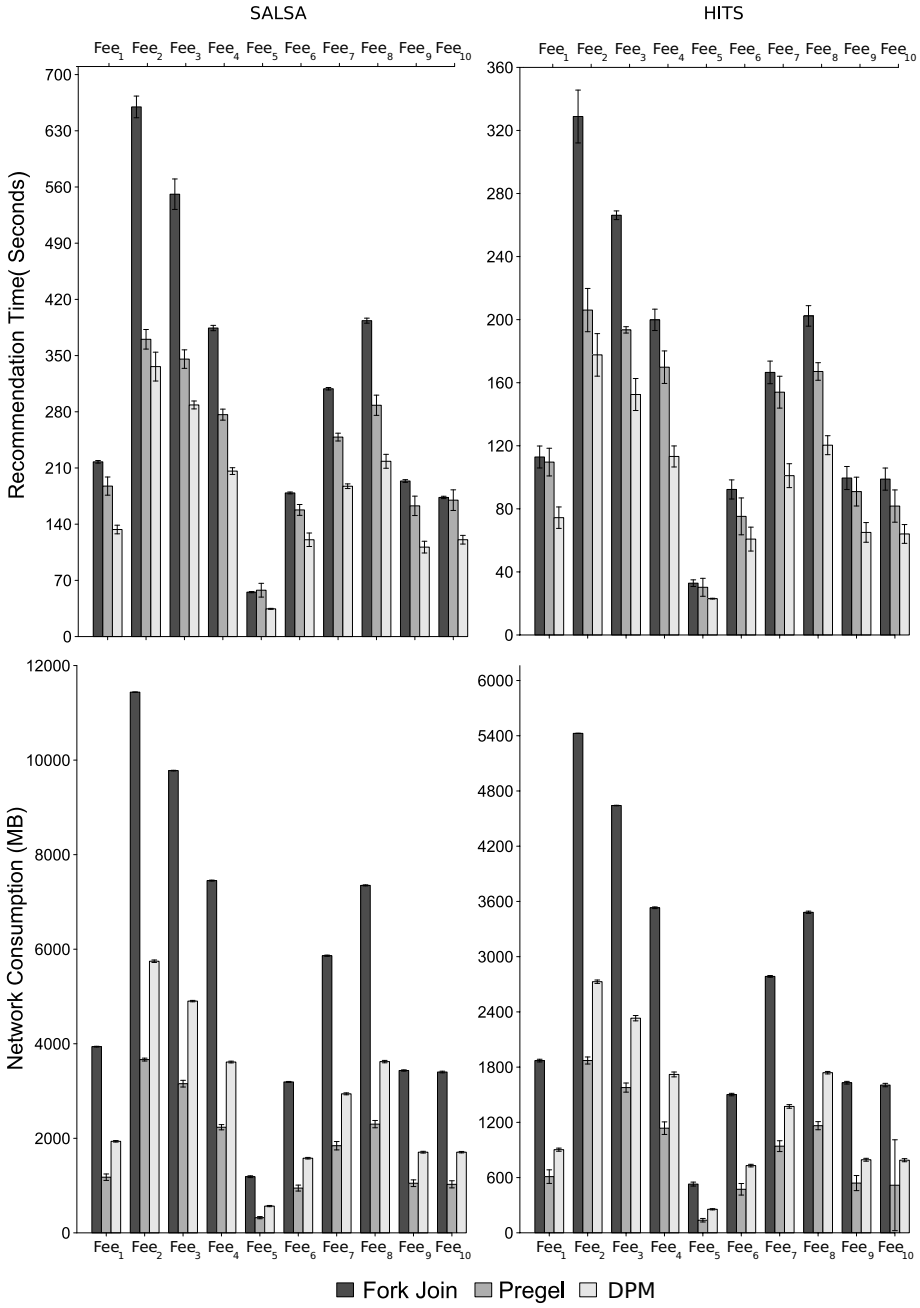


Fig. 3. Results achieved for the "Followees Set" of users

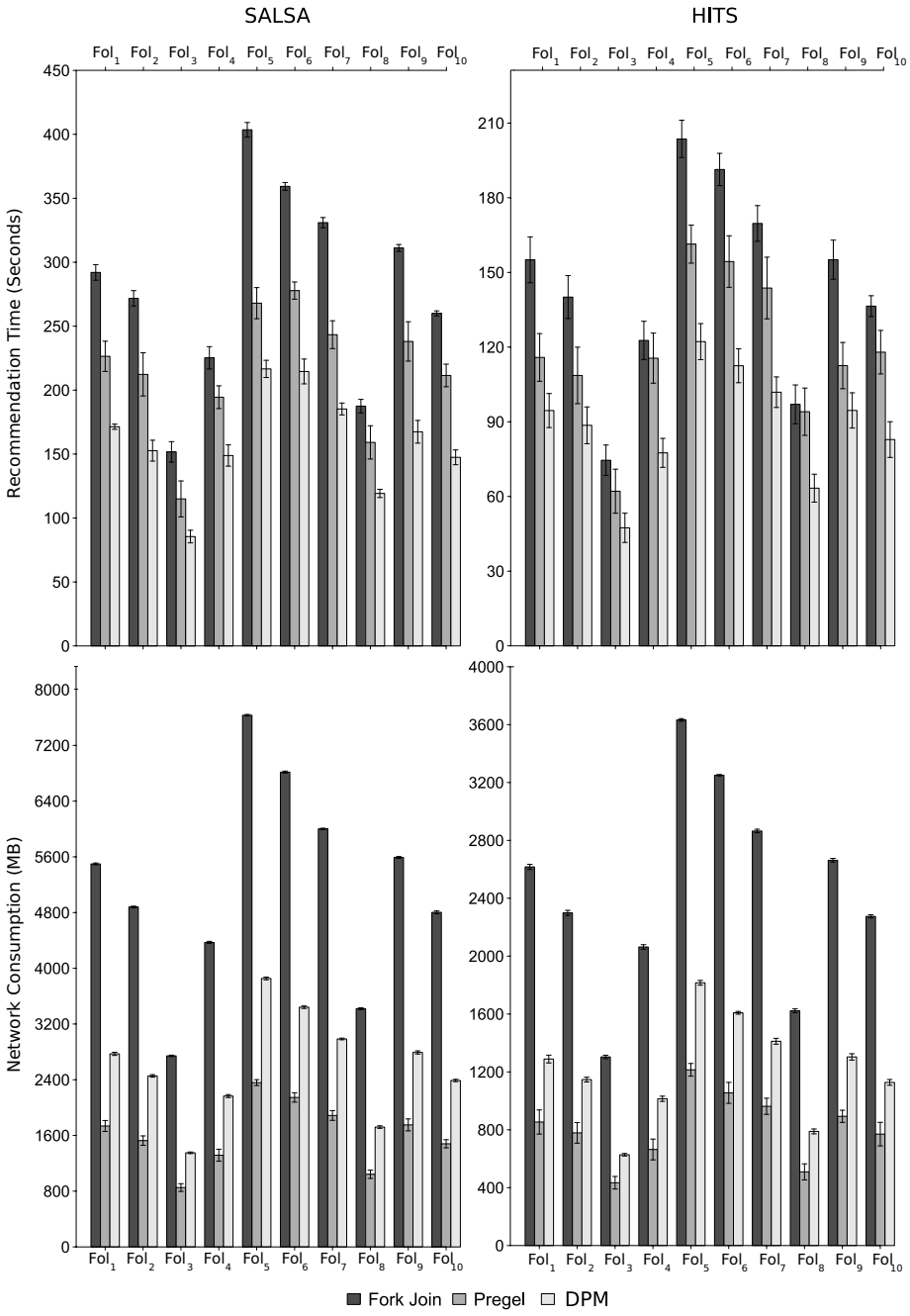


Fig. 4. Results achieved for the "Followers Set" of users

graphs, on top of which link prediction algorithms are run. However, as the size of a network increases, so does the computational complexity of running these algorithms. Then, scaling up a specific kind of algorithm requires using a distributed processing model that takes into account the peculiarities of the associated graph traversal operations.

We have evaluated three distributed processing models (Fork-Join, Pregel and DPM) for executing random walk-based link prediction algorithms. To this end, we considered HITS and SALSA and graph data from Twitter. Results show that DPM is the model which delivers the best performance in terms of recommendation time. On the other hand, DPM is not as efficient as Pregel regarding cluster network usage, but considering that link prediction algorithms usually run in clusters with high-speed network connections, the impact of intra-cluster data transfer is lowered. In this context, recommendation time arises as the most important metric to minimize. Notice that since DPM builds upon the way Pregel and Fork-Join handle job creation and coordination of sub-computations, these results might also suggest that hybrid models taking the best of existing general-purpose and graph-specific distributed processing models are the right path to efficiently execute link prediction algorithms over big graph data.

In the future, we will extend our analysis to other kind of algorithms, particularly path-based ones. In addition, we will consider an updated version of the Twitter graph as of November 2015, consisting of more than 300 million users. We are at present finishing crawling and building this graph. Lastly, we will consider alternative ways to partition and store graph data. Up to now, the considered alternative is to store the data associated to a given user (e.g. followers and followees) in the same physical machine. Since the amount of followers and followees may vary depending on the user, this alternative usually leads to unfair storage space usage throughout cluster machines. On the downside, other alternatives –such as the vertex-cut strategy described in [24]– may cause one studied processing models to be more efficient than other upon traversing the graph data, and thus this trade-off should be further investigated.

Acknowledgements

We acknowledge the financial support from ANPCyT and CONICET through grants PICT-2012-0045 and PIP 11220120100185CO, respectively.

References

1. G. Bello-Orgaz, J. J. Jung, and D. Camacho. Social big data: Recent achievements and new challenges. *Information Fusion*, 28:45–59, 2016.
2. A. Corbellini, C. Mateos, D. Godoy, A. Zunino, and S. Schiaffino. An architecture and platform for developing distributed recommendation algorithms on large-scale social networks. *Journal of Information Science*, 41(5):686–704, 2015.
3. J. Dean and S. Ghemawat. MapReduce: Simplified data processing on large clusters. *Communications of the ACM*, 51(1):107–113, 2008.
4. G. Durand, N. Belacel, and F. LaPlante. Graph theory based model for learning path recommendation. *Information Sciences*, 251:10–21, 2013.
5. X. Guo and J. Lu. Intelligent e-government services with personalized recommendation techniques. *International Journal of Intelligent Systems*, 22(5):401–417, 2007.
6. P. Gupta, A. Goel, J. Lin, A. Sharma, D. Wang, and R. Zadeh. WTF: The who to follow service at Twitter. In *22th International World Wide Web Conference (WWW 2013)*, pages 505–514, 2013.

7. Y. Jing, X. Zhang, L. Wu, J. Wang, Z. Feng, and D. Wang. Recommendation on Flickr by combining community user ratings and item importance. In *IEEE International Conference on Multimedia and Expo (ICME 2014)*, pages 1–6, 2014.
8. U. Kang, B. Meeder, E. E. Papalexakis, and C. Faloutsos. Heigen: Spectral analysis for billion-scale graphs. *IEEE Transactions on Knowledge and Data Engineering*, 26(2):350–362, 2014.
9. J. M. Kleinberg. Authoritative sources in a hyperlinked environment. *Journal of the ACM*, 46(5):604–632, 1999.
10. E. Krepska, T. Kielmann, W. Fokkink, and H. Bal. HipG: Parallel processing of large-scale graphs. *ACM SIGOPS Operating Systems Review*, 45(2):3–13, 2011.
11. H. Kwak, C. Lee, H. Park, and S. Moon. What is Twitter, a social network or a news media? In *19th International Conference on World Wide Web (WWW'10)*, pages 591–600, 2010.
12. R. Lempel and S. Moran. SALSA: The stochastic approach for link-structure analysis. *ACM Transactions on Information Systems*, 19(2):131–160, 2001.
13. D. Liben-Nowell and J. Kleinberg. The link-prediction problem for social networks. *Journal of the American Society for Information Science and Technology*, 58(7):1019–1031, 2007.
14. J. R. Lourenço, V. Abramova, M. Vieira, B. Cabral, and J. Bernardino. NoSQL databases: A software engineering perspective. In *New Contributions in Information Systems and Technologies - WorldCIST'15*, volume 353 of *Advances in Intelligent Systems and Computing*, pages 741–750, 2015.
15. Y. Low, D. Bickson, J. Gonzalez, C. Guestrin, A. Kyrola, and J. M. Hellerstein. Distributed GraphLab: A framework for machine learning and data mining in the cloud. *Proceedings of the VLDB Endowment*, 5(8):716–727, 2012.
16. G. Malewicz, M. H. Austern, A. J. C. Bik, J. C. Dehnert, I. Horn, N. Leiser, and G. Czajkowski. Pregel: A system for large-scale graph processing. In *2010 International Conference on Management of Data (SIGMOD '10)*, pages 135–146, 2010.
17. C. Mateos, A. Zunino, and M. Hirsch. EasyFJP: Providing hybrid parallelism as a concern for divide and conquer Java applications. *Computer Science and Information Systems*, 10(3):1129–1163, 2013.
18. I. Neo Technology. Neo4J. http://www.neo4j.org/, 2013. Accessed: 05-08-2013.
19. R. Power and J. Li. Piccolo: Building fast, distributed programs with partitioned tables. In *9th USENIX Conference on Operating Systems Design and Implementation (OSDI'10)*, volume 10, pages 1–14, 2010.
20. K. Rausch, E. Ntoutsi, K. Stefanidis, and H.-P. Kriegel. Exploring subspace clustering for recommendations. In *26th International Conference on Scientific and Statistical Database Management (SSDBM '14)*, pages 42:1–42:4, 2014.
21. P. Sarkar and A. W. Moore. *Social Network Data Analytics*, chapter Random Walks in Social Networks and their Applications: A Survey, pages 43–77. Springer, 2011.
22. L. G. Valiant. A bridging model for parallel computation. *Communications of the ACM*, 33(8):103–111, 1990.
23. X. Wang, J. Ma, and M. Xu. Group recommendation for Flickr images by 4-order tensor decomposition. *Journal of Computational Information Systems*, 10(3):1315–1322, 2014.
24. R. S. Xin, J. E. Gonzalez, M. J. Franklin, and I. Stoica. GraphX: A resilient distributed graph system on Spark. In *First International Workshop on Graph Data Management Experiences and Systems (GRADES '13)*, pages 2:1–2:6. ACM, 2013.

Part VII
Intelligent and Decision Support Systems

Integrating Client Profiling in an Anti-Money Laundering Multi-Agent Based System

Claudio Alexandre and João Balsa

Faculdade de Ciências da Universidade de Lisboa, BioISI-MAS, Lisbon, Portugal,
calexandre@di.fc.ul.pt jbalsa@ciencias.ulisboa.pt

Abstract. Continuing previous work by the authors, where an Anti-Money Laundering (AML) agent-based system was introduced, we now provide some detail on one of the elements of this system — the learning component. The system we are developing focuses on how a financial institution, a bank, can obtain better results in AML initiatives. More specifically, we're trying to improve the suspicious transaction signaling process and the subsequent final decision. For this, it is critical to model client behavior, having a clear definition of the different client profiles. Having available a real world data set of bank transactions, we explain in this contribution how some data-mining techniques were used in order to build the needed client profiles, and how the results obtained can be integrated in the system.

Keywords: anti-money laundering; data mining; classification; customer clustering; multi-agent systems; suspicious transactions

1 Introduction

In the last decades money laundering (ML) has been increasingly recognized as a significant global problem and was prioritized by almost every government in the world. An evidence that ML is a global worry was its prioritization at the same level of the most relevant global issues.

ML is frequently a transnational crime that occurs in close relation to other crimes, like illegal drug trading, terrorism, or arms trafficking [18]. It's a crime that typically consists in making a certain illegal financial gain into a legal gain. According to the United Nations Office on Drugs and Crimes (UNODC) the annual global estimate of laundered money is about 2% - 5% of the Gross World Product, or US$800 billion - US$2 trillion [20].

Money-laundering operations develop by means of a dynamic process that typically includes three independent stages – placement, occultation (or layering), and integration – that might occur simultaneously [5][6].

Anti-money laundering (AML) regulations are typically defined by a country's monetary authority (usually a central bank) and must be complied by all financial institutions. The role of financial institutions is to find ways to identify, among the huge number of operations that occur every day, those suspicious

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_88

transactions, then investigate them in more detail and, ultimately, send transaction information to the regulatory authority, when the suspicion is confirmed. However, the constant increase on the amount of financial transactions, along with the high frequency of publication of new national and international rules, causes the lack of efficiency and inappropriate timing of the fight and prevention activity.

Usually, financial institutions use semi-automated processes to flag suspicious ML transactions, based on medians and predetermined standard irregularities. Still, due to the sophistication of this criminal activity, the most critical part of process is still performed by human analysts.

The motivation for using an intelligent agent based solution results from the analysis of the problem and, mainly, in the observation that some of the tasks that we want to automate (at least partially), match perfectly the principles behind multi-agent system definition [22].

In this paper we resume on how to integrate in the learning component of the agent-based system introduced in [1], the results of a set of data-mining experiments, performed to build the bank's client profiles (details of this process in [2]). In the following sections we will start by referring some related work (section 2). Then we will present our agent-based approach (section 3) and the data mining process in more detail (section 4). Finally present some conclusions and the plan for future work (section 5).

2 Related Work

Regarding the use of agent based approaches in AML, there are very few authors that have considered them. In [11], an agent architecture is defined to include a set of specialized agents, such as data collecting agents, monitoring agents, a behavior diagnosis agent, and a reporting agent. This last agent is responsible for issuing alerts regarding potential money laundering operations.

Another approach [10] is supported in the definition of a Real-Time Exception Management Decision Model that is used to inform a multi-agent based real-time decision support system to detect money laundering operations. These authors design their system defining three groups of agents: the Intelligence group, with agents responsible for collecting data, profiling clients, and monitoring transactions; the Design group, where the critical analyses are made; and the Choice group, responsible for reporting and user interface.

Another agent-based approach is the one presented in [23]. Besides the inclusion of reporting and user agents, much alike what is done in the above mentioned works, these authors include Negotiation and Diagnosing agents that ultimately are responsible for the most critical decisions, taken on the basis of information provided by two other groups of agents: data collecting and supervising.

In [13], it is proposed that an artificial intelligence approach should model individual clients and look for unusual rather than suspicious behavior. There are also statistical approaches, like the ones described in [24] and [19], but we won't

go here into details regarding this type of approaches, since they correspond to a completely different line of research.

Considering the data transformation process, as in [25], a discretization process was also applied to a data set in order to find a more adequate set of clusters. However, when it is necessary to analyze a big number of clients and transactions over a long period of time, it may become difficult to detect suspicious cases, since there might be few peaks or none at all in the histogram.

A combination of clustering and MLP (multilayer perception) was proposed by [15]. A simple center-based clustering technique is used to detect suspicious cases of money laundering. This technique is based on two main characteristics, which are then used as an MLP creation process entry. The preliminary results show that this approach is efficient. However, the number of characteristics and training patterns is too small and that could have affected result precision.

In [14], the authors present a case study corresponding to the application of a knowledge base solution that combines data mining techniques, clustering, neural networks and genetic algorithms to detect money-laundering patterns.

In his survey about clustering, Sabau [17] asserts that clustering has proven itself a recurrently applied solution for detecting fraud and concludes that algorithms k-means based clustering with Euclidean distance as dissimilarity metric are the most commons used ones.

Chang [7] had proposed the use of the algorithms decision trees based on C4.5 to induce rules and use them to validate the identified cluster.

3 AML Multiagent System Proposed

We need a set of entities (agents) with autonomy to accomplish specific tasks and that keep contact with other agents in order to reach a common objective. Every agent must have its own knowledge and be able to ponder and come to an intelligent decision. Besides, they need to be scalable and flexible [9]. According to their role in the process, we consider two groups of agents: "Capture

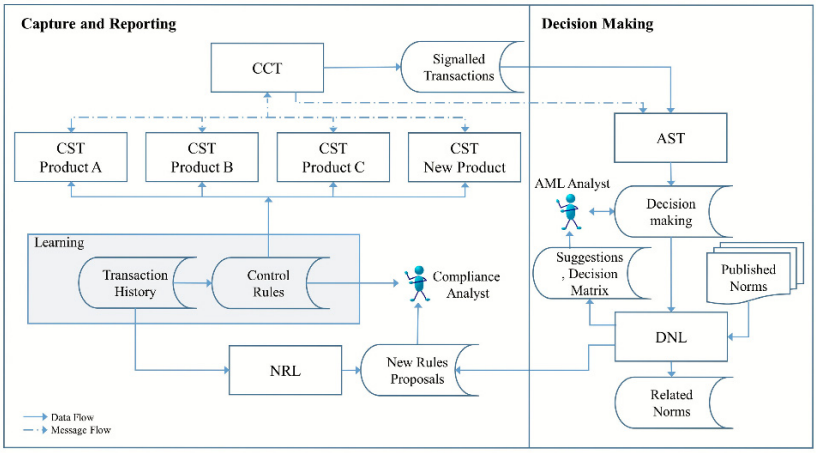


Fig. 1. General Architecture of the Proposed System

and Reporting" and "Decision Making". The first group is responsible for identifying, capturing and reporting suspicious transactions, while the second one is responsible for analyzing suspicious transactions and, in some cases, decide on the fate of the transactions identified by agents from the first group. Fig. 1 shows a schematic view and the global architecture flow of the proposed system.

Capture and Reporting agents – The data is originated in several business processes. We define an agent for each product (current accounts, investment funds, currency exchanges, etc.). This approach has two advantages. Firstly, this allows us to model each agent's knowledge according to the specificities each product has. Secondly, it makes scalability easier, in the sense that the creation of a new product can be incorporated in the system just by adding a new agent specialized in it.

Besides these *capturing suspicious transactions* (CST) specialized agents, there is one that is responsible for the *communication of captured transactions* (CCT), as well as its storage for further use. Whenever a CST agent identifies a suspicious transaction, it sends it to CCT that is responsible for forwarding it to some other CST agents.

So, CST agents have two working modes: **Transaction oriented**, in which agents try to capture suspicious transactions with no assumptions regarding clients; **Client oriented**, in which agents try to capture suspicious transactions for clients that were identified by other CST agent and communicated by CCT.

Finally, this group has a third type of agents — *new rule learning* (NRL). These agents are responsible for learning and proposing new capturing rules regarding each product, from historical transactions database and new clients activity. This agent will automate the learning process initially performed manually and described in the section 4 of this work.

Decision Making agents – These agents perform the analysis of the previously signaled transactions (*analysis of suspicious transactions* – AST) and a learning process that considers both the incorporation of new norms and the outcomes of the decisions (*decision and norms learning – DNL*).

AST agents have autonomy to decide amongst three possibilities regarding a signalization: accept it, discard it, or send it for further (human) analysis. So, these agents assume the role of Compliance Officers or AML Analyst in the analysis of suspicious transactions. They have a learning component that contributes to the improvement of the control parameters and to the enlargement of the set of situations that can be decided automatically. They use the decision matrix built by AML Analyst on based in DNL agent suggestions and historical decisions database.

Also in this group, the DNL agent is responsible for the improvement of the decision matrix. Taking into account all decisions made (namely, those produced by human experts), it is responsible for finding possible refinements or new inclusions in the base parameters.

In addition to the decisions taken, it also considers the repetition of the kind of transactions that were flagged as suspects but were discarded. Additionally, in a different dimension, this agent processes new regulations in order to find new norms that need to be implemented.

Agent Interaction – Cooperation among CST agents happens through their direct interaction with the CCT agent, that coordinates the tasks and receives the results. Only the CCT agent knows all the CST agents existing, besides it can identify the products that the suspect client uses in the institution.

Interaction amongst other agents (CCT, AST, DNL, NRL) has the role to trigger in each of these agents the goal to perform the task under its responsibility. In other words, all agents have their own specific expertise, and they have independent and not conflicting goals. On the other hand, there is plenty of cooperation for the achievement of a common goal. CST and AST agents learn and evolve to reduce the false positive problem, common to systems based only on a set of rules and patterns of behavior.

4 Datamining Process

In order to identify the different client profiles, we performed a set of experiments based on real world data from a bank.

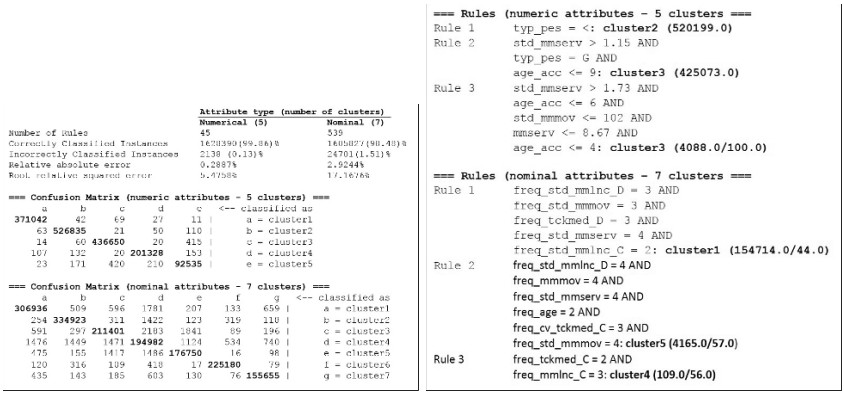
Choice of tools and environment definition – The data used in this paper don't have a class attribute (unsupervised). The initial goal is to discover patterns from any regular characteristic in the dataset (Clustering), trying to form groups of clients with similar characteristics and mutually exclusive (partitional).

Despite the classic problems associated with the K-means algorithm [12], the necessity of defining in advance the number of clusters to be used and present best result with numeric attributes, it is one of the most used partitional clustering algorithm [17].

We decide to use the WEKA tool (*Waikato Environment for Knowledge Analysis*), that natively implementing SimpleKmeans [3] and trying to diminish problems with nominal attributes.

Preprocessing and Clustering - Phase 1 – In a first phase, the dataset used comes from a financial institution and represents the accounts movement over a period of three months. The most relevant tables in this dataset model are the transaction and register ones, with 14.5 million and 4.5 million lines, respectively.

In the preprocessing step, data was aggregated by customer with numerical attributes that indicated some monthly averages: number of services used; transactions made; debit transactions made, credit transactions made. Besides, we included the average monetary value of these transactions. For each of these



	Attribute type (number of clusters)	
	Numerical (5)	Nominal (7)
Number of Rules	45	535
Correctly Classified Instances	1620390(99.88)%	1605077(98.48)%
Incorrectly Classified Instances	2138 (0.13)%	24701(1.51)%
Relative absolute error	0.2887%	2.9244%
Root relative squared error	5.4758%	17.1678%

=== Confusion Matrix (numeric attributes - 5 clusters) ===

a	b	c	d	e	<-- classified as
371042	42	69	27	11	a = cluster1
63	**526835**	21	50	110	b = cluster2
14	60	**436650**	20	415	c = cluster3
107	132	20	**201328**	153	d = cluster4
23	171	420	210	**92535**	e = cluster5

=== Confusion Matrix (nominal attributes - 7 clusters) ===

a	b	c	d	e	f	g	<-- classified as
306936	509	596	1781	207	133	659	a = cluster1
294	**334923**	311	1422	123	319	110	b = cluster2
591	297	**211401**	2183	1841	89	196	c = cluster3
1676	1449	1471	**194982**	1124	534	740	d = cluster4
475	155	1417	1486	**176750**	16	98	e = cluster5
120	316	109	418	17	**225180**	79	f = cluster6
435	143	185	603	130	76	**155655**	g = cluster7

(a) Metrics of Rules

```
=== Rules (numeric attributes - 5 clusters ===
Rule 1      typ_pes = <: cluster2 (520199.0)
Rule 2      std_mmserv > 1.15 AND
            typ_pes = G AND
            age_acc <= 9: cluster3 (425073.0)
Rule 3      std_mmserv > 1.73 AND
            age_acc <= 6 AND
            std_mmmov <= 102 AND
            mmserv <= 8.67 AND
            age_acc <= 4: cluster3 (4088.0/100.0)

=== Rules (nominal attributes - 7 clusters ===
Rule 1      freq_std_mmlnc_D = 3 AND
            freq_std_mmmov = 3 AND
            freq_tckmed_D = 3 AND
            freq_std_mmserv = 4 AND
            freq_std_mmlnc_C = 2: cluster1 (154714.0/44.0)
Rule 2      freq_std_mmlnc_D = 4 AND
            freq_mmmov = 4 AND
            freq_std_mmserv = 4 AND
            freq_age = 2 AND
            freq_cv_tckmed_C = 3 AND
            freq_std_mmmov = 4: cluster5 (4165.0/57.0)
Rule 3      freq_tckmed_C = 2 AND
            freq_mmlnc_C = 3: cluster4 (109.0/56.0)
```

(b) Rules Generated

Fig. 2. Algorithm PART - Phase 1

attributes the standard deviation is also used, since there is a major variation between the minimum and maximum values. This table, called *customers profiles*, resulted in 1.6 million lines.

We decided to separate data and test both scenarios, numerical and nominal attributes. The motivation for this decision was the big variation between the minimum and maximum attribute values mentioned above, where the biggest variation stood between 0.01 minimum and 536,852,446.89 maximum.

As evaluation measures trying to define the initial number of clusters, we used the Silhouette Coefficient and the SSE (sum of squared error), which indicated the numbers of five and seven clusters [2].

Comparing the clusters created in both cases, the clusters created with nominal attributes (seven clusters) showed a more coherent group of customers, for instance: old customers with a high use of services, high monetary values involved, credited values are rapidly withdraw (Cluster 1); customers' account with less than 4 years old, high use of services, high quantity of entries, however, low monetary values and credited values rapidly withdrawn (Cluster 3).

Rules Generation and Evaluation - Phase 1 – In the subsequent step of the process, rule generation, the PART algorithm was used, which is also included in the WEKA environment, and implements the C4.5 Decision Tree algorithm for interactions and uses the best leaf technique in rule generation. In the executions all the default values suggested by WEKA were used.

Fig. 2 shows that, in this case, the metrics have had an inverse result, meaning that the clusters based on numerical attributes had better results. This figure also shows a few examples of rules with little use for the proposed study, whether for its simplicity and incapacity in helping taking a decision; or for its complexity, but resulting in few examples, also becoming disposable.

Preprocessing and Clustering - Phase 2 – Considering that the obtained results were unsatisfactory, a new strategy was adopted. This consisted of cre-

ating a new profile table; use numerical attributes, but more directed towards the research goal; use a more ample database; make experiments with other rule generating algorithms.

Information with the monetary value involved in the transaction, financial transfers between banks and temporality of incoming and outgoing financial resources, started being part of the new customer profile table. The new checking accounts database incorporated transactions for the whole year of 2014 and the main tables, transactions and register, became larger, with 90.6 million and 5.1 million lines, respectively.

The compliance analysts from the financial institution that provided the database, besides confirming the importance of the defined attributes, identified the transactions that have no connection with money laundering. For example, charges made by the bank. With this definition the quantity of lines in the table can be reduced and the generated clusters will be more specialized.

Two indicators are very important for customer profile analysis: the percentage of debits over the credits made in the period; and the time between the input and output of money off the account of this client. To obtain this attribute we decided to weigh the values withdrawn by the time of stay of these values in the financial institution.

The percentage of debit indicates the volatility of the money the client's account, a very high value may indicate a risk. The calculation was based on the following equations.

$$DP(C) = \frac{dv_1(C) + \sum_{k=2}^{n_C} \frac{dv_k(C)}{dd_k(C) - dd_1(C)}}{cv_1(C) + \sum_{k=2}^{n_C} \frac{cv_k(C)}{dc_k(C) - dc_1(C)}} \tag{1}$$

where DP is the client debit percentage, C is a specific client, dv_k is the amount of the k-th debit transaction in the evaluation period, n_C is the number of records for client C in the profile table, dd_1 is the date of the first debit transaction in the evaluation period, cv_k is the amount of the k-th credit transaction in the evaluation period, dc_1 is the date of the first credit transaction in the evaluation period. Note that the difference between two dates is measured in number of days.

Other attributes defined to the profile were: the age of the account; the amount of services used; the amount of transactions carried out; percentage, on transactions, of transfers made to other financial institutions. In addition, the amount of transactions carried out divided into six ranges of values, some of them indicating legal limits on which the financial authorities maintain control.

The new customer profile table remained with 2.4 million lines after the clustering and removal of the insignificant transactions. In the search of the adequate number of cluster to be used the SimpleKmeans was executed 10 times, the Silhouette Coefficient, SSE, VRC (variance ratio criterion) [4], Van Dongen and Rand [21] metrics were analyzed, and the values found.

The Silhouette metric, SSE and VRC, all indicate six clusters as the ideal number, while Van Dongen and Rand indicate seven clusters. Both Silhouette and SSE show a stability line starting from number six, which can corroborate number seven, identified by the other metrics. However, the standard procedure is to make the choice on the curve "elbow" or the higher value, depending on the metric. All the algorithm executions were made using the database split function in the proportion of 66% for training and 34% for testing.

The small difference between six and seven for the suggested quantity of clusters indicates the need to verify the result with seven clusters. The redistribution of instances for the creation of the seventh cluster didn't affect the basic characteristics of the first six clusters. Because of the characteristics presented by Cluster #7, its maintenance is important in the system configuration, thus, we started working with the creation of seven clusters.

Executing the algorithm with the generated cluster evaluation function we obtained a confusion matrix with a level of accuracy above 99% if we consider the incorrect classification rates of 0.0683% for the training base and 0.0596% for testing base.

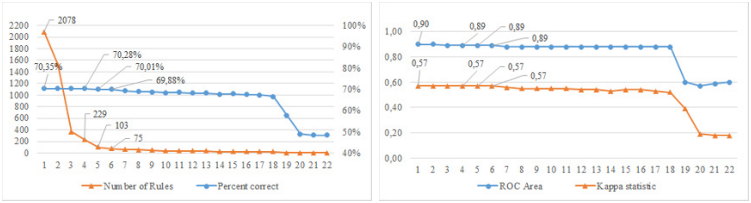
For rule generation, PART algorithm experiments were made, J48 [16] and JRip [8], using the WEKA tool default parameters and restraining the rule coverage to 100 and 1000 instances. To each of these options the PART algorithms and J48 were also executed with the "reducedErrorPruning" option activated, in the JRip algorithm this option is already part of the implementation.

This configuration (15 experiments) was executed twice: one using database Split in the proportion of 66% for training and 34% for testing; and another with cross-validation (10 folds) [2].

Rules Generation and Evaluation - Phase 2 – The rules generated also don't have the expected quality, with strange repetitions of attributes or attributes conflicts. Following these results we decided to discretize the attributes, now with class attribute, and perform the tests again. The attributes were separated in three value groups with equivalent quantity of instances percentage, if possible. Some attributes, because of a concentration of occurrences of one particular value, were divided in only two groups. The experiments were performed executing the same algorithms and using the same parameters of the previous experiment.

The J48 and JPART algorithms present the best results in the group of experiments using split and cross-validation, respectively. In both cases the number 1.000 limited the minimum instances per rule for PART and the minimum of leaves on the J48 tree. Although not being significant, the indicators presented better results if compared with previous experiments.

To improve the experiment with the purpose of verifying the behavior of these indicators, PART and J48 algorithms were executed 22 times each, varying the minimum number of instances by rule and of leaves in the tree. The minimal number is each algorithm's default and the maximal number is the size of the smallest cluster generated (2 – 40,000).



(a) (b)

Fig. 3. Algorithm PART Measure - Phase 2

Fig. 3 shows the experiment results using the PART algorithm and demonstrates that the measure of rule quality is reversibly proportional to the increase of the minimum quantity of instances for the coverage of rules or for the leaves of the tree. Similar behavior has been obtained using J48 algorithm.

With this experiment we understood that the results obtained can be used for generating and analyzing rules. An analysis on rules generated by algorithms J48 and PART, using the parameters of the best result, makes it possible to notice an improvement in quality: more complete, without redundancies. Fig. 4 shows an example of the generated rules [2].

Analysing the clusters obtained in the previous step and using the newly generated rules, it was possible to identify and validate user groups that will be used by the system agents. It was possible to identify clients groups such as:
Cluster #3 – Standard Customer: biggest group of customers with high use of services, transactions financial values indicating intermediate customers. The money flows into account and the following days is withdraw;
Cluster #4 – Group of Risk 1: high quantity of transactions, with low use of services; low financial values; money flows in and the same day or in a small amount of time is transferred to another financial institution;
Cluster #7 – Group of Risk 2: older accounts profile with great use of services and great volume of transactions. Financial values concentrated on areas called “legal limits”. A bigger percentage of outgoing financial resources, although with a low transference rate to other institutions. High rate of transfers between accounts of the same institution.

5 Conclusion

The two main goals of this article are: to propose a system for preventing and fighting money laundering; and to report the results obtained in the initial task

```
PART decision list
------------------

pct_shipment = 1 AND
pct_debit = 2 AND
val_range_3 = 1 AND
val_range_4 = 1 AND
val_range_5 = 1: cluster3 (493683.0/53365.0)

pct_debit = 2 AND
pct_shipment = 1 AND
val_range_5 = 1 AND
val_range_3 = 2 AND
nbr_services = 2 AND
account_age = 3: cluster6 (212291.0/70108.0)
```

```
J48 pruned tree
------------------

pct_shipment = 1
|   pct_debit = 2
|   |   val_range_4 = 1
|   |   |   val_range_3 = 1
|   |   |   |   account_age = 1: cluster3 (200128.0/18790.0)
|   |   |   |   account_age = 2: cluster3 (131883.0/17907.0)

pct_shipment = 1
|   pct_debit = 1
|   |   nbr_services = 1
|   |   |   val_range_4 = 1
|   |   |   |   val_range_3 = 2
|   |   |   |   |   val_range_2 = 1: cluster1 (117958.0/19805.0)
```

Fig. 4. Rules Generated by Algorithms PART and J48 - Phase 2

of learning and generation of production rules. The process of detection and analysis of suspicions transactions is long and laborious; the architecture of the proposed system aims to make it more agile and opportune. The specialisation and cooperation between the agents seeks to achieve this goal.

The first contribution of this system is in automating the detection process and signaling of suspicious transactions (first group of agents), which seeks to solve the problem of the growing volume of transactions with the consequent reduction in time of report of the suspicious transactions for further specialized analysis.

Another contribution of the proposed system, and perhaps the most relevant, is the definition of the agents who will act, as autonomously as possible, in the decision-making process on the fate of the transaction flagged as suspicious (second group of agents).

The learning stage was the initial phase of system construction and in this paper we describe the tasks performed besides showing the excellent results obtained. This description is almost a roadmap of risks and best practices to be observed in the use of algorithms and standard techniques applied to large volumes of data. The Clusters found allowed the clear identification of risk groups, essential for identifying suspicious transactions.

The next step in building the system will be the creation of specialized agents in banking products that will use the clusters and rules discovered in step described in this paper.

References

1. Alexandre, C., Balsa, J.: A multiagent based approach to money laundering detection and prevention. In: Loiseau, S., Filipe, J., Duval, B., van den Herik, H.J. (eds.) Proceedings of the International Conference on Agents and Artificial Intelligence. vol. 1, pp. 230–235. SciTePress, Lisbon (2015a), http://www.scitepress.org/portal/PublicationsDetail.aspx?ID=pJRstwtoDBg=&t=1
2. Alexandre, C., Balsa, J.: Client profiling for an anti-money laundering system. CoRR abs/1510.00878 (2015b), http://arxiv.org/abs/1510.00878
3. Arthur, D., Vassilvitskii, S.: K-means++: The advantages of careful seeding. In: Proceedings of the Eighteenth Annual ACM-SIAM Symposium on Discrete Algorithms. pp. 1027–1035. Society for Industrial and Applied Mathematics, Philadelphia, PA, USA (2007)
4. Calinski, T., Harabasz, J.: A dendrite method for cluster analysis. Communications in Statistics-Simulation and Computation 3(1), 1–27 (1974)
5. Canas, V.: O Crime de Branqueamento: Regime de PrevenÃ§Ã£o e de RepressÃ£o. Coimbra (2004)
6. Castellar, J.C.: Lavagem de Dinheiro - A Questão do Bem Jurídico. Rio de Janeiro (2004)
7. Chang, W.H., Chang, J.S.: Using clustering techniques to analyze fraudulent behavior changes in online auctions. In: Networking and Information Technology (ICNIT), 2010 International Conference on. pp. 34–38 (June 2010)
8. Cohen, W.W.: Fast effective rule induction. In: Proceedings of the Twelfth International Conference on Machine Learning. pp. 115–123. Morgan Kaufmann (1995)

9. Demazeau, Y.: From interactions to collective behaviour in agent-based systems. In: Proceedings of the 1st. European Conference on Cognitive Science. Saint-Malo. pp. 117–132 (1995)
10. Gao, S., Xu, D.: Real-time exception management decision model (rtemdm): Applications in intelligent agent-assisted decision support in logistics and anti-money laundering domains. In: System Sciences (HICSS), 2010 43rd Hawaii International Conference on. pp. 1–10 (Jan 2010)
11. Gao, S., Xu, D., Wang, H., Wang, Y.: Intelligent anti-money laundering system. In: Service Operations and Logistics, and Informatics, 2006. SOLI '06. IEEE International Conference on. pp. 851–856 (June 2006)
12. Hamerly, G., Elkan, C.: Alternatives to the k-means algorithm that find better clusterings. In: Proceedings of the Eleventh International Conference on Information and Knowledge Management. pp. 600–607. ACM, New York, NY, USA (2002)
13. Kingdon, J.: Ai fights money laundering. Intelligent Systems, IEEE 19(3), 87–89 (May 2004)
14. Le-Khac, N.A., Kechadi, M.: Application of data mining for anti-money laundering detection: A case study. In: Data Mining Workshops (ICDMW), 2010 IEEE International Conference on. pp. 577–584 (Dec 2010)
15. Le-Khac, N.A., Markos, S., Kechadi, M.T.: Towards a new data mining-based approach for anti-money laundering in an international investment bank. In: Digital Forensics and Cyber Crime - First International ICST Conference (ICDF2C). pp. 77–84. Springer, Albany, NY, USA (2009)
16. Quinlan, J.R.: C4.5: Programs for Machine Learning. Morgan Kaufmann Publishers Inc., San Francisco, CA, USA (1993)
17. Sabau, A.S.: Survey of clustering based financial fraud detecton research. Informatica Economica 16(1) (mar 2012)
18. Schott, P.A.: Reference Guide to Anti-Money Laundering and Combating the Financing of Terrorism: Second Edition and Supplement on Special Recommendation IX. The World Bank and The International Monetary Fund, Washington DC, second edn. (2006)
19. Tang, J., Yin, J.: Developing an intelligent data discriminating system of anti-money laundering based on svm. In: Machine Learning and Cybernetics, 2005. Proceedings of 2005 International Conference on. vol. 6, pp. 3453–3457 (Aug 2005)
20. UNODC: United nations office on drugs and crime - annual report 2014. Online (2014), https://www.unodc.org/documents/AnnualReport2014/Annual_Report_2014_WEB.pdf, accessed on jul. 10,2015
21. Wagner, S., Wagner, D.: Comparing clusterings – an overview. Tech. Rep. 2006-04, UniversitÃ¤t Karlsruhe (TH) (2007), http://digbib.ubka.uni-karlsruhe.de/volltexte/1000011477
22. Wooldridge, M.: An Introduction to Multiagent Systems. Wiley Publishing, Chichester, UK, 2nd edn. (2009)
23. Xuan, L., Pengzhu, Z.: An agent based anti-money laundering system architecture for financial supervision. In: Wireless Communications, Networking and Mobile Computing, 2007. International Conference on. pp. 5472–5475 (Sept 2007)
24. Xuan, L., Pengzhu, Z.: A scan statistics based suspicious transactions detection model for anti-money laundering (aml) in financial institutions. In: International Conference on Multimedia Communications, 2010. pp. 210–213 (Aug 2010)
25. Zhang, Z.M., Salerno, J.J., Yu, P.S.: Applying data mining in investigating money laundering crimes. In: Proceedings of the Ninth ACM SIGKDD International Conference on Knowledge Discovery and Data Mining. pp. 747–752. KDD '03, ACM, New York, NY, USA (2003)

A Nearby Expert Discovering Mechanism: for Social Support

Ting-Kai Hwang[1] , Yung-Ming Li[2], Bih-Huang Jin[3]

[1] Department of Journalism, Ming Chuan University, Taiwan,
tkhwang@mail.mcu.edu.tw
[2] Institute of information Management, National Chio Tung University, Taiwan
yml@mail.nctu.edu.tw
[3] Department of Business Administraiton, Tunghai University, Taiwan
bihuang.jin@gmail.com

Abstract. Recently, with the rise of crowdsourcing, the concept that problems can only be solved by known experts has gradually been replaced. More and more people try to solve the problems via crowdsourcing, with not only efficiency but also inexpensiveness. In this research, we develop a nearby expert discovering mechanism by combining mobile intelligence and social community, and taking crowd wisdom, context, and social impacts into considered. The proposed system allows users to find nearby people whom have certain expertise in handling with difficult problems in real-time via a mobile device.

Keywords: Expert finding, social networks, crowdsourcing, So-Lo-Mo

1 Introduction

Due to the smartphone revolution, mobile applications have become hugely popular, especially location-based services. Recently, location-based social networks, LBSN, have been a popular trend. According to a survey conducted by the Pew Research Center, 45% of US adults had used a location-based service as of May 2013, up from 41% in February 2012 [3].

Crowdsourcing is a new concept to gather the power of crowd's resource [6], like Wikipedia. It can gather the wisdom and talents of people to solve some complex and time or human resource consuming problems. In the past, when people need some specific helps, they have to spend a lot of time in searching for someone who have the relevant pipelines or professional abilities and request them to provide some useful advises. However, the process of searching is very tedious and time-consuming. Now, with the development of Internet and social networks, users can get support from the crowd with relevant expertise or resource. Users can look for people with appropriate expertise to solve the problems from the social network [7] [11].

The increasing amount of mobile device and location-based social network poses new challenges for the application designer to develop useful and appealing

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_89

crowdsourcing services for the mobile users and advance the techniques of analyzing mass user-generated content and social activities. When we face a problem we cannot deal with by ourselves, we will commonly look for others who can help. The one who is helping us changing from family member to close friend even to the friend of friend as the usage of social network goes on, and that is the idea of social support.

This research will utilize user's device and social network data as input of the mechanism and we will provide suitable recommendation list for problem-solving after analyzing the combination of contextual information (physical distance), social influence (social relationship), and expertise. By considering three main key factors we propose in this research are expertise, context, and social distance, we propose a new mechanism to provide real-time service for expert and companion finding. The mechanism can find suitable service supporters nearby the service requester to form any kind of problem-solving activity.

This paper is organized as follows: Section 2 discusses related works. Our proposed approach for nearby expert discovering is presented in Section 3. In Section 4 we explain our experiments to test our approach. Lastly, concludes the paper in Section 5.

2 Related Literature

Mobile crowdsourcing involves crowdsourcing activities that take place on smartphones or mobile platforms, frequently characterized by GPS technology. Various research papers explored crowdsourcing based on the use of mobile phones. [4] developed "Txteagle", a mobile crowdsourcing system that enables people to earn small amounts of money by completing simple tasks such as doing translation, transcription, and filling out surveys by using their mobile phones. Social support is a concept which involves the assistance provided by other people and the social network as a mediating construct of social support [5]. It provides people a trustworthy environment where could exchange information with friends. The close friendships' opinions in social networks could be seen as helpful sources of social support, for instance, providing answers to questions. Crowdsourcing can be regarded as one of the significant features for social support, which focus on commerce functional [1]. In this research, we are going to utilize the power of social support and mobile crowdsourcing to construct a mechanism to achieve our goal of accuracy and efficiency real-time problem-solve.

In last few years, social support has been widely used in knowledge management, such as expert-finding due to the growth of social networks [7]. Recently, a new trend, using social networks as crowd platforms and asking questions to their members, has emerged. Social platforms, such as Facebook, Twitter and LinkedIn, easily provide their members with several hundreds of known contacts, with variable expertise about the various questions. Choosing an expert in social networks, researches considered user's profile information and footprints in social media, using text mining and semantic analysis to find an expert. [2][8] considered user's historical records to derive user domain knowledge. [10] stated social media with geo-data such as check-in data and geo-tagged that can model people's mobility. [9] uses user's check-ins as

user preference. [2] focuses on selecting experts within the population of social networks, according to the information about the social activities of their users. In this research we will utilize social data to analysis service supporter's expertise degree and social distance with service requester to carry out our personalize recommendation for problem-solving.

3 The System Framework

The proposed social referral nearby friend discovering mechanism is an innovative model that a service requester can find other nearby friends (service supporter) with certain social relations and equipped with enough expertise at anywhere and anytime. In general, we can divide the social support behaviors into two cases: expert finding and companion finding. In the first case, if a service requester is encountering some difficulty and need assistance from others to deal with questions such as asking route or shopping. In the second case, the service requester are already at a specific location, and just want to find some companions, such as want to purchase big size products at a shopping mall, get group tickets to visit a museum and exhibition, play video games, etc.

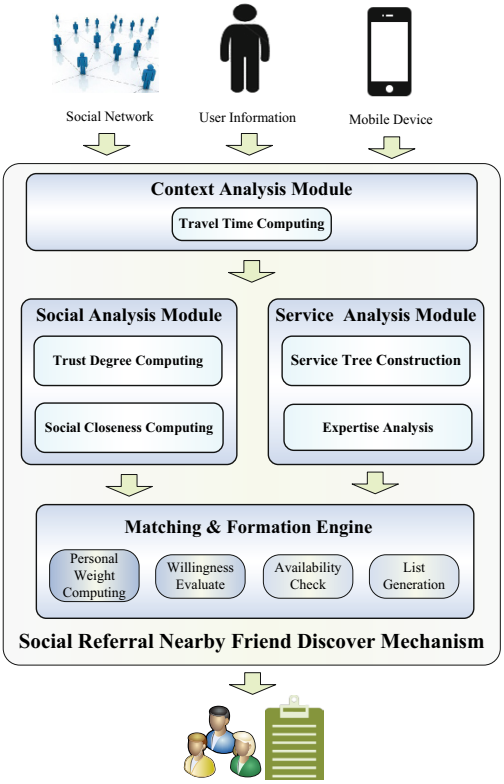


Figure 1.The System Architecture of SRNFD Mechanism

This mechanism detects the service supporter who is nearby the requester and computes their degree of social relationship and expertise to help service requester to evaluate who is most suitable for this problem-solving activity. Each user has three criteria of factors to consider whether to do the invitation or not: (1) context (2) social distance and (3) expertise. Each criterion has its own weight for users in a particular circumstance. After supporter availability check, we have top-k service supporters nearby the requester and we will output recommendation result in two formats for two scenarios. The framework of our system is illustrated in Figure 2.

The four main modules in the system architecture are as follows:

(1) Context Analysis Module: This module collects context data through the mobile devices. Based on the context environment sensed by the mobile device, we would use user's location information to realize where the users in certain area. We use Google Directions API to get user's travel time.

(2) Social Analysis Module: This module utilizes social data collected from social network and history data from database to analyze social trust and social closeness. Social trust is to determine the trust degree of service supporter while social closeness is to analyze the social ties of a service requester and supporter through their interactions on the social network.

(3) Service Analysis Module: This module utilizes user's profiles and hashtag data, including post, like and comment on social network to analyze service supporter's relevant expertise about the service. And the similarity between expertise and the target problem-solve service represent the degree how the service supporter are relevant to the target problem-solve activity.

(4) Matching & Formation Engine: This module receives the analysis results of the expertise analysis, context analysis, and social analysis module to process the willingness score. Using users' preference to calculate the personal weight within the three modules. By the result of the three modules and personal weights, we get a list of service supporter, then we send a message through the system to check whether the service supporter on the list is available or not right now. Finally, we generate the recommendation list with contact information. And after service been used, we ask users' feedbacks information in order to improve our recommendation system in the future.

4 Experiments

We develop a web-based mobile app using HTML5, CSS3, JavaScript and PHP to do the experiments. Specifically, a web-based app was developed on Apache HTTP server to collect data from users and use MySQL as the database in which data is accessed by using PHP. We select Facebook as the main social data source because it is one of the most popular social network platforms and provides FQL (Facebook Query Language) which allow us to get data easily. The location of users will be received by GPS in the mobile device at any time by using HTML5 GeoLocation API.

The experiment processes are as follows.

1. Distributing the System: we distribute our web-based app to potential users and ask them to distribute to their friends as many as possible.
2. Data Collection: Collect users' contextual data from mobile devices and social data on Facebook after authorized.
3. Data Process: Process data collected from users and compute the context, social and expertise analysis modules.
4. Personal Weight Collection: Use AHP method to calculate users' personal weight. Also generate average weight for different scenarios and use the result of questionnaire as the default.
5. Willingness Score Calculation: A user can also choose the default weight if he/she doesn't have specific preference.
6. Matching and Formation: Based on the willingness score, select top-k candidates with highest scores after available check, then output in two kinds of format for scenario 1&2.
7. Evaluation: The users are requested to fill in the feedback questionnaires as system record to improve system's recommendation.

We construct a web-based app on Apache HTTP server to collect data from users and use MySQL as the database. We use MySQL to construct the database because we can connect with database and get data by using PHP conveniently. Because of the privacy policy, when a user uses the web-based app via a mobile device, he will be asked the authority of Facebook first to allow us collect data, or we cannot get his social data. The location of users will be received by GPS in the mobile device at any time by using HTML5 GeoLocation API.

In the experiments, we collected 162 users as initial, at the end of our experiment, we have 59,297 of tags and 86,946 comments, 134,980 likes and 104,980 hashtag data and average number of initial user's friend is 336. In this experiment, we ask users to evaluate the accuracy of the system by review feedback and pick up those people who are actually helpful after recommendation. In this part of evaluation, we measure the accuracy of the referral recommendation mechanism by the equation below, where $\Phi_{recommended\ referrals}$ is the set of referrals on the recommendation list and $\Phi_{recommended\ referrals \cap helpful\ referrals}$ is the set of referrals who are truly useful in our recommended list. In this chapter, we mainly use this accuracy to measure the performance of our system.

$$Accuracy = \frac{|\Phi_{recommended\ referrals \cap helpful\ referrals}|}{|\Phi_{recommended\ referrals}|}$$

We compare the distinct candidate list generated from different approaches by comparing the accuracy. Here we use five approaches including (1) random, (2) E+S model (Expertise and Social Analysis), (3) E+C model (Context and Expertise Analysis), (4) S+C model (Social and Context Analysis) and (5) E+S+C model (Expertise, Social and Context Analysis) were chosen to compare accuracy. We ask user to evaluate how they think the outcome results generated from the random and combination of three factors are really helpful or not. Then we respectively look deep

into the influence on result for each factor. We can see the result from Figure 2 below. We can see from the results that our model, E+S+C, has the highest accuracy, followed by E+S and S+C. We think the reason is people care more about social relationship than context when trying to find a companion to do the problem-solving activity. Randomly generated recommendations unsurprisingly have the lowest accuracy

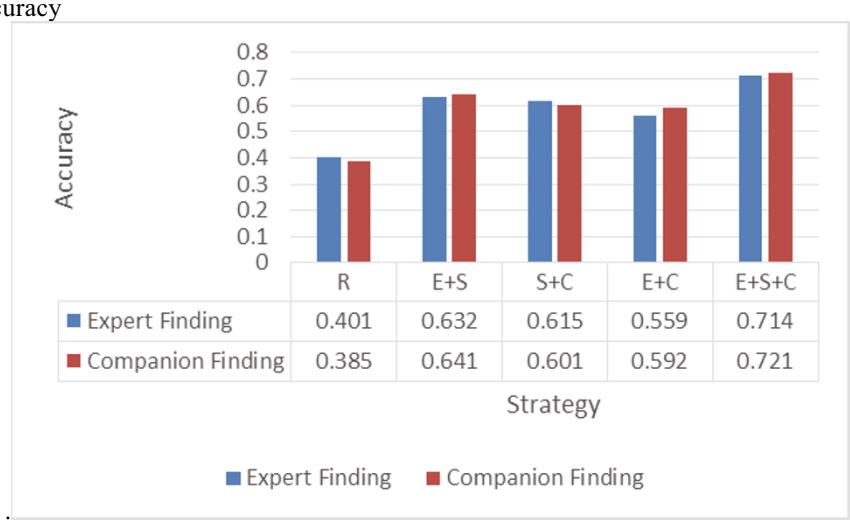


Figure 1. Accuracy of Strategies

A statistical t-test, shown in Table 1, is performed to understand the significance between our model and others. At the 95% significance level, the t-test results show that the significance is under 0.05. We can conclude that our proposed method is the best in comparison.

Table1. Statistical verification results of strategy

Paired Group		Mean	Std. Deviation	Std.error Mean	t	Sig. (2-tailed)
E+S+C	R	.31476	.08901	.01200	26.227	.000
	E+S	.08291	.08455	.01140	7.272	.000
	E+C	.09925	. 07453	.01005	9.877	.000
	S+C	.15582	.07189	.00969	16.074	.000

5 Conclusion

With the prevalence of mobile device and social network platforms, the involvement of social media has become daily routine for people around the world. Nowadays, combining several different social applications to generate new service has been an

irresistible trend. Therefore we propose a social referral nearby friend discovering mechanism for problem solving by recommending a list of experts. Our goal is to find nearby service supporters to help the service requester achieve his/her goal at minimum time and have maximum satisfaction. The criteria of expert recommending are analyzed according to three factors: context, social relations, and expertise. The evaluation results show that the proposed mechanism has higher scores on the evaluation of satisfaction.

There are some related issues desirable for further research. First, besides location data, there are still some other contextual factors, such as weather and nearby events, which might be useful to make recommendation more accurately. Second, in this study, we mainly use tags, comments, and likes as social data to compute. However, there are still other social data may help to compute the social degree between two people, such as pokes and the frequency of messages sent. Lastly, in the future, we might further expand the applications of the proposed system for more widely use, such as job-finding, group commerce recommendation, and male or female recommendation for dating.

References

1. Boujarwah, F., Abowd, G. Arriaga, R. (2012). Socially computed scripts to support social problem solving skills. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, ACM.
2. Bozzon, A., Brambilla, M., Ceri, S., Silvestri, M., Vesci, G. (2013). Choosing the right crowd: expert finding in social networks. Proceedings of the 16th International Conference on Extending Database Technology, ACM.
3. Davis, D. (2012). "More smartphone owners rely on location-based services, but fewer check in." from http://www.internetretailer.com/2013/09/12/more-smartphone-owners-rely-location-based-services.
4. Eagle, N. (2009). txteagle: Mobile crowdsourcing. Internationalization, Design and Global Development, Springer: 447-456.
5. Hall, A., Wellman, B. (1985). "Social networks and social support."
6. Howe, Jeff (June 2, 2006). "Crowdsourcing: A Definition". Crowdsourcing Blog. Retrieved January 2, 2013.
7. Li, Y.-M., Lee, Y.-L., Lien, N.-J. (2012). "Online social advertising via influential endorsers." International Journal of Electronic Commerce 16(3): 119-154.
8. Liu, D.-R., Chen, Y.-H., Kao, W.-C., Wang, H.-W. (2013). "Integrating expert profile, reputation and link analysis for expert finding in question-answering websites." Information Processing & Management 49(1): 312-329.
9. Yang, D., Zhang, D., Yu, Z., Yu, Z. (2013). Fine-grained preference-aware location search leveraging crowdsourced digital footprints from LBSNs. Proceedings of the 2013 ACM international joint conference on Pervasive and ubiquitous computing, ACM.
10. Zheng, Y., Capra, L., Wolfson, O., Yang, H. (2014). "Urban computing: concepts, methodologies, and applications." ACM Transactions on Intelligent Systems and Technology (TIST) 5(3): 38.
11. Ziegler, C.-N., Golbeck, J. (2007). "Investigating interactions of trust and interest similarity." Decision support systems 43(2): 460-475.

Implementation of multiple criteria decision analysis approaches in the supplier selection process: a case study

Dmitry Kisly[1], Anabela Tereso[2], Maria Sameiro Carvalho[3]

[1] Master Student in Industrial Engineering, Department of Production and Systems Engineering, University of Minho, 4800-058 Guimarães, Portugal
[2, 3] Department of Production and Systems Engineering / ALGORITMI Research Centre, University of Minho, 4800-058 Guimarães, Portugal

Abstract. Supplier evaluation and selection is recognized as a multiple criteria problem. Having considerable economic impact and influencing a competitive position of a buyer, supplier selection has been modelled by different multiple criteria decision analysis approaches. This case study focuses on the reported "relevance gap" between theoretical approaches to the supplier selection problem and practice. The research was conducted in a textile group, addressing a typical buying situation of a main raw material. The decision process was structured with weighted score, AHP and goal programming models. Three models elaborated have led to the very similar output, recognized as realistic and consistent by the decision makers. Acquired skills of multiple criteria decision analysis were considered as beneficial for supplier selection decisions.

Keywords: Supplier evaluation, supplier selection problem, multiple criteria decision analysis, MCDA, case study, AHP, goal programming.

1 Introduction

The supplier selection problem is seen as a four stage process: problem definition (i.e. the recognition of a need for a new supplier), the formulation of relevant decision criteria, qualification of potential alternatives and final selection decision [1].

The importance of supplier selection is a consequence of the weight of acquired goods and services in the total cost of a product, and of the exposure to suppliers´ performance [2]. The weight of purchasing in the total cost of a product varies from industry to industry and with the market´s conditions.

The multiple criteria nature of the supplier selection problem is widely accepted by researches, with qualitative and quantitative criteria involved in the analysis [3]. No closed list of supplier selection criteria might be elaborated, the set of applicable criteria is a function of the buying needs and of the market conditions.

Qualitative criteria are such as integration potential, financial stability, research & design capability, etc. Quantitative criteria might be of financial type (price and costs) and non-financial type (such as standards, specifications, quality control data, delivery performance data, etc.). There are three main evaluation criteria for the supplier

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_90

selection problem - quality, delivery and price (cost) [4], each of them is mentioned in more than 80% of papers on the topic [5].

In last decades the problem has been modelled by different techniques of multiple criteria decision analysis (MCDA). The modern trend is to combine techniques, being analytic hierarchy process (AHP), goal programming (GP) and fuzzy logic the most usual components of such integrated approaches [5][6].

At the same time, the growth of theoretical research on the subject does not imply *per se* a linkage with practice, so there is a stated gap between development and implementation of MCDA approaches to the supplier selection problem. Most of the papers are based on numerical examples with illustrative purposes, regardless of the dataset being real or simulated [1][3]. According to Arnott and Pervan [7], most research on decision support systems is disconnected from practice and enhancing case studies research is necessary.

This case study aims to describe and compare two distinct situations: real purchasing decision with and without application of MCDA techniques. The objective of this research work is to provide some additional insights on such critical aspects as decision makers' perception, feedback and difficulties of implementation.

The reminder of this paper is organized in 4 sections. Section 2 presents the methodology and description of the context of the case. Section 3 describes the initial dataset and following analysis, and elaboration of MCDA models. Section 4 focuses on the analysis of perceived value and end-user impact. Section 5 concludes the study.

2 Research method and context description

A case study methodology was adopted to focus on the relevance of theoretical approaches to the supplier selection problem to procurement practice. Methodological rigor is crucial for validity and reliability of case studies [8]. In terms of reliability, a case study protocol was elaborated and a considerable database was gathered with the following data: initial and final semi-structured interviews, initial dataset and transcriptions of meetings. This research has common features with other studies [1][3], and the possibility to compare results enhance the external validity. The different sources of data analyzed, derived from interviews, from field involvement and from key participant´s validation, contribute to construct validity of the study.

The case studied is of a Portuguese textile group, with its own trademark but also working for world-known labels. The Group is vertically organized: tissue production, design, production and distribution of final product. Purchasing represents about 40% of total cost of production, with yarn, the principal raw material, weighting 80-85% of purchasing costs.

The number of parameters involved in the analysis of potential yarn suppliers by the Group has been increased in last years. Criteria to include such new parameters are: relevance for product quality and impact on production process. There are two types of sources of information necessary for the Purchasing Department: internal clients (Production and Quality) and external expertise in textile quality control (*USTER*®) [9]. Such semi-structured analysis, albeit without underlying MCDA approach, has been proved successful: there were reported increments up to 20% in

production capacity, with less waste and line-stops. The next step would be representation of the supplier selection processes as a MCDA problem, improving internal and external communication and analysis in search of overall optimality.

3 Elaboration of multiple criteria decision models

3.1 Initial dataset

The initial dataset provided was based on a recent and typical purchasing situation; two decision makers from Purchasing and Production departments were involved. The objective was to choose a supplier of cotton yarn on Title NE50/1, to be delivered monthly in 6 equal orders of 5000 kg.

Criteria involved, target/upper values and data for supply alternatives A, B, C, D and E (i.e., performance of alternative i in criteria j, s_{ij}) are shown in Table 1, as formulated by the decision makers. The relative importance of criteria is expressed in a scale from "5" to "1", i.e. from the most to least important.

Table 1. Dataset on criteria, target/limit levels and matrix of alternatives, as initially formulated

Criteria	Value	Target/limits	A	B	C	D	E
Hairiness, max	5	4.5	4	4	4.5	5.09	3.5
Contamination, per kg, max	5	0.5	0.5	0.5	0.5	0.5	0.5
Thick places (+50%), max	4	22	22	42	21.3	22	6
Title (NE)	3	50+/-0.5	50	50	50.66	49.5	50
Coef. of variation %, max	3	1.4	1.2	1.4	0.97	1.2	1.2
Thin places (-50%), max	3	6	5	5	2.5	3	1
Neps (+200%), max	3	76	40	94	55.3	86	22
Twist (1/m)	3	[3.5 - 4]	3.7	3.75	3.52	3.75	4
Unit price, €/kg, max	2	4.6	4.6	4.6	4.8	4.5	4.85
Availability for order, kg	1	30000	yes	yes	yes	yes	yes

Some important conclusions were made in this preliminary stage through analyses and discussion with decision-makers. All criteria were quantitative, measured in different scales (or indexes); all data was treated deterministically, with possibility to carry out laboratorial samples quality testing. In this particular case it was decided to order from only one source, to guarantee the lot´s homogeneity.

Contamination criterion is redundant for this particular case, but should not be excluded. *Availability* criterion must be transformed in capacity constraint; in this case any supplier must have capacity equal to or greater than monthly (and total) demand, to be considered as a valid alternative for the final stage.

For the remaining criteria minimizing is the sense of optimization, i.e. “less is better”, with exception of two dual-side criteria where “exact is better”. These dual-side criteria are *Title (NE)* and *Twist*. *Twist* criterion seems like interval of acceptance (as initially formulated), but it is really dual-side target value. The value of 3.8 was defined as target, with values of 3.5 and 4.0 as rejection thresholds. In such cases a sum of dual-side deviations should be minimized.

There is one important issue related with target values: only one of the 5 alternatives, chosen for final analysis, actually fulfils all limits - supplier A. Consequently, the nature of the target/upper limits is not clear: are they rejection or aspiration thresholds? To simplify the final selection, compensatory decision rule should be employed in that stage. Thus, all alternatives out of the feasible area must be excluded by defined rejection thresholds (veto levels) on respective criteria.

3.2 Weighted score model

Weighted score models are widely used by professionals, being a common model recommended in procurement and supply chain management manuals [10]. It is worth mentioning that this tool is familiar for decision makers and is normally used by the Group in suppliers’ performance evaluation.

A sum of the scores of a supplier multiplied by relative weights of each criteria, gives a total score of the supplier. Possible subjectivity in defining criteria weights [11] and proper scaling of criteria values are known difficulties for the implementation of simple weighted models.

In order to define criteria relative weights objectively, analytic hierarchy process (AHP) was used. This well-known decision-making heuristic, based on pairwise comparisons, was introduced by Saaty in 1981 [12]. Thus, criteria were compared to each other in a 1 to 9 scale, with 1 meaning “equally important” and 9 meaning “extremely more important”. The resulting pairwise comparison matrix and relative weights of criteria (W_j) are presented in Table 2.

Table 2. Calculation of criteria relative weights with AHP

Criteria	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	W_j
(1) Hairiness	1	1	2	4	4	4	4	4	5	0.2430
(2) Contamin.	1	1	2	4	4	4	4	4	5	0.2430
(3) Thick places	0.5	0.5	1	3	3	3	3	3	4	0.1610
(4) Title (NE)	0.25	0.25	0.33	1	1	1	1	1	3	0.0645
(5) CV%	0.25	0.25	0.33	1	1	1	1	1	3	0.0645
(6) Thin places	0.25	0.25	0.33	1	1	1	1	1	3	0.0645
(7) Neps	0.25	0.25	0.33	1	1	1	1	1	3	0.0645
(8) Twist	0.25	0.25	0.33	1	1	1	1	1	3	0.0645
(9) Unit price	0.2	0.2	0.25	0.33	0.33	0.33	0.33	0.33	1	0.0303

Decision makers showed preference in developing the models in the familiar Excel spreadsheet interface to avoid investment of time and money in software in this experimental stage. Consistency ratio was calculated in the same Excel form and was equal to 0.014; the calculation was repeated in BeSmart2 free software [13], with the same result. It means that the matrix is almost consistent, apparently due to the initial criteria ordering.

The criteria weights obtained were considered realistic by decision makers, being necessary to explore the low weight of *Price* criterion. There were discussed two complementary explanations. Firstly, some lot of yarn, which doesn´t meet upper limits of the technical specifications, has drastically diminished its value. The second explanation concerns the decision makers´ knowledge that price might vary more or less 10% around the target value. Hence, *Price* criterion was "undervalued" because price is expected to fluctuate within known and limited interval.

In order to solve the scaling problem, the following linear normalization procedure was applied to 7 criteria (one-side) of minimization type:

$$r_{ij} = \min\{s_{ij}\}/s_{ij} \quad \textbf{(1)}$$

Where s_{ij} is an actual value of alternative i on criterion j, r_{ij} is a score of alternative i on criterion j, with $i = 1, 2, \ldots, m$, $j = 1, 2, \ldots, n$, being m the number of alternatives and n the number of criteria. Alternative(s) with the lowest value, on a particular criterion, will be scored as equal to "1", other alternatives will be scored proportionally less than "1" (for maximization the inverse should be used).

For two dual-side criteria, decision-makers suggested to divide the range of acceptable values in intervals with declining utility function. Mathematically, it is the same as the calculation of the membership function of triangular fuzzy numbers, as described in [14]. Having alternative(s) matching the exact target value, data will be already normalized in the same sense as in equation (1), otherwise the inverse of (1) is applied.

In the process of analyzing different normalization schemes, attention was drown to the question of the distinction between rejection and aspiration levels on criteria. Rescreening performed, decision makers decided to drop the supplier B, which exceeds largely rejection thresholds on *Thick places* and *Neps*. Supplier E, which does not meet *Price* criterion, was kept in analyses, being price a mere target value. Options C and D are kept; zero score will be assigned to alternatives on criteria where original limits are matched or exceeded. For *Thin places* criterion the indifference level of "3" was established.

With the purpose to demonstrate sensitivity analysis, the relative criteria weights were recalculated with Simple multi-attribute rating technique (SMART), as described in [13]. Having significant differences between relative weights obtained with AHP and SMART, AHP criteria weights were hold up as more realistic ones.

Normalized data, two types of criteria weights and final total scores of suppliers are shown in Table 3. Total scores of alternatives in percentage display the proximity to the ideal solution, in accordance with the preference set of the decision-makers.

Supplier D, the cheapest one, is clearly a dominated option; supplier E, the most expensive one, is considered as the best alternative. Supplier A, the only one which does not violate initial target/upper limits, is the second best alternative. Different relative criteria weights have no significant impact on total score of suppliers. The

way in which the data was structured and visualized was innovative to the decision makers, but final scores of suppliers are consistent with their experience.

Table 3. Weighted score model

						Criteria weights	
Criteria	Ideal vector	A	C	D	E	AHP	SMART
(1) Hairiness	3.5	0.8750	0.7778	0.0000	1.0000	0.2430	0.1779
(2) Contamin.	0.5	1.0000	1.0000	1.0000	1.0000	0.2430	0.1779
(3) Thick places	6	0.2727	0.2817	0.2727	1.0000	0.1610	0.1383
(4) Title (NE)	50	1.0000	0.0000	0.0000	1.0000	0.0645	0.0988
(5) CV%	0.97	0.8083	1.0000	0.8083	0.8083	0.0645	0.0988
(6) Thin places	3	0.6000	1.0000	1.0000	1.0000	0.0645	0.0988
(7) Neps	22	0.5500	0.3978	0.0000	1.0000	0.0645	0.0988
(8) Twist	3.8	0.8000	0.0800	1.0000	0.0000	0.0645	0.0711
(9) Unit price	4.5	0.9783	0.9375	1.0000	0.9278	0.0303	0.0395
Total score, AHP, %		77.17	66.56	49.85	92.09		
Total score, SMART, %		75.91	63.49	50.50	90.71		

3.3 Goal programming model

Dropped one source strategy, in this or future buying decisions, the weighted score model will be of little use. If individual suppliers´ capacities meet total of demand, the final choice will be the same – to assign the whole order to the "best" alternative. But will it be the most efficient solution? Mathematical programming models are indicated in such decision situations as multiple-source, multiple-product and multiple-period decisions, with lot-sizing problem and possible price discounts [15].

Goal programming is one of the main approaches for the supplier selection problem [5]. With expressed underlying philosophy of satisfying multiple objectives and without evidence of different priorities levels, weighted goal programming model was chosen.

Model indices, parameters and decision variables are stated as follows:

i set of suppliers, $\forall i \in \{1, \ldots, 4\}$
j set of criteria, $\forall j \in \{1, \ldots, 9\}$
k_j set of goals to achieve on criteria j
s_{ij} performance of supplier i on criterion j
d buyer´s demand
c_i supplier´s i capacity
w_j relative weights of criteria j, assigned by the decision makers
x_i decision variable of order quantity, allocated to supplier i
n_j underachievement deviational variable on criterion j
p_j overachievement deviational variable on criterion j

Objective function is expressed as follows:

$$\min a = w_1p_1/k_1 + w_2p_2/k_2 + w_3p_3/k_3 + w_4(n_4 + p_4)/k_4 + w_5p_5/k_5 + w_6p_6/k_6 + w_7p_7/k_7 + w_8(n_8 + p_8)/k_8 + w_9p_9/k_9 \quad (2)$$

Subject to:

$$\sum x_i = d, \forall i \in \{1, \ldots, 4\} \quad (3)$$

$$c_i \geq d, \forall i \in \{1, \ldots, 4\} \quad (4)$$

$$\sum x_i s_{ij} + n_j - p_j = k_j, \forall i \in \{1, \ldots, 4\}, \forall j \in \{1, \ldots, 9\} \quad (5)$$

$$n_j, p_j \geq 0, \forall j \in \{1, \ldots, 9\} \quad (6)$$

$$x_i \geq 0 \text{ and binary}, \forall i \in \{1, \ldots, 4\} \quad (7)$$

The formulation allows minimization of deviations from stated goals on 9 criteria: deviational variables are multiplied by the weighting vector w_j of criteria importance (given by Table 2) and divided by the set k_j of targets on criteria to obtain normalized unites [14]. Performance data of supplier i on criterion j, s_{ij}, is given in the Table 1. The problem solution was obtained using Solver from Excel and a set of experiences was performed to familiarize decision makers with the mathematical programming.

With initial set of targets/limits used as first set of goals, the solution was to order to the supplier A. The solution is consistent with the fact that supplier A is the unique one which does not violate the initial set of targets. But such result is based on pessimistic setting of targets.

Switching to more rigorous set of targets (4, 0.5, 22, 50, 1.2, 3, 55.3, 3.8, 4.6) or to the ideal vector as set of targets, the solution is to order to supplier E, which is consistent with the output of the weighted score model. Only two criteria, *Switch* and *Price* were not completely satisfied.

The next step was relaxing of capacity restriction (4) and of the binary condition of decision variables x_i (7), with the same target setting. The solution found was to split the order between all suppliers in the following proportions: A: 0.399, C: 0.102, D: 0.125 and E: 0.374. Thus, the achievement function value decreased 7.47 times, with total cost of solution reduced from 145500€ to 141043€ (less 3.06%). Only the price criterion was slightly overachieved.

In this way, two different policy scenarios (one- and multiple-sourcing strategies) and "supplier A" scenario might be visualized and compared, with sensitivity analysis facilitated, providing an analysis tool for the decision makers.

Such factors as familiar Excel interface, and known, important but not very complex decision process, were crucial to draw attention and genuine interest of decision makers to the approach based on mathematical programming. With such experience it will be easier to assure openness and acceptance of more complex decision modelling with integer variables, additional policy and systems constraints.

3.4 Analytic hierarchy process model

In the final stage of the case it was commented by the decision makers that *Title (NE)* dual-side criterion might be seen as asymmetric. It is a density index - yarn lot with

less than 50 is thicker, provoking major consumption. Thinner lots, with *Title (NE)* more than 50, also have diminished value, but without consumption problem. Therefore, the utility function on this criterion might be seen as linearly decreasing to the left of the target level, and non-linearly to the right.

This specific issue was not seen as very relevant, but the pertinent question of an appropriate technique to introduce the concept of non-linearity was emerged. Already used, AHP technique is a decision making heuristic, able to aggregate tangibles and intangibles factors and non-linearity [11]. The AHP model with three levels was elaborated: supplier selection level, criteria level and alternatives level.

The vector of relative weights of criteria was already calculated for the previous models, as shown in Table 2. Comparisons on one-side criteria were based on numerical data, with no need to calculate consistency ratios. Performance of alternatives on dual-side criteria was assessed on a 1 to 9 scale, with asymmetry of *Title (NE)* criterion taken into account; consistency ratios on *Title (NE)* and *Twist* criteria were 0.00599 and 0.00597 respectively. Resulting data of AHP model is shown in Table 4.

Table 4. Final AHP evaluation matrix

Criteria	Weights	A	C	D	E
(1) Hairiness	0.2430	0.2619	0.2328	0.2059	0.2994
(2) Contamination	0.2430	0.2500	0.2500	0.2500	0.2500
(3) Thick places	0.1610	0.1493	0.1542	0.1493	0.5473
(4) Title (NE)	0.0645	0.4251	0.0938	0.0561	0.4251
(5) CV%	0.0645	0.2360	0.2920	0.2360	0.2360
(6) Thin places	0.0645	0.1034	0.2069	0.1724	0.5172
(7) Neps	0.0645	0.2496	0.1805	0.1161	0.4538
(8) Twist	0.0645	0.3221	0.0704	0.5371	0.0704
(9) Unit price	0.0303	0.2545	0.2439	0.2602	0.2414
Total weights of suppliers on criteria		0.242	0.204	0.215	0.339
Scores of suppliers on criteria, %		71.54	60.20	63.40	100.00

Recognized as realistic and consistent, the output of AHP model differs from the one of weighted score model: suppliers E and A are maintained as best alternatives, but suppliers C and D switched their ranking position. This score differences are consequent of the fact that AHP model maintains intrinsic values of alternatives on criteria even when upper limits are matched or surpassed. One more time it highlights the importance of a clear definition of rejection levels on the screening, pre-selection stage of the supplier selection problem.

With 11 tables designed, the process of modelling was not really difficult or work intensive, but using of decision-support software, such as Be Smart2, makes the process more fluent. With rejection levels, nature of data and of utility function defined, the use of AHP model to evaluate and select suppliers was seen as an approach very intuitive, objective and universal. AHP was considered as an excellent

initial decision-making technique; also it's potential to make part of integrated approaches and to provide input data for mathematical programming was commented.

4 Evaluation and feedback of the decision makers

A final interview was dedicated to the feedback and analyses of perceived value by the decision makers. The framework for decision makers´ evaluation and validation, developed by Boer and Van der Wegen [1], served as a base for this interview.

It was found that modelling of the real purchasing decision was performed properly, matching the decision situation in 90-95%. Some criteria, considered unimportant, were excluded from the final decision process by the decision makers, but all available information was incorporated, inclusively opinions and experience. Capacity of the decision models to structure, facilitate and enhance internal and external communication was strongly recognized. Models elaborated were seen as flexible to include new aspects of the problem and to be extended or used in a different context.

The process of structuring and visualization of the supplier selection problem was found practically useful, giving mathematical tools to analyze multiple criteria, especially *USTER*® parameters, in the aggregated manner. Previously the process was more experience-based, subjective and qualitative, without aggregation approach.

The real output of the supplier selection was to order from the supplier A, the second best alternative. The supplier E was seen as the best alternative but only with declared level on *Thick places* criterion confirmed in laboratory. Tests performed accused higher levels on this criterion, though the supplier E was dropped. All three models defined these two suppliers as the best options, the decision modelling outcome was considered acceptable and consistent with the decision makers´ experience.

Elaboration of such decision support models had no direct monetary costs; cognitive efforts and time investment were considered justified, bringing new skills and insights to the decision making process.

Such concepts as rejection levels, compensatory decision rule, quantitative and qualitative data, sensitivity analysis, non-linearity and asymmetry were seen as valuable contributes to practical decision making skills of managers. Albeit the problem of yarn supplier selection is well-known for the decision-makers, decision modelling process actually brought some new knowledge and angles of it. In long-term perspective, the interest to keep implementation of MCDA techniques in the procurement practice was firmly assumed by the decision makers.

5 Conclusions

The process of decision modelling with analysis of relevant criteria and of rejection/aspiration levels, criteria weights calculation, normalization procedures and goal programming formulation, was considered as benefic to the deep understanding of the decision problem. Structured, aggregated and visualized data enforces analysis

and facilitates objective final choice decision. Approaches applied have demonstrated potential to be extended within and out of the context of the supplier selection problem.

The research trend of more and more complex theoretical modelling of the supplier selection decisions may not be beneficial for the problem of practical implementation. Modelling a typical and important, but not very complex, decision process with some basic MCDA techniques was crucial to capture attention of managers and to gain synergies. Positive experience with realistic and useful outputs, acquired knowledge and skills of the decision makers (the capacity to analyze a decision problem and the ability to apply different approaches) showed to be the important elements for the successful implementation of MCDA by procurement professionals.

Acknowledgment. This work has been supported by *FCT - Fundação para a Ciência e Tecnologia* in the scope of the PEst-UID/CEC/00319/2013.

References

1. De Boer, L., Van Der Wegen, L. L. M.: Practice and promise of formal supplier selection: A study of four empirical cases. J. Purch. Supply Manag. 9(3), 109–118 (2003)
2. De Boer, L., Labro, E., Morlacchi, P.: A review of methods supporting supplier selection. Eur. J. Purch. Supply Manag. 7(2), 75–89 (2001)
3. Bruno, G., Esposito, E., Genovese, A., Passaro, R.: AHP-based approaches for supplier evaluation: Problems and perspectives. J. Purch. Supply Manag. 18(3), 159–172 (2012)
4. Jadidi, O., Zolfaghari, S., Cavalieri, S.: A new normalized goal programming model for multi-objective problems: A case of supplier selection and order allocation. Int. J. Prod. Econ. 148, 158–165 (2014)
5. Ho, W., Xu, X., Dey, P.K.: Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. Eur. J. Oper. Res. 202(1), 16–24 (2010)
6. Chai, J., Liu, J.N.K., Ngai, E.W.T.: Application of decision-making techniques in supplier selection: A systematic review of literature. Expert Syst. Appl. 40(10), 3872–3885 (2013)
7. Arnott, D., Pervan, G.: Eight key issues for the decision support systems discipline. Decis. Support Syst. 44(3), 657–672 (2008)
8. Gibbert, M., Ruigrok, W., Wicki, B.: What passes as a rigorous case study? Strateg. Manag. J. 29(13), 1465–1474 (2008)
9. Uster Technologies, http://www.uster.com
10. Monczka, R.M., Handfield, R.B., Giunipero, L.C., Patterson, J.L.: Purchasing and Supply Chain Management, 4th edition.South-Western Cengage Learning, Mason (2009)
11. Ghodsypour, S.H., O'Brien, C.: A decision support system for supplier selection using an integrated analytic hierarchy process and linear programming. Int. J. Prod. Econ. 56/57, 199–212 (1998)
12. Figueira, J., Greco, S., Ehrgott, M.: Multiple Criteria Decision Analysis: State of the Art Surveys. Springer Science + Business Media Inc., New York (2005)
13. Tereso, A., Amorim, J.: BeSmart2: A Multicriteria Decision Aid Application. New Contributions in Information Systems and Technologies, in Advances in Intelligent Systems and Computing, vol. 353, pp. 701–710. Springer International Publishing (2015)
14. Jones, D., Tamiz, M.: Practical Goal Programming. Springer US, Boston (2010)
15. Aissaoui, N., Haouari, M., Hassini, E.: Supplier selection and order lot sizing modeling: A review. Comput. Oper. Res. 34(12), 3516–3540 (2007)

Computer-aided support system for metal diagnosis of patrimonial objects

Antoine Rosselet[1], Marcel Grosjean[1], Christian Degrigny[2] and Cédric Gaspoz[1]

[1]Information Systems and Management Institute, HES-SO // University of Applied Sciences Western Switzerland, HEG Arc, Neuchâtel, Switzerland
{antoine.rosselet, marcel.grosjean, cedric.gaspoz}@he-arc.ch

[2]Haute École Arc Conservation-restauration, HES-SO // University of Applied Sciences Western Switzerland, HE-Arc CR, Neuchâtel, Switzerland
christian.degrigny@he-arc.ch

Abstract. Metal diagnosis of heritage objects is a difficult task performed by conservators, mainly due to the fact that invasive techniques are not allowed on these artifacts. Therefore, conservators have developed diagnosis methods based on the observation of the corrosion forms of the objects. However, although these methods are useful to share a common representation of one specific object, they are very difficult to use to compare or search for objects presenting similar corrosion forms. To support the comparison of different objects, we propose a new support system built upon these methods. This paper presents an innovative way to use C-K theory in order to build an artifact in an interdisciplinary context. The resulting artifact integrates concepts and knowledge borrowed from both the conservation-restoration and the information systems fields.

Keywords: Decision support, design theory, interdisciplinary research.

1 Introduction

Besides advanced technical skills, the treatment of ancient heritage metal artifacts requires a univocal identification of the metal composing the artifacts. Due to their unique nature, any analysis must be carried out in a non-invasive way. This implies that no physical sampling can be performed on them for diagnosis purposes. Bertholon [1] developed a new methodology to standardize the description of corrosion forms observed macroscopically or in detail using a microscope. They are represented as stratigraphies comprising multiple strata, each representing a specific layer of the corrosion forms. Such graphical descriptions can be used by conservators to locate the limit of the original surface. Furthermore, active corrosion layers might be identified within the stratigraphy. Therefore, this methodology can orientate the conservation treatment to be employed [2].

Currently, there is no known support tool to assist conservators in using this methodology to perform non-invasive diagnosis of ancient metal artifacts. Due to the pencil/paper nature of the method, it is extremely difficult to find similar

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_91

stratigraphies across publications or databases. In order to support the broader diffusion of the method, its initiators are looking for a tool to assist conservators during the identification process of the metals composing the artifacts [3]. To support the design process of an integrated decision support system (DSS) aimed at supporting non-invasive diagnosis on ancient heritage metal artifacts, we decided to use the C-K theory framework. "C-K theory bears upon existing design theories, yet it re-interprets these theories as special cases of a unified model of reasoning" [4]. C-K theory integrates creative thinking and innovation in its core, giving space for the emergence of something unknown from what is known. Thus, in the context of interdisciplinary research characterized by our topic and defined as "a process of answering a question, solving a problem, or addressing a topic that is too broad or complex to be dealt with adequately by a single discipline, and draws on the disciplines with the goal of integrating their insights to construct a more comprehensive understanding" [5], C-K theory will support the emergence of a more comprehensive solution of the problem, relying on the distinction of the spaces of "Concepts" (C) and "Knowledge" (K) from multiple fields [4].

Borrowing concepts and knowledge from information systems (IS) and conservation-restoration (CR) fields, we were able to design a new tool aimed at supporting the non-invasive diagnosis of heritage metal artifacts. In the first part of this paper, we briefly present C-K theory and the issues raised by the current application of Bertholon's methodology [1] in the context of the diagnosis of heritage metal artifacts. In the second part, we present the design process of an integrated decision support system aimed at supporting the stratigraphic methodology during the diagnosis process of heritage artifacts. In the third part, we discuss how C-K theory was able to support the process and, moreover, how we were able to create new knowledge (K) from the process itself.

2 C-K Theory in an Interdisciplinary Research Context

C-K theory was invented and has been developed by Hatchuel and Weil [6] since the early 2000s. The authors proposed what is called a unified design theory. Its name is composed of the first letter of "Concepts" and "Knowledge", as it is built around the distinction between and yet the complementarity of these two components. Indeed, it is based on the idea that the dynamics of design can be modeled "as a joint-expansion of a space of concepts (C-space) and a space of knowledge (K-space)" [4].

On the one hand, K is a "knowledge space, the space of propositions that have a logical status for a designer D" [4]. The idea of a logical status of a proposition is "an attribute that defines the degree of confidence that D assigns to a proposition" [4]. On the other hand, a concept is "a proposition, or a group of propositions that have no logical status in K" [4]. This means that "when a concept is formulated it is impossible to prove that it is a proposition of K" [4].

Given the interdisciplinary nature of this research, C-K will support bridging the concepts and knowledge from two independent fields in order to build a unified response to an interdisciplinary problem.

2.1 C-K Theory in Practice

C-K theory breaks down a general concept into smaller parts, each of which relies on knowledge or activates knowledge. At the end of the process, a design is found when new knowledge is generated from a concept, i.e. when a concept can be validated. During the design process, concepts can be validated. However, as long as they do not represent a satisfactory design, they are expanded further. Thus, both the concept and the knowledge spaces need to expand to lead up to a feasible solution. This expansion takes numerous forms, because it can in both cases come from C or K. In C-K theory, there are four operators that fall into two categories: external and internal. The following table sums up the different expansion cases (Table 1):

Table 1. The four operators in C-K theory

–>	C	K
C	Internal	external – conjunction
K	external – disjunction	internal

From C to K (C → K): this is a concept that gets validated by an expert, an experimental plan, a prototype, etc. This operator comes from C and expands the available knowledge in K [4].

From K to C (K → C): this illustrates a knowledge that is transformed into a concept. It generates alternatives in the C-space that come from the knowledge space [4].

From C to C (C → C): starting from a concept, the C-space is expanded by partitioning it. The C-space is tree-structured, as several expansions are generated from a single concept [4].

From K to K (K → K): this is an expansion of the K-space that comes from other knowledge. For instance, proving new theorems constitutes such an expansion, as they mobilize existing knowledge [4]. The required knowledge can then lead to K → C operators and an expansion of the C-space.

The modeling of C-K theory starts with a disjunction, which generates a first concept that constitutes the basis for the expansion of both the C- and K-spaces. It ends when a satisfactory conjunction is found, when a product or a solution that is recognized to be feasible is created from a concept [4].

In the case of an interdisciplinary research, where design needs to emerge from knowledge of several fields of study, the C-K theory proves to be particularly useful. In a project-based study called “Design and Application of Intelligent Electronic Systems” [7], a feasible design was found using the C-K theory and an interdisciplinary approach. Engineering and design students attended the same course and then were asked to create an object that embedded an electronic system, each group borrowing knowledge from its own field of study and from the course they attended. The study concluded that collaboration between engineering and design students through brainstorming – which created disjunctions and conjunctions by

activating knowledge – helped to design an object that met the initial requirements. Moreover, the use of C-K theory showed how new concepts were generated by simultaneously applying knowledge from the design and the engineer fields, while expanding the K-space.

Along with the development of the C-K theory, Hatchuel [6] also introduced the idea of "K-relativity". He declares that "a specialist may see a fantastic innovation in something where we see nothing new, as the expansion is invisible to us. Our ability to recognize an expansion can depend on our sensitivity, our training or the knowledge at our disposal" [6]. Collective design and K-relativity are both embedded in an interdisciplinary context, as designers have other knowledge or different interpretation of a given knowledge. This interpretation will depend on their respective field of study. Chou [7] deals with this issue by adding tags to concepts and knowledge in his use of the C-K theory. Thus, in his case, concepts and knowledge can either be formulated by engineering students, design students, or both. This led to new and technique-proven designs.

2.2 Interdisciplinary Research Supporting the Non-invasive Diagnosis of Heritage Artifacts

In order to design a tool which is usable and which constitutes an added value for the conservators, researchers in CR and in IS have to collaborate closely with each other. Indeed, it is from an interdisciplinary context and a gathering of knowledge that a first solution has been found. Building on this complementarity, actionable data structures have been designed. They constitute the first step for further development and refinements [3].

If each department had worked alone, limits would have been reached rapidly. As far as the CR department is concerned, they use a methodology developed by Bertholon [1] that allows them to model stratigraphies using his framework and nomenclature. Using a pencil/paper method and/or Adobe Illustrator [8], they are able to represent the stratigraphies. Then they can make visual comparisons between different artifact structures. However, they cannot go any further by themselves, as they would need knowledge from the IS field to implement automatic comparison and matching of stratigraphies under construction with those in a database.

With regards to the IS department, we also noticed that techniques borrowed exclusively from the IS field (e.g. image recognition) could not address the issues raised by the conservators in a satisfactory way [3]. Indeed, the tool needs to take the business-specific aspects of CR and their methods into account, as the end users are the conservators, who are used to working with their own methodology.

Thus, in the final step of DSS conception, we merge the knowledge that comes from both of these fields (CR and IS) to expand the C- and the K-spaces. We can therefore achieve our goal and design an appropriate tool to be used by the conservators.

3 C-K Supported Design Process of a DSS

In our use of the C-K theory, the starting concept emerged from the CR department. They wanted a tool that could help them compare a corrosion form of an artifact under investigation with those of a database. Then we used C-K theory to break it down using C → C and K → C. This framework helped us find a feasible solution that met their requirements.

As far as the K-space is concerned, we focused our research on decision support systems (DSS), as the knowledge we have in this field was useful for fulfilling the needs of the researchers in CR [3]. This notion of DSS will play an important role in the expansion of the K-space (K → K) in our process and in the design of the new tool. That is why DSS constitutes the primary knowledge in our framework.

We can then decompose the first concept into two categories: support of invasive and non-invasive analysis. The first one would be to support sampling techniques used on ancient artifacts. This triggers a C → K conjunction which mobilizes the knowledge the conservators have about such methods which are used on non-heritage artifacts. However, the professional ethics prevent the researchers from applying such techniques to heritage artifacts which are meant to be restored, as these techniques can permanently damage the object. Therefore, our tool will need to support non-invasive analysis. This implies a visual observation of the artifact in the first place and a disjunction (K → C) (Fig. 1).

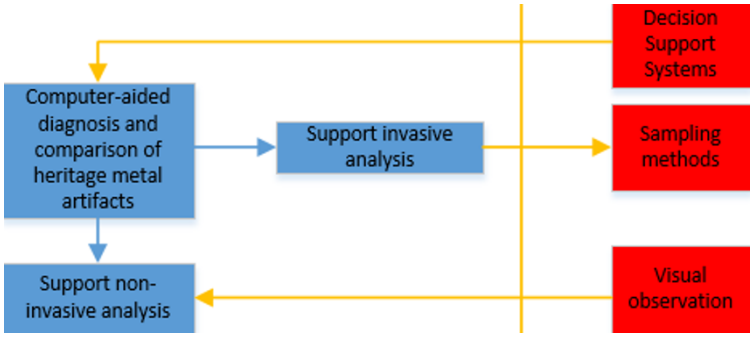


Fig. 1. Starting concepts, knowledge and their links in the C-space (left) and the K-space (right)

Further refinements of the concept of supporting non-invasive analysis based on visual observation leads to a new decomposition between human analysis and computer-automated analysis. As far as the latter is concerned, we thought about the possibility of mobilizing the knowledge we have about image recognition. If we followed this path, a tool that would support such a method could be implemented. Therefore, the knowledge which results from this conjunction constitutes a possible solution. However, we wanted to enquire more deeply about other potential developments, as we are only at the beginning of the C-space decomposition. In addition, we did not have the necessary technology to implement a solution based on image recognition. That would have also meant that most of the process would have been automated, and this is not what the conservators wanted.

Unlike computer-automated analysis, human analysis is based on the use of a binocular microscope in order to capture more information about the corrosion forms of the object. Using binocular vision could also be deduced from the knowledge about visual observation, as it represents a more accurate tool to perform non-invasive diagnosis (Fig. 2). Hence, we can notice that a knowledge can simultaneously emerge from a conjunction and an internal expansion of the K-space, as suggested by Hatchuel [9] in an illustration of the C-K theory.

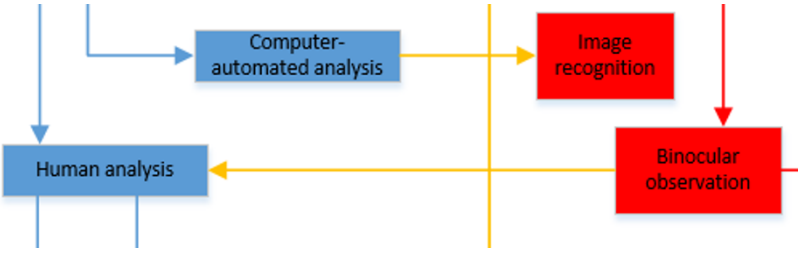


Fig. 2. The concept of a support for non-invasive analysis can be broken down into computer-automated and human analysis

Concerning the K-space, new knowledge is activated from the use of binocular vision to perform relevant diagnosis. Indeed, a closer look on the metal artifacts which are analyzed by the conservators shows that they are corroded and therefore composed of layers which can be more or less distinguishable, depending on the artifact. The knowledge about the layers which form the structure of the artifact is well established for the conservators. Indeed, as we saw previously, Bertholon [1] has developed a stratigraphy model that is used by conservation professionals to categorize the different layers according to their families and comprehend the ongoing corrosion processes.

This is a critical knowledge as the conservators want to standardize their analysis around this method. Consequently, human analysis can further be broken down into two other concepts: a representation of the artifact layers based on the model developed by Bertholon or a simple drawing of the layers. The drawing could be performed either by hand on paper or with the help of a computer drawing software [8] (Fig. 3), which allows the user to draw what he sees without following any particular technique. This drawing is often performed by the conservators as a preliminary task to catch a glimpse of the artifact strata corrosion structure. As this method is currently used by conservators, they already have knowledge about this option. Thus, there is a conjunction from the concept “Drawing” to the knowledge “Drawing software”.

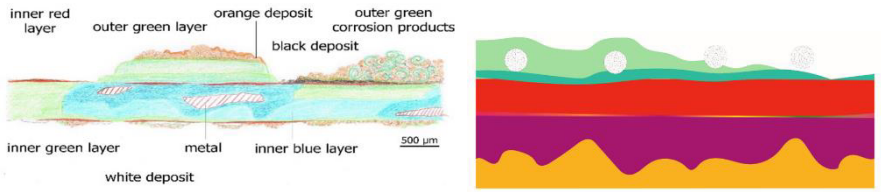


Fig. 3. Drawing using a pencil/paper method (left) and Adobe Illustrator [8] (right) © HE-Arc CR

Nevertheless, what really interests the conservators is a solution that utilizes Bertholon's conceptual model. Hence, our C-K framework will explore possible conjunctions based on this method. From the representation of a conceptual model, two other concepts arise. Once again, the representation can be performed using drawing techniques, either by hand or by computer. However, there is a difference from the previous conjunction, as the drawing will need to follow the methodology for representing stratigraphies. In addition, the drawing could be carried out within or without a framework. Drawing without a framework is what is currently performed by conservators once the artifact structure is known. Thus, a conjunction can be made from the concept of drawing to the knowledge of a drawing software which allows such visual representation. Then, this knowledge can be expanded to a knowledge of visual comparison (K → K) (Fig. 4). However, the conservators' idea is to follow the methodology developed by Bertholon to visually compare stratigraphies, using a common language [2]. Therefore, they now want to go further and be able to automatically compare stratigraphies between them.

On the other hand, drawing within a framework would provide the conservation professionals with a tool that could draw stratigraphies on a blank page with regard to what the conservators add as characteristics (Fig. 5). This idea was rapidly abandoned after being tested. Although it allowed characteristics to be automatically drawn, a similar problem to drawing without a framework occurred: automatic comparison was not possible. Indeed, we would have needed a tool that was able to perform image recognition in order to store the image and extract its characteristics.

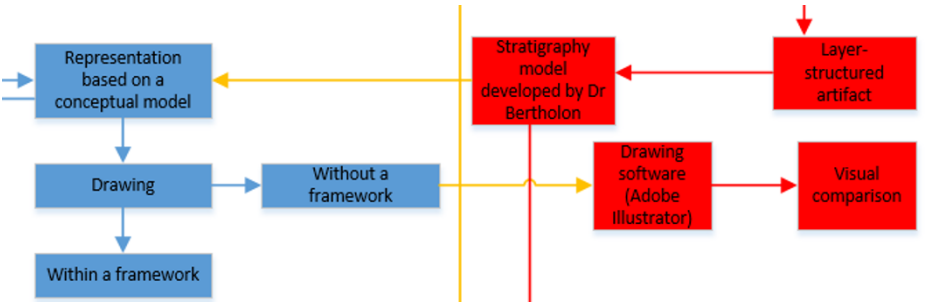


Fig. 4. The concepts that spring from the conceptual model representation (left) and their associated knowledge (right)

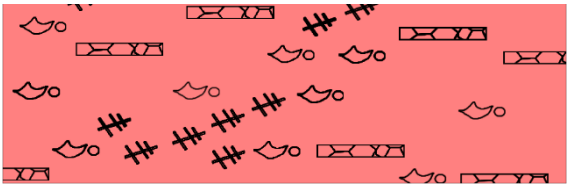


Fig. 5. The framework provided for conceptual model-based representation, tested and eventually abandoned

An alternative to drawing using exclusively the rules of a conceptual model is to expand from the knowledge of the different characteristics that can be used to represent the stratigraphies. Indeed, depending on the family it belongs to, a stratum can only be constituted of precise characteristics. The characteristics emerge from the stratigraphy model of Bertholon and allow the conservators to choose between a finite number of attributes to model their artifact structure. In this way, an ontology could be developed for representing the strata. Here, we use the term ontology as an explicit representation of concepts and their relationships [10] and not in its philosophical sense. The ontology could comprise all concepts needed in order to represent the artifacts, their stratigraphies, the strata, and the strata characteristics. However, due to the nature of the expected result, this option was not pursued. Nonetheless, it certainly makes sense to study this option in further research as such an ontology could assist the conservator in building stratigraphies while being assisted by its the inferences.

As the conservators know what the different characteristics of a stratum can be according to its family, a database which gathers this information can be set up. A disjunction can then be made to enable the use of data structures based on the characteristics included in the database. This data structure can later be utilized to generate pertinent drawings according to observed characteristics of the artifacts. Indeed, once a stratigraphy is designed, a representation based on the data structures can be generated if there is a drawing for each characteristic. Rules also need to be added to avoid the creation of an uninterpretable drawing due to too many colliding characteristics. Whereas the stratigraphy could be interpretable by a computer, it also needs to be visually understandable for a conservator, as the conservator will use it in his/her reports (Fig. 6).

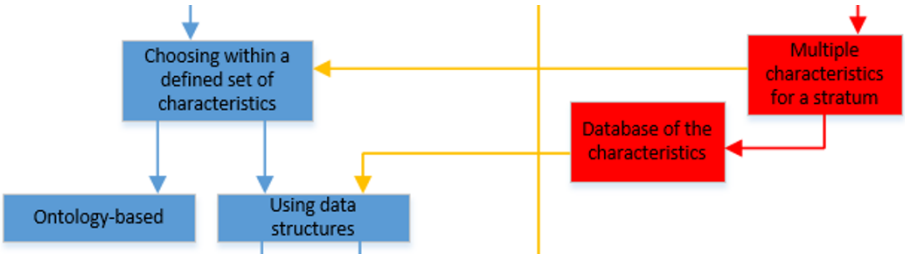


Fig. 6. The concepts embedded in the characteristics of the model developed by the conservators

Furthermore, comparison is made possible through the use of a database and data structures: the closer two stratigraphies are from each other, the higher the matching score of those stratigraphies is between them. Therefore, the database can use that score to return accurate stratigraphies according to the studied artifact. This allows the conservators to find other stratigraphies that are close to the one they study and to give them clues about which methods they could use in order to conserve their artifact [3]. As a result, a conjunction can be made from "Comparison" to "Search the database for similar stratigraphies" (Fig. 7).

In addition to comparison, images can be generated from the use of data structures, as the characteristics can be unequivocally drawn. We can therefore export the generated images to allow the conservators to include them in reports.

Joining the previously mentioned knowledge about DSS and the last two conjunctions, our tool is designed based on the knowledge created and mobilized by the interdisciplinary concepts and knowledge expanded in the C- and K-spaces. Thus, it addresses the conservators' needs to make use of a tool that is able to return similar stratigraphies and therefore help them in the diagnosis of ancient metal artifacts. Moreover, it allows them to export the built stratigraphies into an image that can easily be included in reports and analyses. The tool results from a concept that sprang from the conservation professionals. It was broken down into sub-concepts that activated knowledge from both the CR and IS fields and resulted in a founded solution.

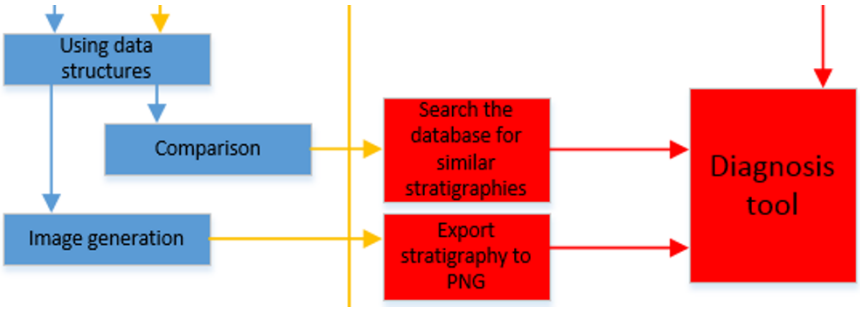


Fig. 7. Our application of the C-K theory led to the design of a diagnosis tool

4 Evaluating Knowledge Creation with C-K Theory

Using C-K theory allowed us to efficiently explore the different solutions that could be implemented. Moreover, it showed how knowledge coming from different fields can join to lead up to a usable and satisfactory solution. In addition, we noticed that our tool integrated concepts and knowledge that were developed throughout the expansion of both the C- and K-spaces. However, our tool cannot be used alone; other techniques (i.e. binocular observation and modeling the stratigraphies on Adobe Illustrator [8]) constitute preliminary steps in the diagnosis and comparison of heritage metal artifacts. Thus, our tool can be seen as the final component in the process of artifact diagnosis.

In our case, using the C-K theory first ensured that we covered most of the possibilities that constitute possible development of a diagnosis tool which could answer the conservators' needs. Moreover, breaking down their concept into sub-concepts allowed us to figure out the knowledge that was needed to be mobilized in order to expand both the C- and the K-space, as well as the conjunctions that could spring from this expansion. We also realized that the knowledge came from the IS and the CR fields and that we needed to merge to reach a satisfactory solution. The result of this process is a tool that embeds all the necessary elements the conservators need to complete the process of artifact diagnosis.

5 Discussion

Interdisciplinary research projects, given their orientation, are often the result of some power relations between different fields, not because of some sort of desire to monopolize the problem space, but because of some bias regarding the possible contributions of each fields. Choosing a method like C-K, which focuses on the C- and K-spaces assisted us in integrating concepts and knowledge from both fields as the research progressed and new refinements of the concepts space required new knowledge to be addressed. Each concept refinement provided an opportunity to seek expertise from the two fields in order to identify the possible extensions of the C-space. Likewise, it was the opportunity to bring knowledge on how to address the newly defined concept from two different points of view. This helped us integrate and build on the two visions of CR and IS at each step in the process.

The second contribution of C-K in this research is the post-mortem identification of the knowledge and concepts that build the core of the result. Given the two views that are integrated in the result, it could be seen as a black-box by people external to the process. In fact, IS researchers, bringing a specific set of knowledge and concepts, will probably come to a different solution on their own, simply given their lack of the C- and K-spaces of the CR field. The contrary is also true with CR researchers lacking the C- and K-spaces of the IS field. Therefore, without an explicit presentation of the various concepts and knowledge used in the process, it will be very difficult to understand not only the choices that were made during the process, but also the assumptions that the result is built upon.

Finally, by explicitly identifying the knowledge and concepts built into the process, users of the tool can better grasp its functioning as well as the required knowledge to use it effectively.

6 Conclusion

In this paper, we present an innovative way to design IS artifacts in an interdisciplinary context by relying on C-K design theory. By adopting the notions of concepts and knowledge spaces, we were able to bridge the expertise of the CR and IS fields in order to solve an interdisciplinary problem. Starting from a generic concept of the problem, the problem was iteratively refined, bringing new concepts

from each field at each iteration. These refinements in turn were addressed with knowledge from both fields. Each refinement raised new challenges that needed to be addressed by combining expertise from the two fields. The resulting artifact, besides providing the expected support for the metal diagnosis of patrimonial objects, is also more valuable for the community because each decision and design choice can be linked to proper concepts or knowledge from the domains. This will support future researchers in finding areas of improvement, being able to rely on the K-space that was used to build the solution. It also provides an opportunity to review the artifact based on analyzing the proper usage of the various concepts and knowledge integrated in the process.

Acknowledgments. This paper is partly based upon work supported by the RCSO ISnet under Award No. 38996. We would like to thank our colleagues, Valentin Boissonnas, Régis Bertholon and Romain Jeanneret from the Conservation-Restoration department of the Haute École Arc, who supported our work on this project with their continuous feedbacks.

References

1. Bertholon, R.: La limite de la surface d'origine des objets métalliques archéologiques. Caractérisation, localisation et approche des mécanismes de conservation., (2000).
2. Degrigny, C., Senn, M.: MIFAC-Métal: Methodology to Study and Analyse the Microstructures and Corrosion Forms of Ancient and Historic Metals: Application to Metallographic Samples from Swiss Collections. , Neuchâtel (2012).
3. Rosselet, A., Rochat, V., Gaspoz, C.: Design of a new data structure to support non-invasive diagnostic on heritage metals. In: Proceedings of the 9th Mediterranean Conference on Information Systems (MCIS). , Samos, Greece (2015).
4. Hatchuel, A., Weil, B.: A new Approach of Innovative Design: an Introduction to CK Theory. In: Proceedings of the 14th International Conference on Engineering Design (ICED). p. 15. , Stockholm (2003).
5. Repko, A.F.: Interdisciplinary research: Process and theory. SAGE Publications, Inc., Thousand Oaks, CA, USA (2012).
6. Hatchuel, A.: C-K theory: Notions and applications of a unified design theory. In: Herbert Simon International Conference on « Design Sciences ». p. 22. , Lyon (2002).
7. Chou, W.H.: Divergent and Convergent Thinking Projects in Interdisciplinary Studies. Online J. New Horizons Educ. 5, 36–48 (2015).
8. Adobe: Adobe Illustrator, http://www.adobe.com/products/illustrator.html.
9. Hatchuel, A., Le Masson, P., Weil, B.: C-K theory in practice: lessons from industrial applications. In: International Design Conference. p. 13. , Dubrovnik, Croatia (2004).
10. Uschold, M., Gruninger, M.: Ontologies: principles, methods and applications. Knowl. Eng. Rev. 11, 93–136 (1996).

Multiple case study of the supplier selection decision process

Dmitry Kisly[1], Anabela Tereso[2], Maria Sameiro Carvalho[3]

[1] Master Student in Industrial Engineering, Department of Production and Systems Engineering, University of Minho, 4800-058 Guimarães, Portugal
[2, 3] Department of Production and Systems Engineering / ALGORITMI Research Centre, University of Minho, 4800-058 Guimarães, Portugal

Abstract. The complex and important problem of the supplier selection has been modelled with the involvement and integration of different multiple criteria decision techniques. Nevertheless, there is little empirical evidence of the relevance of such approaches to the procurement practice. In order to overcome the relevance gap it is imperative to analyze the practical decision process in the procurement function. With this aim an exploratory multiple case study was undertaken, based on semi-structured interviews with senior procurement managers of eight Portuguese enterprises, and triangulation with previous research. The results suggest that supplier selection decisions tend to be based on the non-compensatory decision strategy (conjunctive decision rule) in the pre-selection stage, followed by the price bidding and qualitative analysis in the stage of final choice.

Keywords: Supplier evaluation, supplier selection problem, non-compensatory decision rule, multiple criteria decision analysis, multiple case study.

1 Introduction

In the last decades the complex decision problem of supplier selection has been an object of growing theoretical research, which employs multiple criteria decision analysis (MCDA) approaches such as Analytic Hierarchy Process, Analytic Network Process, Goal and Mixed Integer Programming, Data Envelopment Analysis among others. Systematic literature reviews show that modern research tends to combine different techniques in integrated approaches, with increasing use of the Fuzzy Set Theory [1][2].

Meanwhile, there is the problem of relevance, to the procurement practice, of the modelling of the supplier selection as a MCDA problem. Most papers on the topic are based on numerical examples, or real data with illustrative purposes. However, few information is given about practitioners feedback and implementation process of such approaches[3][4]. Also, "the relevance gap" is a known issue in the field of the decision support systems [5].

Additionally, above mentioned MCDA approaches to the supplier selection problem are based on the compensatory decision rule, i.e. the poor performance of an

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_92

alternative on one criterion might be compensated, to some extent, with good performance on other criteria. However, there is research reflecting the use of the non-compensatory decision rule in the procurement practice [6][7]. For instance, such practical approach, based on a non-compensatory pre-selection procedure, followed by price bidding, was denominated as *bespoke approach* by Holt [8].

In order to understand the relevance of theoretical research of the supplier selection problem and to overcome eventual bottlenecks of implementation, it is imperative to analyze the real decision process in the context of the purchasing function. The present research is based on a multiple case study design and it was aimed to analyze the decision-making process of procurement professionals, applied to supplier selection. The unique assumption made prior to the field involvement stage of the research was that the real supplier selection process is expected to be based on the multiple criteria evaluation. The way how criteria information is aggregated and what decision strategy is used are to be explored, aiming to confirm the relevance problem of the MCDA-based approaches and to discover the possible explanations of it.

Next section (section 2) presents the methodology and context issues of the research. In section 3 the main research topics are discussed. Section 4 summarizes overall findings of the study and is followed by section 5 that presents the final conclusions.

2 Methodology and context description

Taken into account the complexity of the topic, lack of empirical research and necessity to enhance generalization potential of the findings, a multiple case study qualitative research was adopted. It was reasonable to expect purchasing managers not to be familiar with decision theory and multiple criteria decision analyses terminology; the point was to understand how purchasing managers perceive the supplier selection process and how they describe it. In order to address this issue, the semi-structured interview model with open-ended questions was chosen, as advised by Yin [9]. The main topics covered by the interviews are presented in the Table 1.

Table 1. Topics covered by the semi-structured interviews

T01	Description of the company from the purchasing perspective
T02	Organization and internal regulation of the purchasing function in the company
T03	Initial sourcing decisions
T04	Contracts and legal tools applied to the purchasing
T05	Criteria of evaluation of the potential suppliers
T06	Supplier selection as a formalized process: internal regulation and procedures
T07	Underlying principles of the supplier selection
T08	MCDA techniques and decision support software applied in the supplier selection
T09	Post-contract sourcing analyses and supplier performance evaluation

To enhance reliability of the research, the following auxiliary documents and forms were elaborated: the case study protocol (with background, purpose and design of the research), the bulletin of the participant and the guide for the semi-structured interviews.

The bulletin of the participant was a part of a formal invitation to participate in the multiple case study, presenting the objectives of the research, the research team and the commitment to conduct an ethical research process. Being the procurement function a sensitive issue for many companies, it was decided not to record interviews. The guide of topics to cover was used to make notes during interviews and to structure transcriptions immediately after them.

Eight cross-industry enterprises, operating in Portugal, participated in the research. They were represented by senior purchasing officials as interlocutors of the semi-structured interviews. Brief description of the participants is given in Table 2, providing some contextual details.

Table 2. Description of the multiple case study participants

C01	Company	Electrical equipment manufacturer, infrastructures and engineering solutions; export-oriented, gross sales of about €800 millions
	Interlocutor	Director-coordinator responsible for purchasing and logistic
C02	Company	Multinational technological holding - industry, mobility, consumer goods; 4 plants in Portugal with annual operations of €750 millions
	Interlocutor	Coordinator of *indirect* purchasing (i.e., out of the bills of materials)
C03	Company	Multinational automotive OEM company, with one plant in Portugal, gross sales up to €100 millions
	Interlocutor	Head of purchasing and logistic
C04	Company	Cutlery manufacturer, exporting about 90% of production, with gross sales of €5 millions
	Interlocutor	Financial director
C05	Company	Textile manufacturing group, with its own trademark, also working for world-known labels; gross sales of about €40 millions
	Interlocutor	Head of purchasing department
C06	Company	National paints and coatings manufacturer, with 5 production facilities around the world and gross sales of €180 millions
	Interlocutor	Vice-director of purchasing department
C07	Company	Portugal-based international group in food distribution and manufacturing, with annual sales above €12 billions
	Interlocutor	Commercial director of retail division
C08	Company	Portuguese production facility of one of the world's leading automobile manufacturers, exporting up to 99% of cars produced
	Interlocutor	Factory´s general purchasing coordinator

Low generalization capacity is an implicit limitation of the qualitative case study researches [10], but some valuable insights were obtained and discussed. Cross case analyses with the main topics examined through the set of the cases, and comparisons with previous research papers approaching the similar issues, were used to enhance the validity of the research and to provide a basis for the analytical generalization.

3 Analyses of main topics covered by the research

In this section the importance and organization of the purchasing function will be analysed, as well as the observed evaluation criteria used for the supplier selection. Finally the supplier selection decision process and supplier performance evaluation will be addressed.

3.1 Importance and organization of the purchasing function

Undoubtedly, purchasing represents a significant parcel of the product costs. Its percentage weight varies from industry to industry, and is also sensitive to the technology and external markets´ conditions. Some rough estimations made by the participants were 60% for C03, 30-35% for C04, 40% for C05. In the C02 case the weight of *indirect purchasing* in the product costs (i.e., components out of bills of materials, equipment and services) was estimated as 5%. An example of the exposure to market´s conditions would be, for the C06 case, the dynamic market of titanium dioxide TiO_2, which is the most widely used industrial white pigment.

In all cases studied there were difficulties to perform ABC analysis of suppliers' portfolio. Three main reasons to consider a supplier as a *key ("A") supplier* were identified: financial importance (e.g. a supplier with turn-over of more than 1 million €/year for C01), criticality to the quality or to the production (e.g. products considered as potential *job stoppers*, a typical situation for the lean-oriented supply chains of the automotive industry), and a dominating position of a supplier on the respective market (e.g. assembly line robotics).

There was a clear distinction between *active* and *non-active* suppliers, the last ones being casual and back-up suppliers. In the C01 case, for instance, active suppliers represent about 37% of the total. The weight of key suppliers in active suppliers´ base was estimated as about 1.8% for C01 and 4.2% for C08. From 250 active suppliers in C06, there were from 3 to 5 key suppliers for each of five main purchasing areas.

In all cases the policy of long-term relationship with key suppliers was chased. Portfolio-based approaches to the supply management were identified in the first three cases but, to some extent, the same underlying principals were common to all cases.

Such areas as R&D (research and design), quality and production were seen as responsible for the formulation of a new or modified buying need, including corresponding specifications. It is up to a purchasing department to decide whether to use the current supply sources or to look for new alternatives. Straight re-buy situations are commonly under responsibility of a company´s operational units.

The complex structures of the purchasing function of large enterprises are of the main focus for this research. It is common for international companies to have central

and also local purchasing departments, i.e. a decentralized organization of the purchasing function. Central purchasing departments were commented as responsible for key suppliers and methodological support, with local departments being responsible for back-up, equipment and services suppliers.

In C03 case, for instance, the central purchasing department is directly responsible for a share of 6-7% of the plant's total acquisitions. Meanwhile, up to 70% of the plant´s purchases are electronical components, for which the respective suppliers are chosen, over again, by the central department. In C02 case, the central, regionals and locals purchasing offices are vertically integrated, being autonomous from the local plants.

Other common features were strict individual specialization of purchasing managers on one family of products or services acquired, and the practice to evaluate their performance accordingly to the cost-reduction criterion (as a part of the supply chain cost management). Such organizational decisions and managerial practices have strong reasons to be implemented, but some interesting conclusions were drawn.

Firstly, a large enterprise might create some internal barriers between purchasing managers and R&D, production, quality areas and operational units. Such barriers are the consequence of the organizational and geographical distance between the central purchasing department (responsible for the key suppliers) and respective plants. As purchasing managers are specialized and assigned to some strict type of product (component, raw material, services) acquired, those factors are not favorable for an overall multi-disciplinary analysis of some buying situations.

Secondly, being cost-reduction programs an important performance indicator to evaluate procurement officials, it is reasonable to expect that purchasing managers by themselves will tend to choose an alternative with a lower cost of acquisition as soon as minimal requirements are fulfilled.

3.2 Evaluation criteria of the supplier selection

No ready-to-use list of applicable criteria was suggested to the participants of the research. Notwithstanding, and as expected from literature [11][7], supplier selection was treated by the purchasing officials as multiple criteria evaluation. The summary description of the supplier evaluation criteria mentioned by case studies participants is given in the Table 3. The three most cited criteria were placed separately: price *(P)*, quality (*Q)* and logistic performance *(L)*; if some criterion was mentioned as the most important one, it was signalized with capital "X". The quality and price criteria were stated as the most important ones in four cases each.

Price criterion was not seen as simple unit price, but more in the sense of the total cost of acquisition (or formal total cost of ownership (TCO) model in the case C02). With many commercial conditions and long-run costs taken into account, such observations were consistent with the exploratory study of Plank and Ferrin [12].

The relative importance of the quality criterion, one of the always mentioned top priorities, tended to decrease drastically as soon as minimal quality requirements were fulfilled. The same controversy was mentioned in the experimental study of Verma and Pullman [11]. On time in full (OTIF) delivery performance was implicitly expected to be high, as a kind of benchmarking standard.

Table 3. Summary of the supplier evaluation criteria

Case	*P*	*Q*	*L*	Comments
C01	X	x	x	As soon as potential suppliers are approved on minimum requirement levels, the price is an unblocking criterion
C02	X	x	x	Evaluation of *essential/preferred* suppliers is based on the total cost of ownership model with prior analysis of minimum requirements and qualitative criteria (ex.: technological competencies); minimum requirements and price for *commodity* suppliers
C03	x	X	x	Criteria seen as *general* are commercial conditions (price included), quality (minimum level, certificates), flexibility and delivery, switch costs, tools dependency; *additional* criteria are qualitative, such as technical and innovative capacity
C04	X	x	-	The purpose is to obtain the same quality for the lower price or a better quality for the same price; technical support and flexibility
C05	x	X	x	Quality, as a set of technical parameters, and price; trade-off between foreign suppliers (lower price, longer lead-times) and national suppliers (more flexible and stockless supply)
C06	x	X	x	Quality, seen as consonance with the specifications, is the main criterion, followed by the price; capacity, flexibility and collaboration are relevant criteria as supply markets are turbulent
C07	x	X	x	Quality (food safety and specifications) is the main criterion; with quality requirements fulfilled and panel customers tests performed, a new product will be launched only if it is competitive (therefrom quality and cost criteria for potential suppliers)
C08	X	x	x	As soon as specifications and minimum requirements are fulfilled, the lowest bid will be chosen (grounded exceptions are possible)

Qualitative criteria were seen as pre-requisites or/and as post-bidding adjustment criteria. Qualitative analysis was commented as based on expert opinions, with documental analyses and site visits. Some kind of Likert scale might be employed to express qualitative criteria numerically.

Standards and certifications, varying from industry to industry, were seen as qualifying requisites. Among them there were ISO9000, 14000, 22000 and 26000 families, SA8000 Standard, VDA6 Quality Management System and Good Manufacturing Practices (GMP). In the *C05* case, for instance, the company had to implement SA8000 Standard and to guarantee socially acceptable practices in its supply chain to work for North-American market.

Formal or informal use of the concept of a base of approved suppliers was common to all the cases, which is consistent with the results of Plank and Ferrin [12]. In such cases, once approved by a purchasing department as matching all legal and minimum requisites and requirements, a supplier enters some list of approved suppliers. Consequently, it might be requested for quotation either by the purchasing department or by an operational unit when the respective buying need arises.

3.3 Supplier selection decision process and *a posteriori* supplier performance evaluation

Nowadays there is a growing trend for implementing cost management, total quality management, lean logistics, of enterprise resource planning systems and web-based companies´ supply portals. Meanwhile, in the context of this multiple case study, the observed *ad hoc* algorithms of the supplier selection process had much in common with *bespoke approach* described by Holt in 1998 [8]. With some contextual differences, the supplier selection decision process was the following.

Firstly, a set of potential suppliers is evaluated against minimal requirements on non-financial quantitative criteria (ex.: quality and logistic requirements). Qualitative "capacities" (such as technical competence or R&D potential) and conformity with legal or sectorial standards required are also evaluated in this stage. This pre-selection stage of qualification of the potential suppliers as acceptable alternatives is based on the conjunctive non-compensatory decision rule.

Secondly, suppliers qualified as acceptable ones are requested for quotation and the best bid wins (alternatively, qualified suppliers are included to a list of approved suppliers).

Thirdly, the final choice decision might be adjusted by experience-based qualitative analyses, if grounded.

The same decision algorithm of the supplier selection process might be recognized in the empirical research of the buying process for new components of Matthyssens and Faes [13] and in the case of Toyota Industrial Equipment Manufacturing [14]. The case of supplier selection described by Naudé [15] was partially compensatory. Potential suppliers were screened by a set of excluding criteria, followed by a scoring model with eight attributes. But the output of the scoring model was used only to qualify alternatives for the bidding stage. No decision technique to trade-off scores and cost criterion in the stage of the final choice was commented.

Albeit criticized for the non-compensatory nature and subjectivity, the *bespoke approach* was seen by Holt [8] as a commonplace practice (for construction contractor selection). The term of *bespoke approach* was adopted to describe the observed *ad hoc* decision algorithms within the scope of this research.

The non-compensatory conjunctive decision rule, applied in the qualifying stage, is important to define a set of feasible alternatives. But, within the scope of this research, there were not identified compensatory MCDA-based approaches to trade-off conflicting criteria of different nature in the stage of the final choice decision. Consequently, the described *bespoke approach* to the supplier selection cannot be considered as based on the semi-compensatory decision strategy.

The C02 case is slightly different because of the formal total cost of ownership model implemented to evaluate potential supply sources. But, as it is common for cost-based approaches, qualitative and non-financial criteria are expected to be analyzed separately from the financially quantifiable attributes. Without compensatory decision strategy to trade-off this two groups of criteria, such TCO-based approach is only a rough approximation to the multiple criteria supplier selection decision analyses [16].

The importance of the supplier performance evaluation for the purposes of this research is twofold. To start, data on actual performance of the suppliers chosen is

used to rectify supplier selection decisions. Also, simple weighted score models were identified as a common tool of the suppliers performance evaluation.

An actual supplier might be dropped if it was proven as non-competitive, face to changed market conditions (e.g. as stated in general Purchase and Supply Agreement of Yazaki Europe Limited [17]), or if it is not able to maintain agreed levels of performance (the quality level agreement, for example). It was common for the participants to monitor permanently supplier performance (conformity with specifications, the quality and logistic dimensions), being a responsibility of the internal clients, but oriented by the purchasing and quality areas.

If some supplier does not meet the agreed levels of performance, there were some different immediate or sequential scenarios: negotiations and elaboration of a plan of corrective actions, suspension of a supplier in the list of approved suppliers (for future buying needs), or contract cancelation.

Scoring systems for the evaluation of supplier performance were directly mentioned in six cases, sometimes jointly with the internal questionnaires. In the C07 case a project of Supplier Performance Scorecard was under implementation. Such scoring evaluations are done with weighted scoring models, based on the semi-compensatory decision rule. A detailed real-life example of Supplier Scorecards might be consulted from Yazaki Europe Limited [17].

Albeit the relative weights of criteria are subjective (or based on the sectorial standards), such scoring models might be useful as a starting point for the practical implementation of MCDA-based approaches to the supplier selection. Also it is worth to mention that such weighted scoring models are commonly advised by supply chain and procurement manuals [14][18].

4 Overall analyses of the findings

The overall findings of the present study are to be treated carefully, with concern to the qualitative nature of the research. Nevertheless, cross-case analyses and comparisons with previous research allowed to draw some relevant conclusions to the field of the supplier selection problem.

The problem of the relevance of the MCDA-based approaches to the supplier selection for the procurement practice was present in all the cases. In all the cases, senior procurement managers were not familiar with multiple criteria decision analyses techniques. The actually implemented formal models of supplier selection were based on the conjunctive non-compensatory decision rule (with a set of exclusion criteria), followed by price bidding and qualitative analyses. Following the description of Holt [8], such models might be denominated as *bespoke approach* to the supplier selection problem.

Albeit the MCDA techniques were seen as interesting and, to some extent, promising, the actually implemented *ad hoc* models of supplier selection were considered by the purchasing managers as effective and efficient (with the exception of the C05 case, in which the head of the purchasing department was interested to implement MCDA approaches to tackle yarn quality specifications). Thus, the proposition of the relevance gap problem, as mentioned in [3][4], cannot be discarded.

In designing empirical research of perceived value of supplier selection criteria (e.g. questionnaires), it will be necessary to take into account such possible features as: presence of organizational barriers complicating interaction of multiple points of view; evaluation of procurement managers´ performance based on the cost-reduction goals; and importance of the exclusion criteria and of the minimum level requirements. No closed list of applicable criteria might be elaborated, and their relative weights are quite situational.

Taken into account the results of this research, the supplier selection problem modelling based on the semi-compensatory decision rules was seen as the appropriate way to implement MCDA-based approaches.

At the same time, the experience of procurement professionals cannot be ignored. In other words, the observed *bespoke approach* to the supplier selection should be further studied in the following sense: is it capable, in certain conditions, to represent the complex multiple criteria supplier selection problem objectively and comprehensively?

The use of simple weighted score models was identified as a common tool for the post-contract supplier performance evaluation. With necessary modifications, such models would be a natural *initial* approach to start the implementation of multiple criteria decision analyses tools for the supplier selection.

5 Conclusions

With the purpose to find the relevance of the MCDA-based approaches to the supplier selection, a multiple case study research was performed. Eight enterprises, operating in Portugal, participated in the research through semi-structured interviews with the senior procurement managers.

The multiple criteria nature of the evaluation of potential suppliers was confirmed. The observed *ad hoc* decision approaches for supplier selection were clearly based on the conjunctive non-compensatory decision rule, defining the set of feasible alternatives, and followed by the price bidding. For the qualified suppliers (as feasible alternatives) the application of multiple criteria decision techniques capable to trade-off multiple evaluation criteria in the stage of the final choice decision was not identified.

The capacities and limitations of the observed decision method, denominated as *bespoke approach*, need to be further studied. MCDA-based approaches to the supplier selection, to be successfully implemented, should be seen as a part of a complex decision process with underlying semi-compensatory decision rule and adapted to the context of a buying organization.

Acknowledgment. This work has been supported by *FCT - Fundação para a Ciência e Tecnologia* in the scope of the PEst-UID/CEC/00319/2013.

References

1. Ho, W., Xu, X., Dey, P.K.: Multi-criteria decision making approaches for supplier evaluation and selection: A literature review. Eur. J. Oper. Res. 202(1), 16–24 (2010)
2. Chai, J., Liu, J.N.K., Ngai, E.W.T.: Application of decision-making techniques in supplier selection: A systematic review of literature. Expert Syst. Appl. 40(10), 3872–3885 (2013)
3. De Boer, L., Van Der Wegen, L. L. M.: Practice and promise of formal supplier selection: A study of four empirical cases. J. Purch. Supply Manag. 9(3), 109–118 (2003)
4. Bruno, G., Esposito, E., Genovese, A., Passaro, R.: AHP-based approaches for supplier evaluation: Problems and perspectives. J. Purch. Supply Manag. 18(3), 159–172 (2012)
5. Arnott, D., Pervan, G.: Eight key issues for the decision support systems discipline. Decis. Support Syst. 44(3), 657–672 (2008)
6. De Boer, L., van der Wegen, L., Telgen, J.: Outranking methods in support of supplier selection. *Eur. J. Purch. Supply Manag.* 4(2–3), 109–118 (1998)
7. Aissaoui, N., Haouari, M., Hassini, E.: Supplier selection and order lot sizing modeling: A review. Comput. Oper. Res. 34(12), 3516–3540 (2007)
8. Holt, G.D.: Which contractor selection methodology? *Int. J. Proj. Manag.* 16(3), 153–164 (1998)
9. Yin, R.K.: Qualitative Research from Start to Finish. The Guilford Press, New York (2011)
10. Gibbert, M., Ruigrok, W., Wicki, B.: What passes as a rigorous case study? Strateg. Manag. J. 29(13), 1465–1474 (2008)
11. Verma, R., Pullman, M.E.: An analysis of the supplier selection process. Omega. 26(6), 739–750 (1998)
12. Plank, R.E., Ferrin, B.G.: How manufacturers value purchase offerings. Ind. Mark. Manag. 31(5), 457–465 (2002)
13. Matthyssens, P., Faes, W.: OEM buying process for new components: Purchasing and marketing implications. Ind. Mark. Manag. 14(3), 145–157 (1985)
14. Monczka, R.M., Handfield, R.B., Giunipero, L.C., Patterson, J.L.: Purchasing and Supply Chain Management. 4th edition. South-Western Cengage Learning, Mason (2009)
15. Naudé. P.: Changes in attribute salience among DMU members during a decision: some empirical results. In: Biemans, W.G., Ghauri, P.N. (eds.) Industrial Marketing and Purchasing: Meeting the challenge of New Frontiers. Proceedings of the 10th IMP Annual Conference, pp. 95–116. Groningen (1994)
16. Morssinkhof, S., Wouters, M., Warlop, L.: Effects of providing total cost of ownership information on attribute weights in purchasing decisions. J. Purch. Supply Manag. 17(2), 132–142 (2011)
17. Yazaki Europe Limited, http://www.yazaki-europe.com
18. Sollish, F.B., Semanik, J.: The procurement and supply manager´s desk reference. John Wiley & Sons, Inc., Hoboken, New Jersey (2007)

Decision Support in Big Data Contexts: A Business Intelligence Solution

José Luís Pereira[1] and Marco Costa[1],

[1] Universidade do Minho, Departamento de Sistemas de Informação,
Campus de Azurém, Guimarães, Portugal
jlmp@dsi.uminho.pt, a44037@alunos.uminho.pt

Abstract. In the last few years we all have witnessed an enormous growth in the production of data. According to some estimates, ninety percent of the existing world's data was created over the past two years! Indeed, we are in the era of Big Data which is characterized by the continuous creation of vast amounts of data, originated from different sources, and with different formats. First, with the rise of smart devices, mobile applications, cloud computing, and social networks and, more recently, with the advent of the Internet of Things (IoT), data with enormous potential for organizations is being continuously generated. In order to be more competitive, organizations want to access and explore all the richness that is present in those data, which is the main purpose of Business Intelligence. In this paper we continue the presentation of an experiment in which data obtained from a NoSQL database (database technology explicitly developed to deal with the specificities of Big Data) is used to feed a Business Intelligence solution.

Keywords: Big Data, NoSQL, Business Intelligence, Dashboard, Pentaho.

1 Introduction

According to IDC, ninety percent of the existing world's data was created over the past two years [1]. IBM confirms these figures stating that, as of 2012, every single day 2.5 Exabyte (2.5×10^{18} bytes) of data were generated. Due to the explosion in the use of smart devices, mobile applications, cloud computing, and social media, we have witnessed an increase in the volume of data that is produced by organizations and by people in their daily life activities. In the latter case, as a result of the boom occurred with social networks, increasing amounts of data are being generated by people. Of course, these new data have great potential for organizations as a source of insight about people needs, opinions, market tendencies, and so on.

In the near future, with the so-called *Internet of Things* (IoT), in which virtually any electronic device with processing capacity will be integrated in the Internet, generating and consuming data, the amount of data we will have to deal with will increase dramatically.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_93

These new data come in larger amounts, at higher rates, from different sources, and with distinct features. In this context one might distinguish among three kinds of data to store and process [2]:

- **Structured data** – data with a rigid and previously known structure, in which all elements share the same format and size. This is the kind of data, traditionally found in business applications, that has been stored in relational databases;
- **Semi-structured data** – data with a high degree of heterogeneity, which is not easily represented in fixed data structures. Typically, these kind of data have been stored using specific languages such as XML (*Extensible Markup Language*) data, RDF (*Resource Description Framework*) data, and so on;
- **Unstructured data** – data without a structure, such as text, video, or multimedia content. In this group one can find the kind of data which has grown exponentially in the last decade, with some estimates pointing that, nowadays, as much as 90% of the generated data is unstructured data. Examples include documents, images, photos, email messages, webpages, and so on.

Although, much of the data growth has been in unstructured data, IDC estimates that by 2020, business transactions on the Internet – B2B and B2C – will reach 450 billion per day [3].

In a few words, this is what characterizes the era of the *Big Data*: huge amounts of both structured and unstructured data, produced and consumed at increasing higher rates. These new features constitute an enormous challenge to the more traditional relational database technology. To answer to the new challenges created by Big Data, a new family of database technologies has emerged – the NoSQL databases.

In the present there are four families of NoSQL databases (*Document*, *Column*, *Key/Value* and *Graph* databases), each one of them with their own characteristics, strengths and weaknesses, but all sharing the same goal: to deal with the new challenges brought by Big Data [4], [5].

Despite their youth, NoSQL databases are becoming major players in the database market. For instance, DB-Engines (http://db-engines.com/en/ranking), a well-known ranking site which ranks databases according to their popularity, puts three NoSQL databases in the top 10: MongoDB, Cassandra and Redis[1].

With Big Data organizations understood the enormous potential underlying those vast amounts of available data. Indeed, Big Data is only as valuable as the insights organizations gather from it to make better decisions. They only have to use the right tools to treat those data, in order to better understand their business and their market. *Business Intelligence* (BI) tools are what organizations need to access those data and extract the insights needed to make the best decisions and outshine their competition.

Organizations can benefit in several ways when they decide to develop and use BI solutions. Ranging from a better understanding of their business operations, to an easier sharing of information among decision makers, or improving the decision making process, there are multiple advantages (see Fig. 1).

[1] Site accessed in December, 2015.

Fig. 1. Organizational Benefits of a BI Solution

In this paper, we continue the presentation of the development of a BI solution, which is being used by a Portuguese firm, that we have initiated in another paper [6]. This firm deals with the detection and monitoring of people movements in closed spaces, using a very common and disseminated technology – GSM (*Global System for Mobile Communications*), which we all use, nowadays, in our mobile phones. In this project, client movements in a shop of a large shopping mall was used as an example. The purpose of the BI solution is to provide decision makers with information about the habits of the shoppers, time spent in shopping, shop zones visited, etc., which is needed for them to decide how to better organize the shopping space.

Concerning the structure of the paper, after a very brief presentation of the main concepts around Big Data and the database technology that promises to solve its major challenges – NoSQL databases, we made a very concise introduction to the area of Business Intelligence, stressing its value to support decision-making in organizations. In the next sections, we describe a development project in which data captured from a NoSQL database is used to feed a specific BI solution. To begin with, we describe the real context in which the BI solution is to be used and then we quickly advance to its development. We divided this project in two parts: the first part deals with the extraction, transformation and loading (ETL) of the NoSQL data into a local database; the second part of the project involves the construction of a dashboard to present data in order to support decision-making. In this paper we present some components of the developed dashboard, that complement the set of components presented in our previous paper [6]. Finally, some conclusions about the project are offered and future work is envisaged.

2 Description of the Project Context

In order to better manage a shopping mall, decision makers would like to know simple facts such as "how many visitors walk by a shop?", "how many visitors enter a shop?", "how many visitors made acquisitions?", "which are the busiest and the quietest hours?", "How much time shoppers spend in the shop?", "which are the zones most visited in a shop?", and so on. In order to accomplish that, a system for the detection and monitoring of people movements in space must be in place. Luckily, nowadays almost everyone use mobile phones so, making use of the GSM technology, in particular using the IMEI (*International Mobile Equipment Identity*) and the IMSI (*International Mobile Subscriber Identity*), one can easily trace the movements of people in a monitored space. This is a very convenient solution as those "mobile identifiers" are never switched off (mobile phones only stop emitting a signal if their battery is removed). Therefore, with a convenient distribution of GSM sensors in a given space one can trace the movements of people in that area.

The data used in this project were obtained mostly through sensors installed in a sporting goods store located in a large shopping mall. Data are collected and stored in a NoSQL database (in this case, a Cassandra system), all day long, every day of the week, non-stop, thus generating large amounts of data. Using an API (*Application Program Interface*), the Cassandra database provides access to the data in the JSON format (*JavaScript Object Notation*), which is a very simple a convenient format. These data are used to feed the developed BI solution.

The development of the BI solution involved two parts. In the first part, data are retrieved from Cassandra using the provided API and, after some processing tasks, are stored in a local database. In the second part a suitable dashboard is developed, according to the needs of decision makers.

Regarding the technologies used in the development of the BI solution, in addition to the PostgreSQL used to manage the data repository, we used the Pentaho family of products. In particular:

- Pentaho Data Integration (Kettle) – the solution offered by Pentaho for ETL. In this project Kettle was used to extract data from the provided Cassandra API, do the necessary treatments, and store the resulting data in the PostgreSQL database [7];
- Pentaho BI Platform – A platform that allows us to take the data from the repository and turn it into useful information for decision makers, by providing tools for creating reports, information panels, or dashboards [8].

In the next section, the first part of the project is briefly described.

3 The Business Intelligence Solution – Part I

By definition, BI is the collection of methods and tools that allow organizations to transform data into valuable information to support decision-making [9]. Since data may come from different sources and in a multitude of formats, BI tools need to have the capacity to *Extract* data from those sources, to *Transform* those data (selecting,

cleaning, joining, calculating, coding/decoding, etc.) according to the purpose of the solution, and to *Load* the data into a repository commonly known as Data Warehouse (DW) (see Fig. 2).

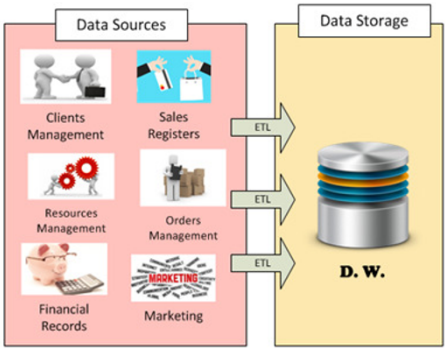


Fig. 2. The Extracting, Transformation and Loading (ETL) Process

In this specific project, in order to develop a BI solution adequate to the needs of decision makers, regarding the management of a sporting goods store located in a shopping mall, we need to access data from which we may extract some metrics.

The following table (Table 1) summarizes those data.

Table 1. Data needed for Decision-Making.

Metric	Description
space-tickets	Number of registered sales in store
space-walk-bys	Number of detected people passing in front of the store
space-visitors	Number of detected people inside the store
space-visiting-time	Average duration of visits to the store
zone-visitors	Number of detected people in each zone of the store
weather	About the weather and temperature

To get those data using the provided API, a request such as the following has to be made:

```
https://(...)/days/2015-08-15T00:00:00Z/2015-08-
16T23:00:00Z?metrics=space-visitors:hour:series
```

In this example we issued a request to search for data about the number of visits to that store from 15 of August to 16 of August of 2015.

To obtain data from Cassandra, and to process and store them into a local database (PostgreSQL) a set of ETL steps were developed in Kettle. This specific ETL was developed in order to be autonomous, that is, it does not require the user to enter the dates in the requests to the API provided. In Fig. 3 we can see the developed ETL steps, used to extract data from the provided API, do the necessary transformations, and finally load/refresh the data in the local database (tables Zones, Dates, Hour_records and Meteo).

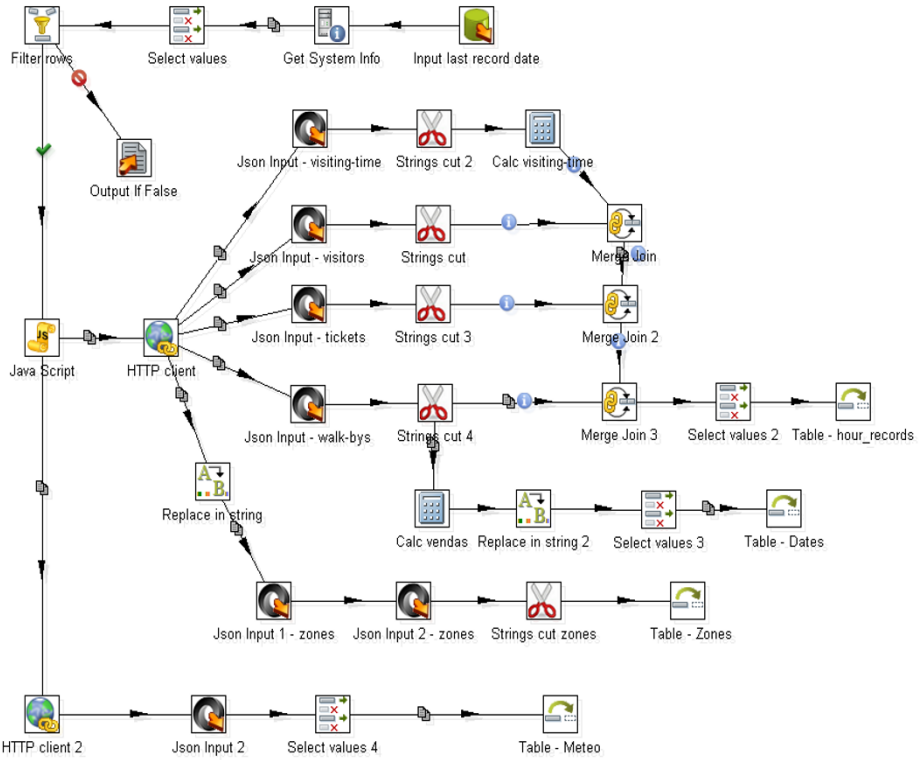


Fig. 3. The ETL used to load and refresh the local PostgreSQL database tables

Unfortunately, due to space limitations, this is not the place to explain each one of the steps in the ETL above. Anyway, the experience using the graphical interface of Kettle (named Spoon) to develop ETL has been quite interesting and rewarding. Spoon has a wide range of steps, such as Data Input and Output, Statistics, Validation, Mapping, Utilities, and so on, which may be added to the workspace in a drag-and-drop fashion.

4 The Business Intelligence Solution – Part II

In addition to the ETL capabilities, BI tools provide the mechanisms to build suitable information delivery front-ends for decision makers, such as reports and dashboards (see Fig. 4). Thus, the second part of the development of the BI solution involves the exploitation of the Pentaho BI Platform tool to visually display the data previously collected through a dashboard. This dashboard is composed of several components, such as graphics, tables and even a map of the store. It was developed using a tool named CDE (*Community Dashboard Editor*), an open source tool designed to simplify the creation and editing of dashboards.

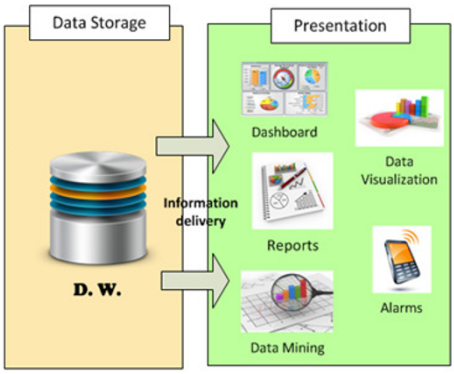


Fig. 4. The BI Solution Information Delivery Front-Ends

The first thing to do in the development of a dashboard is to identify "what" information we would like to have and "how" it should be displayed. In this specific case, it was decided that the dashboard should include the following elements, among others [6]:

- **Element 1** - The value of the metrics 'space-walk-bys', 'space-visitors' and 'space-tickets', compared to the maximum recorded in a previous month;
- **Element 2** – The relation between the metrics 'space-visitors' and 'space-walk-bys' in the form of an area chart;
- **Element 3** - Proportion of the metrics 'space-walk-bys', 'space-visitors' and 'space-tickets';
- **Element 4** - Overview of the metric 'space-visiting-time' over a given day;
- **Element 5** – Map of the store indicating the 'zone-visitors'.

Regarding the **Element 1** of the dashboard, a 'Gauge Component' to visualize each of the three metrics required was used (Fig. 5). This element allows decision makers to know "how many visits the store received in a given day, and how does it relates to the maximum recorded in a month?". With this component the metric value is displayed within a range, thus giving the user a better sense of the magnitude of its value. The range is set between 0 and the maximum value recorded in the current month. These components receive eight values: the title, the value of the metric, the minimum value of the scale, the maximum value of the scale, the main color of the component, and the colors of the minimum, medium, and maximum values.

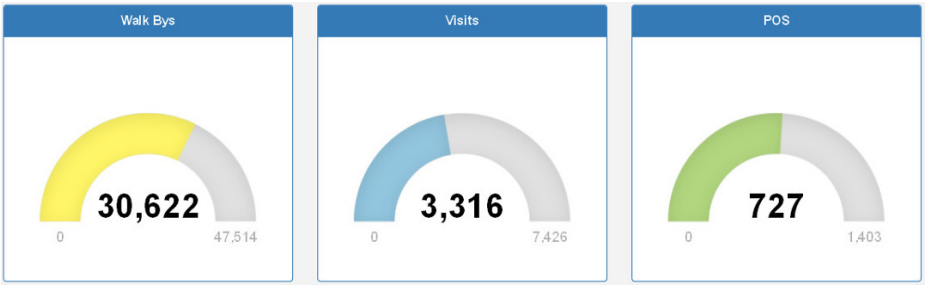


Fig. 5. Information about the metrics 'space-walk-bys', 'space-visitors' and 'space-tickets'

An example of a component to illustrate the **Element 2** of the dashboard appears in Fig. 6. An area chart which allows us to relate the metrics ‘space-visitors’ and ‘space-walk-bys’ in a given day, along with three text components, highlighting the hours and the maximum and minimum values recorded for the metric ‘space-walk-bys’ and the average value of the selected day.

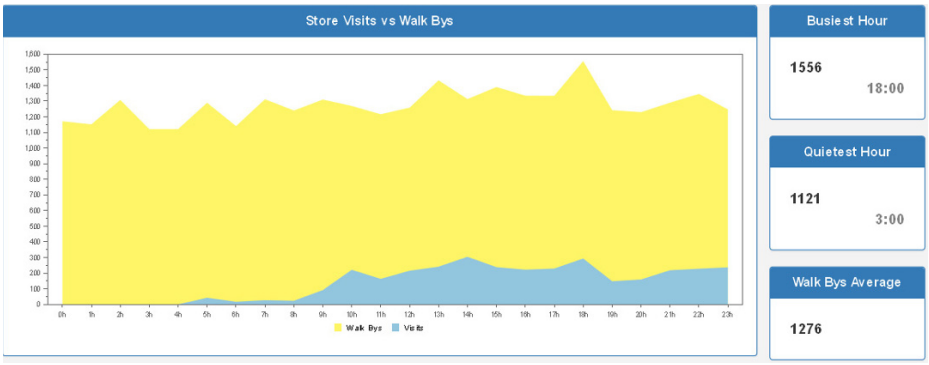


Fig. 6. The relation between the metrics ‘space-visitors’ and ‘space-walk-bys’ in a given day

The **Element 3** of the dashboard gives users of the BI solution a more comprehensive analysis of the metrics 'space-walk-bys', 'space-visitors' and 'space-tickets', showing the proportion between these three metrics (Fig. 7). This element allows decision makers to know “Which is the proportion between the people who has passed in the front of the store, the people who had entered the store, and the people who had actually shopped something?”.

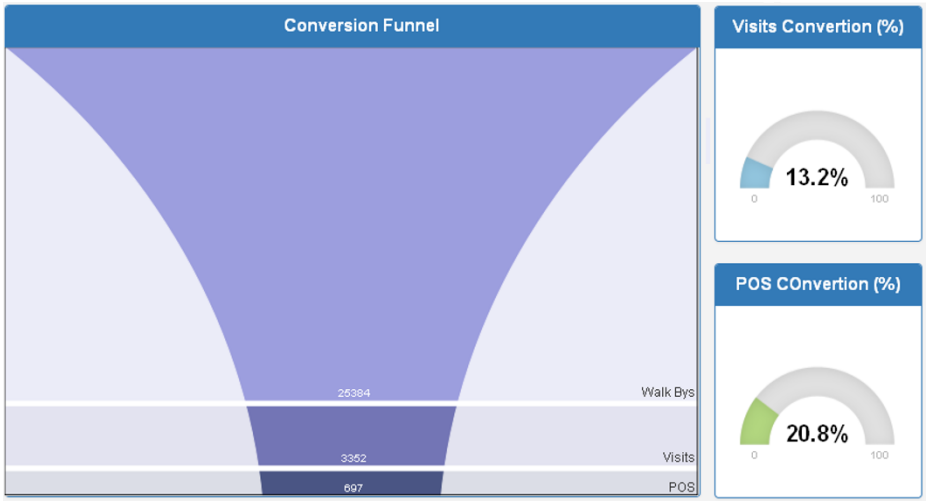


Fig. 7. Proportion of the 'space-walk-bys', 'space-visitors' and 'space-tickets' in a given day

The **Element 4** of the dashboard was implemented using the component in Fig. 8, below. This element allow us to know "how long the costumers remain inside the shop during the day?".

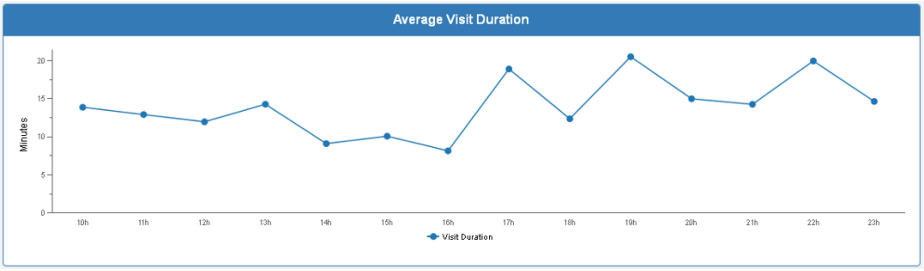


Fig. 8. Overview of the metric 'space-visiting-time' over a given day

Finally, the **Element 5** of the dashboard intends to illustrate the areas of the store that are most visited by shoppers (Fig. 9). This element allows decision makers to know "Which store areas are receiving more attention by people?"

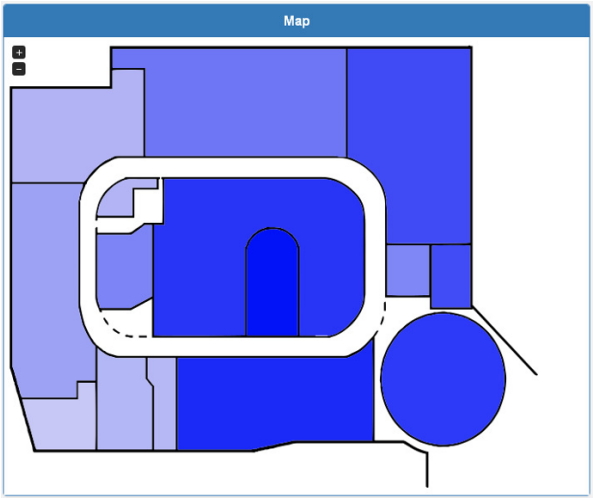


Fig. 9. The most visited areas of the store

This ends the second part of the BI solution development project, with a dashboard which includes five components (among others that we have already presented in another paper). The main purpose is to allow decision-makers to better understand what happens in the store and so, making them more able to manage their business.

5 Conclusions

With this paper we have concluded the presentation of a project involving the development of a Business Intelligence (BI) solution which gets its data from a non-

traditional source. The purpose of the project was to experiment the use of BI tools in a context close to those known as Big Data, in which a new kind of database technology is used to store data – NoSQL databases.

The setting of the project comprises a sporting goods store located in a large shopping mall, in which the movement of visitors, around and inside the store, as long as the time spent in each zone of the store is constantly monitored and the corresponding data registered in a NoSQL database (in this case, a Cassandra system). Those data, completed with data about sales, allowed the definition of several metrics in order to understand the behavior of visitors.

As we have claimed in a previous paper, BI solutions allow decision-makers to easily understand what is going on with their business, in order to make the best decisions. In the era of Big Data, with the enormous amounts of data which are available to organizations, BI solutions are even more relevant to their success. This project showed us that, using suitable BI tools, one can develop solid BI solutions, very quickly and with a small amount of resources.

Regarding the dashboard developed during the project, despite the wide range of components available to the Pentaho community, not all of the desired functionality was available in the components we have used. This has not proved to be an obstacle since, as usually happens with open source environments, it was possible to change existing components in order to create the new desired functionalities.

References

1. Vesset, D., Woo, B., Morris, H.D., Villars, R.L. et. al. (2012). Worldwide Big Data Technology and Services 2012-2015 Forecast (IDC, March, 2012).
2. Halper, F., & Krishnan, K. (2014). TDWI Big Data Maturity Model Guide Interpreting Your Assessment Score. TDWI Benchmark Guide 2013–2014.
3. Reinsel, D. & Gantz, J. (2012). The Digital Universe in 2020: Big Data, Bigger Digital Shadows, and Biggest Growth in the Far East (IDC, December, 2012).
4. Cunha, J.P., & Pereira, J.L. (2015). Column-Based Databases: Estudo Exploratório no Âmbito das Bases de Dados NoSQL. Proceedings da 15ª Conferência da Associação Portuguesa de Sistemas de Informação. CAPSI 2015. Lisboa.
5. Sousa, G., & Pereira, J.L. (2015). Document-Based Databases: Estudo Exploratório no Âmbito das Bases de Dados NoSQL. Proceedings da 15ª Conferência da Associação Portuguesa de Sistemas de Informação. CAPSI 2015. Lisboa.
6. Costa, M., & Pereira. J.L. (2015). From a NoSQL Data Source to a Business Intelligence Solution: An Experiment. Proceedings of the 4th International Conference on Virtual and Networked Organizations, Emergent Technologies and Tools. ViNOrg 2015. Póvoa de Varzim – Portugal.
7. PDI. (2015). “Pentaho Data Integration - Kettle ETL tool” (http://etl-tools.info/en/pentaho/kettle-etl.htm; accessed in April of 2015).
8. PBIP. (2015). “Pentaho Business Intelligence Platform” (http://www.pentaho.com/product/business-visualization-analytics; accessed in June of 2015).
9. Kimball, R., & Ross, M. (2013). The Data Warehouse Toolkit: The Definitive Guide to Dimensional Modeling, 3rd Edition, Wiley.

Cloud Computing in Smart Educational Environments: application in Learning Analytics as Service

Manuel Sánchez[1], Jose Aguilar[2], Jorge Cordero, Priscila Valdiviezo-Díaz, Luis Barba-Guamán, Luis Chamba-Eras[3]

[1] Universidad Nacional Experimental del Táchira, San Cristóbal, Venezuela
mbsanchez@unet.edu.ve
[2] Universidad de Los Andes, Mérida, Venezuela
Prometeo researcher, Universidad Técnica Particular de Loja, Loja, Ecuador
aguilar@ula.ve
[3] Universidad Técnica Particular de Loja, Loja, Ecuador
{jmcordero, pmvaldiviezo, lrbarba, lachamba6}@utpl.edu.ec

Abstract. In this paper, we present an extension of a Middleware for Smart Educational Environments based in agents, using the paradigm of Cloud Computing. In that sense, we detail the Middleware components, which enable the process of management of the Cloud Computing. We also present the utilization of this Middleware to provide services on the cloud about task of Learning Analytics that allow processing of data of students and learning environments, to understand and optimize the learning processes.

Keywords: cloud computing, smart educational environment, learning analytics.

1 Introduction

In educational environments, the Ambient Intelligence (AmI) allows to follow the dynamics of teaching and learning of users [1, 2, 3, 4], such as: supervise the student performances, provide digital contents according to the student's learning style, link students studying similar topics, etc. On the other hand, cloud learning (C-Learning) allows a reuse of learning resources in a distributed manner. C-Learning provides available educational services in the cloud, using the mechanisms and tools that provides cloud computing. In particular, the AmI for education based on the cloud could be used as a space, where the technologies of the cloud and ubiquitous, help the learning processes in an unobtrusive manner, to improve their scalability and integration capabilities [5, 6, 7].

In previous work, we have developed a middleware based on multi-agent system, called AmICL, to support smart educational environments [8, 9, 10]. This Reflective Middleware allows to manage an Intelligent Environment (IE) of Learning. This middleware proposes five levels, one for the management of the multi-agents community, other to manage the access to services, applications, etc., and the last one to characterize the different components (software and hardware) of AmI for education. This article aims to present the detailed design of the implementation of

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_94

the paradigm of cloud computing in AmICL, as well as verify their operation in a use case. Basically, the use case is linked to providing cloud services linked to Learning Analytics (LA) tasks. LA refers to the processing of data of students and learning environments, in order to understand and optimize their learning processes [11].

This paper is organized as follows: Section 2 provides detailed specification of the components in AmICL. Section 3 presents the components in AmICL responsible for the management of the cloud computing. Section 4 describes the use case, design and utilization of the services and the context of the AmI where they are used. Finally, Section 5 has some conclusions and acknowledgments.

2 Middleware for intelligent cloud learning environments (AmICL)

In this work, we are going to use the middleware AmICL proposed in [8, 9, 10]. This Middleware proposes five levels (see Fig. 1). The IE physical Management layer represents the different devices in the environment, defined as agents. MMAL is composed by a multi-agent community to support the execution of multi-agents applications. This level follows the FIPA standard (see [12]). The Services Management Layer (SML) has the responsibility of finding, searching, etc., services required by the applications. ILL represents the different software components in the educational platform. Particularly, it has two agents: the first is a profile agent to represent each student (SPA), and the second is the tutor agent (TA) to represent the professor. Finally, IPL is where are deployed the different devices and software of a smart classroom (SaCI). AmICL is an Autonomic Reflective Middleware that enables the integration of objects in the educational environment, with educational resources in the cloud, in a flexible an adaptive way, so that objects can adjust their behavior according to the context, and the requirements of the users.

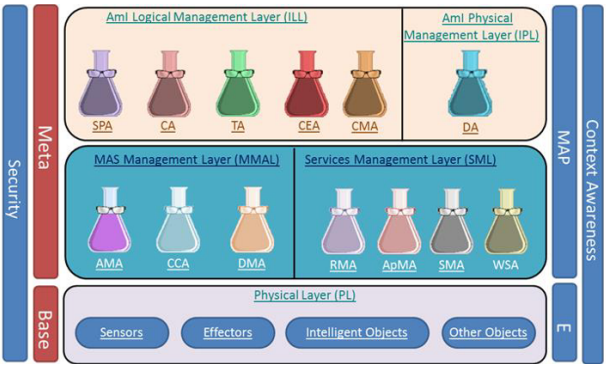


Fig. 1. AmICL architecture.

The difference between AmICL and other similar researches is in the way that combines the AmI with academic services that provides the cloud learning paradigm (C-Learning). In AmICL, academic cloud services are combined with intelligent and non-intelligent objects in the environment, to adapt and respond to the teaching and

learning requirements of users. In particular, the new aspect that fuses an AmI with the cloud computing paradigm is SML. This layer has some agents which are an extension of FIPA standard, because the layer not only handles the resources and applications, but also educational services (locals and in the cloud), to adapt the AmI to current learning conditions required by its users.

In general, the agents of the middleware are, in MMAL: Agent Management of Agents (AMA), CCA (Communication Control Agent) and DMA (Data Management Agent, they are defined in [12]; SML is defined by the Services Management Agent (SMA), the Web Service Agent (WSA), the RMA (Resource Management Agent) and the ApMA (Applications Management Agent). The agents of ILL are: the Student's Profile Agent (SPA), the Collaborative Agent (CA), the Tutor Agent (TA), the Content Management System Agent (CMA), and the Collaborative Environments Agent (CEA). Finally, the IE Physical Management Layer is composed of a single type of agent, the Device Agent (DA).

3 Specification of the Cloud Management Subsystem of AmICL

In this paper, we define the agents that compose SML. Therefore, we define a general type of service agent (framework) to represent the different services on the cloud, which can be invoked by the educational platform. Additionally, we define a subsystem to manage the services provides on the cloud for the other components of AmICL via communications protocol based on the service-oriented architecture (SOA) paradigm. Specifically, this layer defines two agents (they are the bridge between the AmI and the cloud):

- *SMA*: controls, records and manages Web Services (WS) available on the system (whether they are in the cloud or locally); so when an agent requires a specific service it should contact this agent to locate the WSA that characterizes that service. The SMA is a hybrid between what is known in WS as UDDI (Universal Description, Discovery and Integration), which is a platform-independent framework to describe, discover, and integrate WS; with an enterprise service bus (ESB) (this software architecture model is used in the design and implement communication between applications based in the SOA paradigm).
- *WSA*: it is the logical representation of a Web Service. It characterizes the WS, knows how to invoke them (it has their interfaces) and what are the requirements necessary to access the WS. The WSA has access to the services description file (WSDL), and creates a local proxy to consume the services' methods. There is one instance of it for each Web Service on the SMA.

In this section, we will use the MASINA models [13] to specify the agents. Basically, we are interested in the models of agents (for detail each agent, etc.), and their tasks (define the activities to achieve their objectives or provide services).

SMA Agent Model

Table 1 shows the SMA Agent model. Particularly, SMA is a goal-based intelligent agent, who learns how to localize Web Services based on past experiences.

The goals of the SMA are facilitate the: access, location (service discovery) and

consumption of the WS in the cloud, such that other agents can make use of these services in a transparent manner. This agent offers three services; the first is adds a WS into the SMA's WS directory; the second is locate a WS by its category, and finally, to remove a WS from the SMA's WS directory.

Table 1. SMA description.

Service Management Agent
Type: Goal-Based Intelligent Software Agent
Roles: Manage Web Services that are available in the IE.
Description: This agent manages (registering, locating, removing) the WS that will be used by other system agents. This agent characterizes what is known in SOA as UDDI, providing to the agents community, location and consumption of the Web Services required.

SMA Tasks Model

Table 2 shows the relationship between SMA services and its tasks.

Table 2. SMA Tasks and Services.

SMA-S1. Register a Web Service
Receiving the Information of the Web Service (WSDL, service name, web service methods description, category, etc.).
Checking the connection to the Web Service.
Registering the Web Service in the directory.
SMA-S2. Locate a Web Service
Receiving data of the Web Service to localize.
Locating the WSA requested.
SMA-S3. Remove a Web Service
Receiving data of the Web Service to remove.
Removing the WSA that characterizes that Web Service.

The first task, “Register Web Service” (SMA-S1), records the data of a new WS (see Table 3).

Table 3. Receiving the Information of the Web Service.

Task Receiving the Information of the Web Service
Objective: Receive data from the Web Service that will be registered in the SMA's directory.
Pre-condition: N/A.
Frequency: When SMA-S1 starts.
Description: This task is needed to receive the information of the new Web Service that is going to be registered in the SMA's directory.

So, the SMA-S1 will perform a task that will check whether the WS that is being registered is online or not. To do that, SMA will use the WSA's capabilities, which in turn will use the WSDL file to check the status of the WS. The next task that SMA-S1 performs is to register the WS in the knowledge base of the SMA (The rest of task models are in [10]).

The tasks of the service “Locate Web Service” (SMA-S2) of SMA are described in [10]. First, the task “Receiving data of the Web Service to localize” receives the information that is needed to localize the WS that has the ability to meet the requirements requested. Once the data is received, the next task is responsible for determining through a bidding process, which WSA has the ability to meet the

requirements requested. A bid process performs this task because each WSA knows its category and its function, so only those WSA that can meet the requirements will make a proposal. The third service offered by SMA is responsible for "Remove a Web Service" (SMA-S3). This service performs two tasks. The first will receive data of the WS to remove, and the second will update SMA's knowledge base (their task models are in [10]).

WSA Agent Model

Table 4 shows the WSA agent model. This agent is of type reflex simple, because its fundamental role is to invoke the WS that characterizes.

Table 4. WSA Description.

Web Service Agent
Type: reflex simple software agent.
Roles: invoke the WS that characterizes.
Description: This agent is responsible for invoking the method to consume the WS, according to the information requested.

The goal of the WSA is serves as a local proxy to access the remote Web Service (endpoint), so can consume the WS. The WSA offers two services: the first invokes a WS method by providing the method input data, while the second permits to obtain the WS description, which can be used to know what type of information is needed to invoke the service.

WSA Task model.

Table 5 shows the relationship between the services and tasks of WSA.

Table 5. WSA Task and Services.

WSA-S1.	**Invoke Web Service**
T1.	Receiving input data to invoke the WS.
T2.	Inferring method's name that will be invoked.
T3.	Invoking the WS Method.
T4.	Send execution result to the requesting agent.
WSA-S2.	**Get Web Service Description**
T1.	Analyze WSDL file.
T2.	Send Web Service's description to the requesting agent.

WSA-S1 service performs four tasks (Their task models are in [10]). The first receives the input data to the WS and verifies that the data have the appropriate format. The second task infers the method called of the WS, based on the input parameters and the type of operation to be performed (creating, requesting, updating or deleting). The next task calls the WS method. Finally, the WSA-S1 service performs the task "Send execution result to the requesting agent" to send the results of the invocation of the WS requested. The WSA-S2 service must perform two tasks: The first task analyzes the WSDL file to determine the input and output parameters of the WS method. The second task WSA-S1 sends the data extracted by the first task.

Registration of a Service on AmICL.

In general, to use a WS in AmICL, it must be registered in the SMA. To register a WS in the SMA, which means can be discovered and located, the following information is required: i) **Service Name:** specifies the name of the WS. ii) **Business**

Name: specifies the business entity that will offer the WS. iii) **WSDL Location:** specifies a URI that points to a WSDL document that contains a description of the WS. iv) **Web Service Description:** specifies a XML document to describe the operation type of each WS Method. v) **Category:** specifies the category into which the WS is located (Academic, Recognition, etc.) An example of the XML document is:

```
<Service name="Affective Recommender System">
  <description> Content Recommender System based on the student's affective state
  </description>
  <method name="search">
    <description>
      obtains recommendations of contents
    </description>
    <type>request<type>
  </method>
  <method name="register">
    <description>
      Register a new content in the system
    </description>
    <type>create</type>
  </method>
</Service>
```

The "type" element in the XML file is used to know which method WSA should call according to what want to perform. It can take the following values: create, request, update or delete (CRUD). This information does not come within the WSDL file, but it is necessary to take decisions when a WSA is being located or invoked.

4 Experiment

4.1 Case Study

We analyze the case study of an online tutoring process in AmICL. This process adapts the online tutoring requirements of a specific session. In this case, the teacher gives a class and proposes some practical activities to students, to be developed in class. AmICL must be able to act proactively to help users to develop their activities, and access to academic resources available in the environment, combining cloud services with AmI. For this case, it is assumed that in the intelligent classroom there is a smart board to project slides, a student board can display the image of students virtually connected, cameras and microphones to capture images and sounds. In addition, each student has access to a computer where developed certain activities proposed by the teacher. The computer is used to monitor the student activity. Similarly, the environment has a Virtual Learning Environment (VLE) application and a Web content recommendation service.

The online tutoring process begins when the users enter to the VLE. Once that VLE has the UID of the different users in this season, it instantiates the corresponding agents for each user. AmICL determines that it must prepare the smart board in the intelligent classroom. Thus, TA locates the course data and plans the class; with that information, it locates today class' slides through a storage service (in the course plan, it is indicates where the slides are stored, and this way it can call the RMA).

The slides file (managed through the RMA) is sent to the smart board, and then the DA (Smart Board) is prepared to begin class when the teacher gives the order. If the user is a student, the academic data is retrieved to determine the learning style and usage history of the environment for the group of students in the AmI. Thus, VLE invokes a clustering service to define the groups of students (each group is a pattern). With this data, VLE asks the recommender system (it is inside of the RMA) for activities, digital contents, etc. to each group of students. In this case, each group is a pattern or style of learning to be exploited by the recommender system, to search more accurate information. The clustering process allows an intelligent search (that is carried out by the recommender system) of learning resources, which are shown into the environment by the smart board according to the planning defined by VLE. Then, the students interact with these learning resources via the smart board, and TA monitors the work of the students. This is a cyclical process that is done in each tutoring session. At the end, VLE establishes a student score (evaluation), and updates the learning profile of the students in function of these results (learn). Additionally, VLE establishes an online tutoring model of the process to analyze the elements (chat, email, etc.), activities, etc., used during the section. For that, it invokes a data mining service, which is going to determine a descriptive model using the respective agents of SML.

Examples of the LA Services

In the conversation are invoked two LA services: to define the patterns of style learning of the students (clustering task) and to build the online tutoring process model. To test the LA services in AmICL, they have been instanced in the Universidad Técnica Particular de Loja (UTPL), where one of the main activities is the distant education. In the UTPL the student is the central actor in the educational process, and a teaching team, the tutorials, the resources learning and new technologies, mediate the learning process. UTPL uses for online tutoring: a VLE based on MOODLE platform, a Video Conference System, e-mail, phone tutoring, etc. The students in distance modality, through the forums, chats and video conferencing in the VLE, can get points. The information about the interaction of the users of VLE is collected in a file.

Building Service of the Pattern of the Online tutoring process.

Service description

This service builds a descriptive model based on association rules, to identify patterns of the interactions in the tools involved in the online tutoring process through the VLE. This service support the data on student interaction during the process tutoring online through VLE, to understand the learning process that is developing in this environment and optimize the use of tools used as forum, chat, among others. We use this file to determine a descriptive model that characterizes the use of the tools on the platform during the online tutoring process. To obtain the descriptive model, The R tool was used (its "arules" library), and 8 attributes were used: Ads, Learning Resources, Forums, Tasks, REAS, Chats, NumMssEnv, NumParticipantesChat. The best results obtained are shown on the Fig. 2 (10 rules).

```
Best rules found:

 1. Chats='(-inf-0.5]' 37 ==> NumParticipantesChat='(-inf-6.6]' 37    conf:(1)
 2. REASdoc='(-inf-1]' Chats='(-inf-0.5]' 28 ==> NumParticipantesChat='(-inf-6.6]' 28    conf:(1)
 3. Chats='(-inf-0.5]' NumMensajesEnvEst='(-inf-7.2]' 27 ==> NumParticipantesChat='(-inf-6.6]' 27    conf:(1)
 4. Tareas='(-inf-2]' Chats='(-inf-0.5]' 25 ==> NumParticipantesChat='(-inf-6.6]' 25    conf:(1)
 5. Chats='(1.5-2]' 34 ==> Tareas='(-inf-2]' 33    conf:(0.97)
 6. Chats='(1.5-2]' 34 ==> NumMensajesEnvEst='(-inf-7.2]' 33    conf:(0.97)
 7. Chats='(1.5-2]' NumMensajesEnvEst='(-inf-7.2]' 33 ==> Tareas='(-inf-2]' 32    conf:(0.97)
 8. Tareas='(-inf-2]' Chats='(1.5-2]' 33 ==> NumMensajesEnvEst='(-inf-7.2]' 32    conf:(0.97)
 9. Chats='(1.5-2]' 34 ==> Tareas='(-inf-2]' NumMensajesEnvEst='(-inf-7.2]' 32    conf:(0.94)
10. Recursos='(-inf-5]' REASdoc='(-inf-1]' NumMensajesEnvEst='(-inf-7.2]' 26 ==> Tareas='(-inf-2]' 24    conf:(0.92)
```

Fig. 2. Best rules obtained.

Specification as WSA

The registration of this service in AmICL is:

Table 6. Building Service of the Pattern of the online tutoring process.

Service
Name: *Service of the Pattern of the Online tutoring process*
Business Name*: NA*
WSDL location: *defined by the SOA platform*
Description: *Service of obtaining patterns in online tutoring process based on models descriptive*
Category: *Data Mining*

And the XLM document is:

```
<Service name="Service of the Pattern of the Online tutoring process">
  <description> Service of obtaining patterns in online tutoring process based on models descriptive.
  </description>
  <method name="build of the descriptive model">
    <description>
      obtain patterns of user interaction in the VLE
    </description>
    <type>search<type>
  </method>
  <method name=" Analysis of rules">
    <description>
      interpretation of rules
    </description>
    <type>identify</type>
  </method>
</Service>
```

Service of students clustering

Service description

We used the K-means clustering algorithm and the tool WEKA, to identify groups of objects with similar characteristics. Additionally, we use the same data from UTPL. For training, we divide the dataset with 80% for training and 20% for the test. As is noted in Fig. 3, there are three groups with a large supply of ads, but there is a clear distinction between them in relation with the utilization of the tools (chats, messages, etc.) by the students in their interactions.

		Cluster#		
Attribute	Full Data	0	1	2
	(95)	(24)	(21)	(50)
Anuncios	22.6105	25.1667	21.5238	21.84
Recursos	12.6	8.75	14.4762	13.66
Foros	3.9789	3.7917	3.4762	4.28
ComentProfEst	0 a 0	14 a 65	5 a 78	0 a 0
Tareas	1.8421	0.8333	0.8095	2.76
REASdoc	1.1368	0.7083	1.1905	1.32
Chats	1.1263	2.2917	1.5238	0.4
NumForumSentEstudent	4.2316	2.75	8.9524	2.96
NumMensajesEnvEst	5	3.2083	5.1429	5.8
NumParticipantesChat	13.3474	18	38.0952	0.72

Fig. 3. Results of the clustering problem.

Specification as WSA
The registration of this service in AmICL is:

Table 7. Building Service of the Pattern of the online tutoring process.

Service
Name: *Student's Clustering*
Business Name: *NA*
WSDL location: *defined by the SOA platform*
Description: *Service of obtaining student patterns in the process of online tutoring.*
Category: *Data Mining*

And the XLM document is:

```
<Service name="Service of the Pattern of the Online tutoring process">
  <description> Service of obtaining similar behavior patterns in the process of online tutorial.
  </description>
  <method name="Clustering model">
    <description>
      Obtaining of patterns behavior similar in the process of online tutorial.      </description>
    <type>search<type>
  </method>
  <method name="identify user profile">
    <description>
      Obtaining of profiles based on the interaction in the VLE      </description>
    <type>cluster</type>
  </method>
</Service>
```

5 Conclusions

In this work, we have shown the functionality of the cloud component of AmICL, to guarantee a cloud learning. AmICL mixes the benefits and capabilities such as reflective, autonomous and context aware of AmI, with capabilities that provides a learning environment in the cloud with academic services, which can be accessed from anywhere. This result provides improving resources and academic services in a learning environment. Moreover, it allows adapting the environment to the academic needs of users.

In particular, the system allows the invocation of educational WS to be executed by smart objects in the AmI, in transparent manner to users, to improve and adapt their operations to the requirements of these users. In addition, the reflective and contextual awareness capabilities of AmICL allow the system to adapt itself to the needs of the environment, in order to act intelligently to each situation that arises. Thus, AmICL used the intelligent capabilities related with reflection and analysis of the context in the middleware, using the LA paradigm, to adapt appropriately to situations and requirements that occur in the AmI.

We have tested LA services on the cloud for complex tasks, which are used by AmICL to improve the quality of the learning process. In general, the scalability and flexibility properties of an AmI are very good solved in our model. The next work must analyze the emergence and the self-organization of AmICL, and the specific problems of implementation (multi-agent platform, communication protocols, etc.).

Acknowledgments. Dr Aguilar has been partially supported by the Prometeo Project of the Ministry of Higher Education, Science, Technology and Innovation of the Republic of Ecuador. This work has been partially supported by the UTPL Project entitled: "Medios de Gestión de Servicios (Middleware) Inteligentes para Entornos de Aprendizaje Virtual".

References

1. Mhiri, F., Ratté, S.: AARTIC: development of an intelligent environment for human learning. SIGCSE Bulletin, vol. 41, nº 3, pp. 359-359 (2009)
2. Mikulecký, P.: Smart environments for smart learning. In 9th International Scientific Conference on Distance Learning in Applied Informatics DIVAI, Sturovo, Slovakia (2012)
3. Shi, Y., Qin, W., Suo, Y., Xiao, X.: Smart classroom: Bringing pervasive computing into distance learning. Handbook of Ambient Intelligence and Smart Environments, Springer, p. 881–910 (2010)
4. Stenvall-Virtanen, S., Nordell, K.: Smart Environments: Technology, Protocols and Applications. Finland, Tech. Rep.: University of Turku (2014)
5. El-Bishouty, M., Ogata, H., Rahman, S., Yano, Y.: Social Knowledge Awareness Map for Computer Supported Ubiquitous Learning Environment. Educational Technology & Society, vol. 13, nº 4, p. 27–37 (2010)
6. Garruzzo, S., Rosaci, D., Sarné, G.: Isabel: A multi agent e-learning system that supports multiple devices. In IEEE/WIC/ACM International Conference on Intelligent Agent Technology (2007)
7. George Margetis, X. Z., Koutlemanis, P., Antona, M., Stephanidis, C.: Augmented interaction with physical books in an Ambient Intelligence learning environment. Multimedia tools and applications, vol. 67, nº 2, p. 473–495 (2013)
8. Valdiviezo, P., Cordero, J., Aguilar, J., Sánchez, M.: Conceptual Design of a Smart Classroom Base on Multiagent System. In 2015 International Conference on Artificial Intelligence (ICAI'15), Las Vegas, USA (2015)
9. Aguilar, J., Sánchez, M., Valdiviezo, P., Cordero, J.: Mecanismos de Coordinación en un Salón Inteligente. In 6to Congreso Iberoamericano de Estudiante de Ingeniería Eléctrica (VI CIBELEC 2015), Mérida, Venezuela (2015)
10. Sánchez, M., Aguilar, J., Cordero, J., Valdiviezo, P.: Basic features of a Reflective Middleware for Intelligent Learning Environment in the Cloud (IECL). In Asia-Pacific Conference on Computer Aided System Engineering (APCASE'15), Quito, Ecuador (2015)
11. Wolfgang, G., Hendrik, D.: Translating Learning into Numbers: A Generic Framework for Learning Analytics. Educational Technology, vol. 15, nº 3, pp. 42-57 (2012)
12. Aguilar, J., Ríos, A., Hidrobo, F., Cerrada, M.: Sistemas Multiagentes y sus aplicaciones en Automatización Industrial. 2nd ed., Mérida: Talleres Gráficos, Universidad de Los Andes (2013)
13. Aguilar, J., Besembel, I., Cerrada, M., Hidrobo, F., Narciso, F.: Una metodología para el Modelado de Sistemas de Ingeniería Orientado a Agentes. Inteligencia Artificial: revista iberoamericana de inteligencia artificial, vol. 12, nº 38, p. 39–60 (2008)

Specification of a Smart Classroom based on Agent Communities

Jose Aguilar[1], Luis Chamba-Eras, Jorge Cordero[2]

[1] Universidad de Los Andes, Mérida, Venezuela
Prometeo Researcher, Universidad Técnica Particular de Loja, Loja, Ecuador
aguilar@ula.ve
[2] Universidad Técnica Particular de Loja, Loja, Ecuador
{lachamba6,jmcordero}@utpl.edu.ec

Abstract. For the development of distributed applications, it is required to define a formalization of the process of implementation. Particularly, we are interested in one type of Ambient Intelligence (AmI), the Smart Classroom. In this paper we propose the implementation of a Smart Classroom, called SaCI, using the concept of communities of agents. With this concept, we carry out the definition and implementation of sets of agents according to their roles, functionalities, characteristics, among others, in SaCI. Each community can be designed and implemented independently and later be integrated in SaCI. In this paper we present this approach and its implementation in SaCI.

Keywords: smart educational environment, multi-agent system, ambient intelligence.

1 Introduction

Ambient Intelligence (AmI), is an area of Computing Sciences dedicated to design spaces that are composed by smart or not objects which interact with each other, in order to define applications to support users of these, in their activities. AmI is based on new areas in Computing Sciences, especially in Ubiquitous Computing. Among its features are the ability to detect environmental information, based on the interaction of autonomous devices with computing capabilities, and reasoning from data, information and knowledge accumulated, in order to select actions to execute. There are many applications: smart home, services in the health sector, among others.

In this paper, our interest is in education, particularly in the Smart Classroom. A Smart Classroom is an area where the Ubiquitous Technology helps the learning process in a transparent manner, incorporating new ideas and approaches in the educational process [4, 5], [8, 9]. In previous work, we have specified a Smart Classroom called SaCI [6, 7], [10]. SaCI consists of devices and software, primarily educational (e.g., smart boards, Virtual Learning Environments (VLE), Intelligent Tutoring Systems (ITS), among others), which it adapts and integrates to the course according to the necessities of the students. This adaptation of the different components of SaCI is possible due to its autonomic and reflective capacities.

The works [6, 7], [10] define the conceptual design of SaCI, with the details of each component. This conceptual definition of SaCI needs to be implemented in a

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_95

computational platform. This paper has this goal, it defines the procedure to develop SaCI computationally, and presents examples of this implementation.

Particularly, we propose to use the concept of communities of agents in order to guide the implementation process. A community of agents is a set of agents, with the same roles, functionalities or characteristics in SaCI. They can be developed independently of the rest of the communities, for later integration. In this paper we propose this approach to implement SaCI, for that, we have defined the communities to be developed in SaCI, we show the development of two of them, and carry out some tests in the implemented platform, to test SaCI.

2 Smart Classroom SaCI

SaCI is a Smart Classroom proposed in [10], where its deployment environment (middleware) was proposed in [6, 7] (called AmICL). SaCI proposes a smart, student-centered classroom, which supports the learning process, through collaborative devices and applications that facilitate self-training. To do this, SaCI has different types of components: hardware (such as smart boards, projectors, cameras, etc.) and software (ITS, VLE, among others). In [10] has been proposed the SaCI model based on the paradigm of Multi-agent Systems (MAS). The reflective middleware for smart learning environments [6, 7] is shown in Fig. 1.

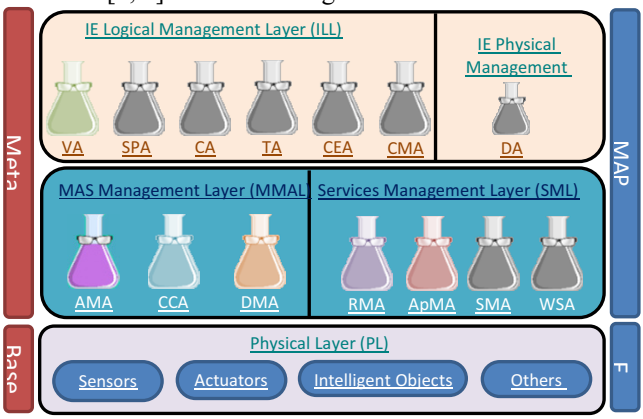


Fig. 1. AmICL architecture.

AmICL has five levels. A physical layer with components that interconnect the elements of an AmI (software or hardware), such as APIs, libraries, etc. That level works directly with the operating system. The SMA management level consists of the classic multi-agent community, defined by FIPA to support the implementation of multi-agent applications [2]. The service management layer has the responsibility to seek the required services in the cloud, particularly educational. The AmI physical layer represents the various devices in the environment, represented as agents. The AmI logical layer (ILL) represents the different software applications used in the educational platform, it is also represented as agents. In particular, this layer defines the applications (software) and individuals present in SaCI as agents, which contain metadata that defines them. The last two layers are those that define SaCI. Finally, in

the real classroom of AmICL is where the devices (sensors, smart cameras, etc.) and software (VLE, etc.) of SaCI are deployed.

In specific, the agents of the middleware are, in MMAL: Agent Management of Agents (AMA), CCA (Communication Control Agent) and DMA (Data Management Agent, they are defined in [2]; SML is defined by the Services Management Agent (SMA), the Web Service Agent (WSA), the RMA (Resource Management Agent) and the ApMA (Applications Management Agent). The agents of ILL are: the Vision Agent (VA), the Student's Profile Agent (SPA), the Collaborative Agent (CA), the Tutor Agent (TA), the Content Management System Agent (CMA), and the Collaborative Environments Agent (CEA). Finally, the IE Physical Management Layer is composed of a single type of agent, the Device Agent (DA).

The SaCI can take advantage of cloud computing. In [6, 7] is described AmICL, as the reflective middleware based in Cloud Learning, which exploits the academic services on the cloud. In particular, the educational services in the cloud are to enhance the learning experience of students. With AmICL, the SaCI avoids any need to locally maintain complex computing infrastructures, and exploits the "as-a-Service" paradigm [12]: Database-as-a-Service, Security-as-a-Service, Sensing and Actuation-as-a-Service, Cloud-Based Analytics-as-a-Service (CLAaaS), Data Mining-as-a-Service (DMaaS), among others. For example, it can use cloud environments like CLAaaS and DMaaS, to obtain services for specific tasks about social learning analytic, which have Big Data challenges [11].

3 Specification of SaCI based on communities of Agents

In this paper, we define SaCI based on the notion of communities of agents, where the agents of SaCI are grouped according to the similarities at the level of characteristics, functionalities or roles in SaCI. In this way, we propose the following communities:

- Community of Agents that manage the Ambient Conditions in SaCI
- Community of Agents that manage the Learning Resources
- Community of Agents that manage the Learning Process
- Community of Agents that represent the Human Beings
- Community of Agents that represent the Mobile Objects (e.g. Robots) in SaCI
- Community of Agents that represent Static Objects in SaCI

According to these communities, we can develop each set of these types of agents of SaCI independently. Now, we define these communities using MASINA [1].

Community of Agents that manage the Ambient Conditions in SaCI

These sets of agents have the task of being managers of SaCI environmental conditions such as temperature, lighting, noise, among others. In particular, they are focused on monitoring and control of the temperature, noise, and lighting in the SaCI. Particularly, we have defined two agents:

- The temperature agent: determines and regulates the temperature in the SaCI.
- The lighting agent: regulates the light in the SaCI.

They adapt these variables to work in an average of the necessities of the people in a SaCI. Table 1 shows the description of one of these agents (for the rest see [3]).

Table 1. **Temperature agent description.**

Name: temperature agent
Position: Community of Agents that manage the Ambient Conditions
Description: This agent determines and regulates the temperature in SaCI

Community of Agents that manage the Learning Resources

This community aims to facilitate the learning processes through a set of agents, which search learning resources required by the students. The next agents compose it:

- Application Manager Agent: it receives the requirement of information from the rest of communities. It creates a recommender agent by request.
- Recommender agent: according to the student profile, it searches the learning resources on the local repository, and if it doesn't exist, it searches in Internet.
- Repository agent: it manages the local repository of educational resources.

Table 2 shows the description of one of these agents (the rest in [3]).

Table 2. Recommender agent description.

Name: Recommender agent
Position: Community of Agents that manage the Learning Resources
Description: This agent searches learning resources according to the student profiles

Community of Agents that manage the Learning Process

This community defines the applications that enable the creation and management of teaching and learning spaces through Internet, where teachers and students can interact during the training process. The main component is the VLE agent, which allows the managing of a course. The VLE agent presents resources and activities within a course; for its different phases. Some of the functionalities of this agent are:

- Content management, creation, storage, and access to learning resources.
- Mapping and planning of the curriculum, lesson planning, etc.
- Student management: student information, etc.
- Space of communication and collaboration - emails, notices, chat, wikis, blogs.

Other applications in this community are the ITS, the educational content management systems, among others. Table 3 shows the VLE agent description.

Table 3. VLE agent description.

Name: VLE agent
Position: Community of Agents that manage the Learning Process
Description: Manages the learning process for a course

Community of Agents that represent the Human Beings

This community aims to represent teachers and students in the SaCI. It has an abstraction of each Human Being in the SaCI, representing their capabilities, skills, learning style (for the students), etc. Table 4 shows the description of this agent.

Table 4. Virtual Student agent description.

Name: Virtual Student agent
Position: Community of Agents that represent the Human Beings
Description: This agent is an abstract of the virtual students, with its style of learning, etc. Each virtual student has a virtual agent in SaCI

Community of Agents that represent the Mobile Objects in the SaCI
This community represents the different Mobile Objects (e.g., Robots) in SaCI like agents. Table 5 shows the general description of this agent.

Table 5. Robot agent description.

Name: Robot agent
Position: Community of Agents that represent the Mobile Objects
Description: This agent is the abstract of the Robot in a SaCI

Community of Agents that represent Static Objects in a SaCI
This community defines the different static objects in SaCI like agents. Some examples of static agents are the smart boards, the cameras, etc. Table 6 shows the description of one of these agents (for the rest see [3]).

Table 6. Smart Board agent description.

Name: Smart Board agent
Position: Community of Agents that represent Static Objects
Description: This agent is the abstract of the smart board in a SaCI

4 Implementation

In this section we describe the implementation of some of the communities, for the rest see [3]. We have used JADE for the implementation of the agents in the SaCI.

Community of Agents that manages the Ambient Conditions in a SaCI
We have defined different agents in this community, one for each sensor in an AmI. Each agent has one sensor to monitor AmI, and a controller (e.g., the temperature (ventilators), light (blinds), etc. Fig. 2 shows the interface between these agents and the SaCI (the detailed implementations of these agents with JADE are in [3]).

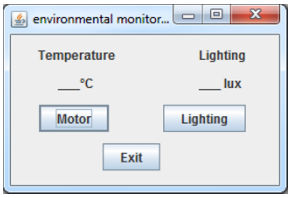


Fig. 2. Interface of the temperature and light agents

Community of Agents that manage the Learning Resources
The main agent in this community is the Recommender Agent. This agent has been developing using an API to call to MERLOT. MERLOT is an application to find online learning materials. With MERLOT, we can access Learning Object Repositories (the detailed implementation of this agent with JADE is in [3]). The Recommender Agent prepares the query and calls MERLOT to search for the information required (see Fig. 3). The sets of agents in this community are:

- Request management agent: manages the requests for information. Many managers will be created, as requests exist.

- Recommender agent: requests learning resources according to the student profile data and the learning component.
- Repository management agent: manages the consultations to the repository of educational resources.

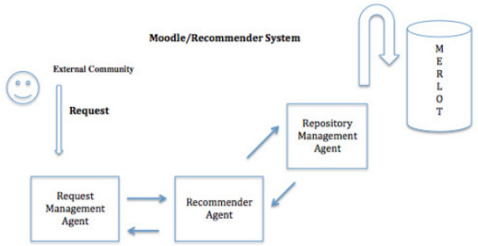


Fig. 3. Architecture of the recommender agent

Community of Agents that manage the Learning Process

The main agent is the VLE Agent. In our case it is defined by MOODLE, a VLE widely used. Fig. 4 shows our VLE agent like an abstraction of MOODLE, with additional capabilities to store information about the context. In general, users request resources they need in a given context, the VLE responds after consulting the database of resources, with the resources that may be useful to users. All interactions are stored in the database of academic management system (SGA) (the detailed implementations of these agents with JADE are in [3]).

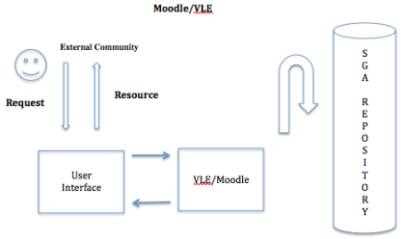


Fig. 4. Architecture of the interaction with VLE

Community of Agents that represent the Mobile Objects (e.g. Robots) in the SaCI

Each mobile object has one agent. To define each robot, we need to use the specific library or API of each Robot. The main aspect is to connect the robot with the agent implemented in JADE. For that, we used FIPA-ACL messages, which allow sending actions and messages between the agent implemented in JADE and the robots (see Fig. 5). Two of these possible actions are move and power-up (the detailed implementations of these agents with JADE are in [3]).

Community of Agents that represent Static Objects in a SaCI

The main agent in this community is the Smart Board Agent (the detailed implementation of this agent with JADE is in [3]). This agent uses the library of the Smart Board to communicate with it (see Fig. 6). The main function of this agent is to receive requests from other communities to present open educational resources, to develop dynamic multimedia activities between teachers and students, among others. SaCI exploits the user interface of the Smart Board to show the learning resources, to allow the interaction of activities between human beings, etc.

```
Application app = new Application(args);
Session session = new Session();
Future<Void> fut =session.connect
("tcp://172.17.41.159:9559");
fut.get();
com.aldebaran.qimessaging.Object tts = null;
tts = session.service("ALTextToSpeech");

boolean ping = tts.<Boolean>call("ping").get();
if (!ping) {
    System.out.println("Could not ping TTS");
} else {
    System.out.println("Ping ok");
}
tts.call("say", "Hola mundo, soy Nao");

Connection objConnection = new Connection();
myAgent.addBehaviour(objConnection);
```

Fig. 5. Code to implement the interface between the Robots and the agents in JADE

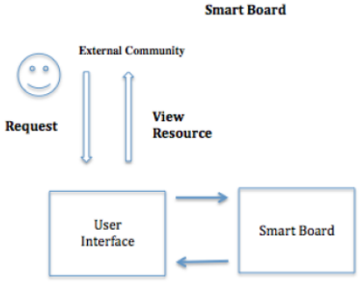


Fig. 6. Smart Board in SaCI

5 Experiments

SaCI has six main conversations in order to adapt the learning process to the needs of the students. The conversations are:

- Online tutoring process
- Set-up environment variables
- Stimulating the learning process
- Teacher´s guides to the learning process
- Feedback processes

In this section, we explain only some of them.

Online tutoring process

The online tutoring process (see conversation in Fig. 7) begins identifying users that enter to the VLE. Once VLE has the UID of the different users of this session, it instantiates the corresponding agents for each user. The AmICL determines that it must prepare the smart board available in the Intelligent Classroom. Thus, TA locates the course data and plans the class; with that information, it locates today class' slides through a storage service (in the course plan, it is indicates where the slides are stored, and in this way it can call the RMA).

The slides file (managed through the RMA) is sent to the smart board, then the DA (Smart Board) is prepared to begin class when teacher ordered. If the user is a student, the academic data is retrieved to determine the learning style and usage history of the

environment for the group of students in the AmI. For that, VLE invokes a *clustering service* to define the groups of students (each group is a pattern). With this data, VLE asks the recommender system (it is inside of the RMA) for activities, digital contents, etc. to each group of students. In this case, each group is a pattern or style of learning to be exploited by the recommender system, to search more accurate information. That is, the clustering process allows an intelligent search (that is carried out by the recommender system) of learning resources, which are shown into the environment by the smart board according to the planning defined by VLE. Then, the students interact with these learning resources via the smart board, and TA monitors the work of the students. This is a cyclical process that is done in each tutoring session. At the end, the VLE establishes a student score (evaluation), and updates the learning profile of the students in function of these results (learn). Additionally, the VLE establishes an online tutoring model of the process to analyze the elements (chat, email, etc.), activities, etc., used during the section. For that, it invokes a *data mining service*, which is going to determine a descriptive model using the respecting agents of SML.

Set-up Environment Variables
The agents of the Community of Agents that manage the Ambient Conditions in SaCI monitor the environment, and can change when a robot agent require it or when they determine in the cloud a change of the environmental variables which are outside of the values allowed. This action of control is carried out by the actuators of the agents (see conversation in Fig. 8).

5 Conclusions

In this work, we have shown the implementation of SaCI. For that, we have introduced a concept, called communities of agent, in order to ease the process of development of the agents. This approach allows defining each community, and arriving at a prototype, in order to test them in an isolated environment. This allows for independent development, and only when the functionality of each community is correct is integrated.

In general, the JADE agent platform simplifies the implementation of SaCI [3], and the MASINA methodology the design of SaCI, but they are not enough for an efficient development of the agents. We need an approach to guide the development process, this should determine how to proceed with the specification of the agents. The "communities of agent" concept allows for a defining group of agents with similar tasks, with similar characteristics and common roles in SaCI. This allows developers and professionals specialize in specific aspects of SaCI. This approach gives a large scalability to SaCI, because new communities can be incorporated, and before to be integrated, they can be tested.

Acknowledgments. Dr Aguilar has been partially supported by the Prometeo Project of the Ministry of Higher Education, Science, Technology and Innovation of the Republic of Ecuador. This work has been partially supported by the UTPL Project entitled: "Medios de Gestión de Servicios (Middleware) Inteligentes para Entornos de Aprendizaje Virtual".

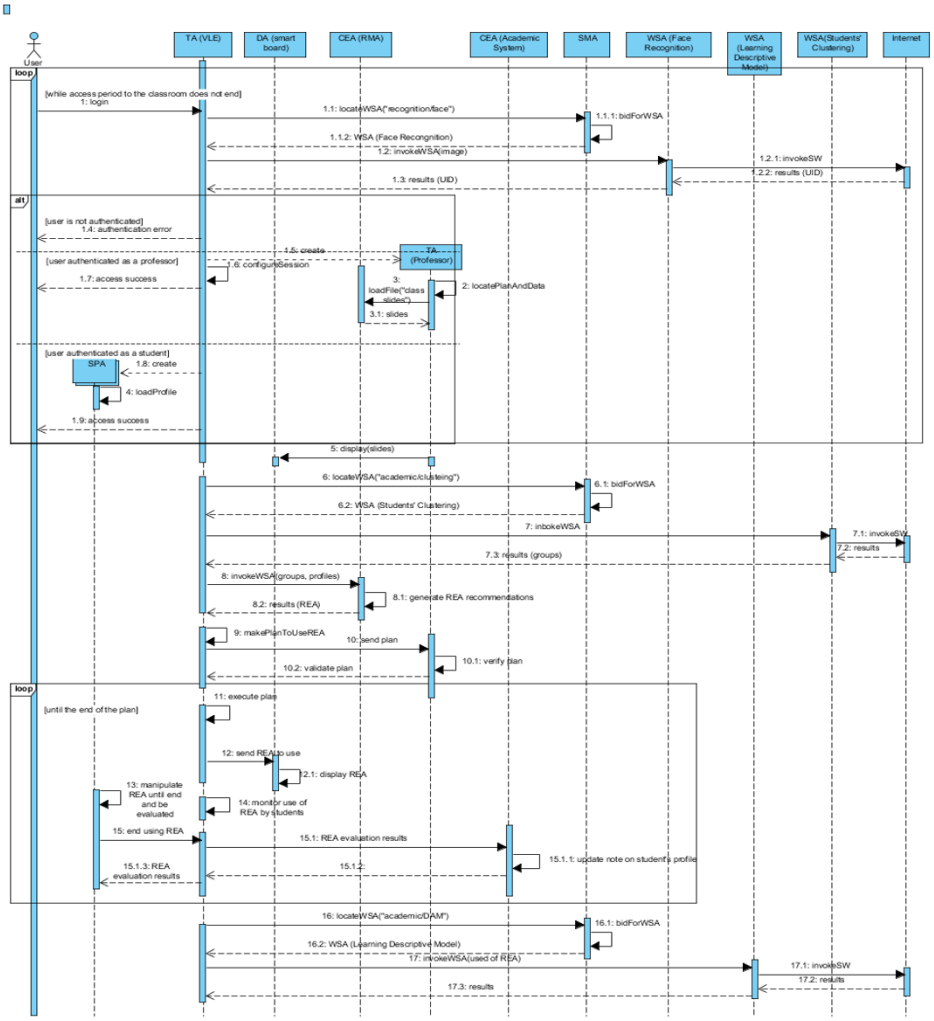


Fig. 7. Conversation "Online tutoring process".

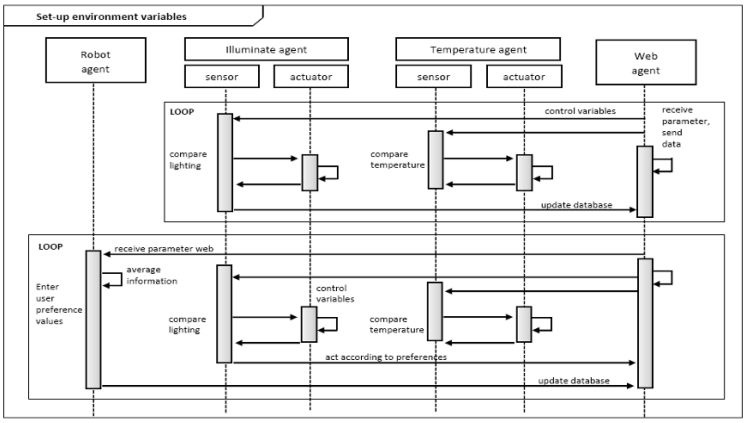


Fig. 8. Conversation "Set-up environment variables".

References

1. Aguilar, J., Besembel, I., Cerrada, M., Hidrobo, F., Narciso, F.: Una metodología para el Modelado de Sistemas de Ingeniería Orientado a Agentes. Revista Iberoamericana de Inteligencia Artificial, vol. 12, no. 38, 39–60 (2008)
2. Aguilar, J., Ríos, A., Hidrobo, F., Cerrada, M.: Sistemas Multiagentes y sus aplicaciones en Automatización Industrial. Universidad de los Andes, Caracas (2013)
3. Aguilar, J., Cordero, J., Chamba-Eras, L.: The details to specify SaCI. Technical report, Universidad Técnica Particular de Loja (2015)
4. Mhiri, F., Ratté, S.: AARTIC: development of an intelligent environment for human learning. ACM Sigcse Bulletin, vol 41, no. 3, 359 (2009)
5. Mikulecký, P.: Smart environments for smart learning. In 9th International Scientific Conference on Distance Learning in Applied Informatics DIVAI, pp. 213-222, Sturovo (2012)
6. Sánchez, M., Aguilar, J., Valdiviezo, P., Cordero, J.: Basic features of a Reflective Middleware for Intelligent Learning Environment in the Cloud. In Asia-Pacific Conference on Computer Aided System Engineering, pp. 1-6. Quito (2015)
7. Sánchez, M., Aguilar, J., Cordero, J., Valdiviezo, P.: A Smart Learning Environment based on Cloud Learning. International Journal of Advanced Information Science and Technology, vol. 39, no. 39, 39-52 (2015)
8. Shi, Y., Qin, W., Suo, Y., Xiao, X.: Smart classroom: Bringing pervasive computing into distance learning. In Handbook of Ambient Intelligence and Smart Environments, pp. 881–910. Springer, USA (2010)
9. Stenvall-Virtanen, S., Nordell, K.: Smart Environments: Technology, Protocols and Applications. Technical report, University of Turku (2014)
10. Valdiviezo, P., Cordero, J., Aguilar, J., Sanchez, M.: Conceptual Design of a Smart Classroom Based on Multiagent Systems. In ICAI-International Conference on Artificial Intelligence, pp. 471-477. Las Vegas (2015)
11. Sharma, S., Tim, U., Gadia, S., Wong, J.: Proliferating Cloud Density through Big Data Ecosystem, Novel XCLOUDX Classification and Emergence of as-a-Service Era Download. Technical Report, Iowa State University, USA (2015)
12. Sharma, S. Evolution of as-a-Service Era in Cloud. Technical Report, Iowa State University, USA (2015)

Part VIII
Big Data Analytics and Applications

Characterizing User-Generated Text Content Mining: a Systematic Mapping Study of the Portuguese Language

Ellen Souza[1], Dayvid Castro[1], Douglas Vitório[1], Ingryd Teles[1], Adriano L. I. Oliveira[2], Cristine Gusmão[3]

[1] MiningBR Research Group, Federal Rural University of Pernambuco (UFRPE), Serra Talhada, PE, Brazil
eprs@uast.ufrpe.br, wellescastro@gmail.com, douglas.alisson17@gmail.com, ingryd_vanessa_@hotmail.com
[2] Centro de Informática, Federal Unversity of Pernambuco (CIn-UFPE), Recife, PE, Brazil
{eprs,alio}@cin.ufpe.br
[3] Programa de Pós-graduação em Engenharia Biomédica, Centro de Tecnologia e Geociências - Federal Unversity of Pernambuco (CTG-UFPE), Recife, PE, Brazil
cristinegusmao@gmail.com

Abstract. Unstructured data accounts for more than 80% of enterprise data and is growing at an annual exponential rate of 60%. Text mining refers to the process of discovering new, previously unknown and potentially useful information from a variety of unstructured data including user-generated text content (UGTC). Given that Portuguese language is one of the most common languages in the world, and it is also the second most frequent language on Twitter, the goal of this work is to plot the landscape of current studies that relates the application of text mining to UGTC in the Portuguese language. The systematic mapping review method was applied to search, select, and to extract data from the included studies. Our manual and automated searches retrieved 6075 studies up to year 2014, from which 35 were included in the study. Text classification concentrates 79% of all text mining tasks, having the Naïve Bayes as the main classifier and Twitter as the main data source.

Keywords: Text Mining, Text Classification, Opinion Mining, User-Generated Content, Portuguese Language.

1 Introduction

The growth of social media and user-generated content (UGC) on the Internet provides a huge quantity of information that allows discovering the experiences, opinions, and feelings of users or customers [1]. The volume of data generated in social media has grown from terabytes to petabytes.

According to [2], about 80% of corporate data are stored in non-structured way, mainly in text format and are growing at an annual exponential rate of 60%. However, unstructured texts cannot be simply processed by machines, which typically handle

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_96

text as simple sequences of character strings. Specific processing methods, techniques and algorithms are required in order to extract knowledge from text [3].

Text mining or knowledge discovery from text (KDT) was mentioned for the first time in 1995 by Feldman and Dagan as a machine supported analysis of text. It is the process of extracting knowledge from a large amount of unstructured data and it is also defined as an extension of data mining. However, in contrast to data mining, text mining focuses on the extraction of knowledge from a large number of documents written in natural language from various data sources, including UGC.

According to the Organization for Economic Co-operation and Development, User-Generated or User-Created Content is defined as: i) content made publicly available over the internet, ii) which reflects a certain amount of creative effort, and iii) which is created outside of professional routines and practices. Types of UGC are: text, novel and poetry; photo and images; music and audio; video and film; citizen journalism; educational content; mobile and virtual content. In this article, we focus on texts that are generated by users, that is, user-generated text content (UGTC).

Whereas data mining is largely language independent, text mining involves a significant language component, justifying its study associated with one target language. Most text mining tools focus on processing English documents [4], but many other languages, including Spanish and Portuguese, have also been considered.

Given that Portuguese is among the most spoken languages in the world, with almost 270 million people[1] speaking some variant of the language, research interests on Portuguese processing is shared mainly with Portugal and Brazil [5]. Therefore, the growing interest for the Portuguese is also related to the fact that the language is the second most used on Twitter, which is one of the main sources of UGTC [6].

Thus, combining the guidelines to perform Systematic Mapping [7] and Systematic Reviews Studies [8], the goal of this article is to characterize the current researches that report the use of text mining for UGTC in the Portuguese language, driven by the following general research question (RQ): *What is the current state of text mining in the Portuguese language for UGTC?*

The automated and manual search procedures retrieved 6075 papers published up to the year 2014, from which 35 were included in this study. The data[2] extracted from the primary studies were systematically structured and analyzed to answer the historical, descriptive and classificatory research questions presented below:

RQ1: what is the evolution in the number of publications up to year 2014?
RQ2: which individuals, organizations, and countries are the main contributors in the research area?
RQ3: what are the adopted text mining tasks?
RQ4: what are the techniques, algorithms, methods and tools applied?
RQ5: what are the characteristics of UGTC data sources and how they were evaluated?

The remainder of this article is structured as follows: Section 2 provides the related work. Section 3 details the systematic mapping study protocol. In Section 4, a

[1] Brazil (202.656.788), Mozambique (24.692.144), Angola (24.300.000), Portugal (10.813.834), Guinea-Bissau (1.693.398), East Timor (1.201.542), Equatorial Guinea (722.254), Macau (587.914), Cabo Verde (538.535) and São Tomé e Príncipe (190.428). Data extracted from US/CIA - The World Factbook (July, 2014)

[2] Data is available in: http://bit.ly/1MX58hY

comprehensive set of results is presented. Section 5 discusses the results, limitations and threats to validity. Finally, Section 6 contains the conclusions and directions for future work. Due to lack of space, the list of primary studies was not included in this article, it is available online[2].

2 Related Work

Although we have made an extensive search, we did not found any text mining systematic mapping for the Portuguese language and more specifically from UGTC. However we found several language independent text mining surveys [2, 4, 9], a paper [5] describing the computational linguistics area in Brazil, a survey [10] of automatic term extraction for Brazilian Portuguese and a systematic review [11] of user-generated content (UGC) applied to tourism and hospitality.

In [5], an overview of the computational linguistics or natural language processing (CL/NLP) in Brazil is presented. According to the authors, research in Brazil is varied and deals mainly with Portuguese, English and Spanish processing. They also state that research on text mining is mostly carried out by non-computational linguistics researchers, but instead by researchers from general artificial intelligence and database areas. They estimate that Brazil has about 250 researchers in CL/NLP area. The largest CL/NLP research group in Brazil is the Interinstitutional Center for Research and Development in Computational Linguistics (NILC), which includes researchers mainly from University of São Paulo, Federal University of São Carlos and State University of São Paulo. The authors also state that the Brazilian Symposium on Information and Human Language Technology (STIL) is the main event in South America and the International Conference on Computational Processing of Portuguese Language (PROPOR) is the main conference with focus on Portuguese language, giving equal space to research on text and speech processing.

In [10], a survey of the state of the art in automatic term extraction (ATE) for the Brazilian Portuguese language is presented. According to the authors, there are still several gaps to be filled, for instance, the lack of consensus regarding the formal definition of meaning of 'term'. Such gaps are larger for the Brazilian Portuguese when compared to other languages, such as English, Spanish, and French. Examples of gaps for Brazilian Portuguese include the lack of a baseline ATE system and the use of more sophisticated linguistic information, such as the *WordNet* and *Wikipedia* knowledge bases.

In [11], a systematic review was conducted to examine how UGC data have been used in empirical tourism and hospitality research. 122 articles were systematically surveyed. The main sources of UGC data are consumer review websites and blogs. Twitter was classified as a blog. Texts were the dominant UGC data type.

3 Review Method

Secondary studies review all the primary studies relating to a specific research question with the aim of integrating and synthesizing evidence related to a specific

subject [8]. The systematic mapping study, also referred to scope studying, provides a structure of the type of research reports and results that have been published by categorizing them. It often gives a visual summary, the map, of its results [7].

Fig. 1 shows the adopted systematic mapping process. The first step comprises the definition of research protocol. The second, third, and fourth steps encompass the primary studies identification, selection, and evaluation in accordance with the inclusion and exclusion criteria established in the review protocol. In the fifth step, data from the included studies is extracted and synthesized in order to answer the research questions.

We searched the literature looking for full papers (primary studies) that reported text mining applications for UGTC in the Portuguese language. Primary studies that met at least one of the following *exclusion criteria* were removed from the study: (i) written in a language other than English or Portuguese; (ii) not available on online scientific libraries; (iii) keynote speeches, workshop reports, books, theses, and dissertations;

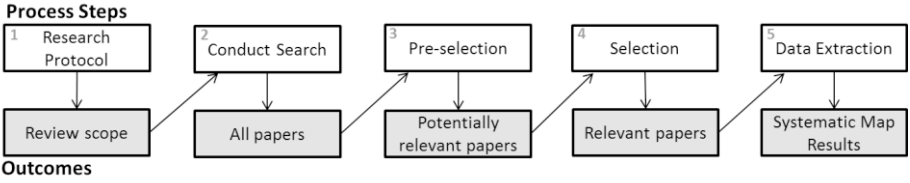


Fig. 1 Systematic Mapping Process based on [7]

3.3. Data Sources and Search Strategy

Automated and manual search processes were combined to achieve high coverage. The automated search was constructed based on two search terms extracted from the general research question presented in Section 1 (see Fig. 2). Synonyms for both terms were extracted from the literature and, as we were looking for primary studies written also in Portuguese language, the translation of terms for Portuguese was also included in the final query. This search retrieved studies from all kind of text sources from which we selected only the ones generated by users, that is, the UGTC.

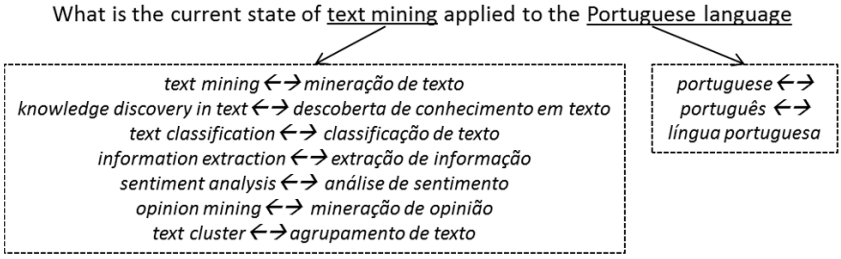


Fig. 2 Generic Search String

Primary studies published up to year 2014 were analyzed using the same procedure for both search strategies. Six researchers divided into three groups applied the inclusion and exclusion criteria's on all retrieved papers after reading the title,

abstract and keywords. For the 661 potentially relevant studies, the researchers reapplied the inclusion criteria and exclusion criteria after reading the full paper. This resulted in a list of 203 studies, from which 35 relate to the use of text mining for UGTC in Portuguese. Table 1 contains the manual (M) and automated (A) data sources details.

Table 1. Manual and Automated Data Sources

Data Source	Type	Retrieved Studies	Included Studies	UGTC
International Conference on the Computational Processing of Portuguese (PROPOR)	M	217	22	1
Text Mining and Applications (TEMA) track of Portuguese Conference on Artificial Intelligence	M	34	6	1
Brazilian Workshop of Social Network Analysis and Mining (BRASNAM)	M	99	11	8
Brazilian Symposium on Information and Human Language Technology (STIL)	M	251	44	3
ACM symposium on Document engineering (DocEng)	M	273	1	-
Linguateca Database (www.linguateca.pt)	M	1312	30	1
Message Understanding Conferences (MUC)	M	159	-	-
Text Analysis Conference (TAC)	M	322	-	-
Text REtrieval Conference (TREC)	M	1715	-	-
Document Understanding Conference (DUC)	M	167	-	-
IEEE Xplore Digital Library	A	306	19	6
ACM Digital Library	A	277	29	11
Science Direct	A	159	4	1
Scopus	A	552	21	2
Portal de Periódicos Capes	A	229	15	1
SciELO Scientific Electronic Library Online	A	2	1	-
TOTAL		6075	203	35

4 Results

In this section, we present the main findings of our review, organized according to the five specific research questions.

4.1 *RQ1: what is the evolution in the number of publications up to year 2014?*

As shown in Fig. 3, the three first primary studies were published in 2009 and the number of studies has grown over the years, despite the drop in 2010 and 2011. Primary studies were classified according to the Portuguese language variant: the European Portuguese (from Portugal) represents 6%, while Brazilian comprises 77% of all studies. 6% make use of text written in both Brazilian and European Portuguese. 11% did not provide the Portuguese variant information. Table 2 lists the Portuguese variant dataset used for each primary studies.

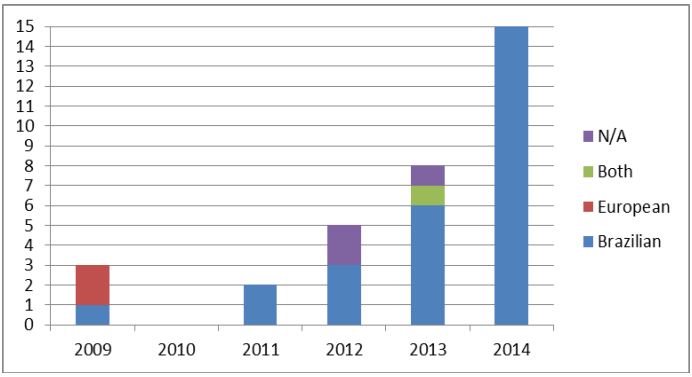


Fig. 3 Temporal distribution of primary studies

Table 2. List of primary studies according to the Portuguese language variant

Variant	Primary Studies
Both	UGC09, UGC10
Brazilian	UGC01, UGC02, UGC03, UGC05, UGC07, UGC08, UGC11, UGC12, UGC13, UGC14, UGC15, UGC16, UGC17, UGC18, UGC20, UGC21, UGC23, UGC24, UGC25, UGC26, UGC27, UGC28, UGC29, UGC30, UGC31, UGC33, UGC34
European	UGC06, UGC32
N/A	UGC04, UGC19, UGC22, UGC35

4.2 *RQ2: which individuals, organizations, and countries are the main contributors in the research area?*

As expected from Fig. 3, Brazil has a greater number of researchers in the field. Renata Vieira from UNISINOS (Table 3) and UFMG (Table 4) appear as the main author and the main organization, respectively. In addition to Brazil (BR) and Portugal (PT), research interests on Portuguese processing is shared with other countries like the USA and Canada as primary studies (UGC04, UGC05, UGC10, UGC12, UGC14, UGC24, UGC26, UGC35) propose multilanguage approaches.

Table 3. Number of articles published by main researchers

Quant	Author	Institution	Quant	Author	Institution
6	Renata Vieira	UNISINOS-BR	3	Larissa A. Freitas	PUCRS-BR
4	Wagner Meira Jr.	UFMG-BR	3	Eugénio de Oliveira	Univer.of Porto-PT
4	Marlo Souza	UFRGS-BR	3	Adriano Veloso	UFMG-BR
3	Karin Becker	UFRGS-BR	3	Luís Sarmento	Univer.of Porto-PT

Table 4. Number of researchers per organization

Quant.	Organization	Country	Quant.	Organization	Country
23	UFMG	Brazil	8	UFRGS	Brazil
15	PUCRS	Brazil	8	Ulisboa	Portugal
11	UFRJ	Brazil	8	USP	Brazil
9	UP	Portugal			

4.3 *RQ3: what are the adopted text mining tasks?*

Four primary studies have performed two research with different text mining tasks (e.g. classification and information extraction) resulting in 39 text mining task occurrences (Table 5). Text Classification appears as the main task for UGTC in Portuguese Language. Three primary studies (UGC02, UGC23, and UGC27) reported the use of balanced classes while eleven (UGC01, UGC05, UGC06, UGC13, UGC17, UGC18, UGC21, UGC22, UGC28, UGC33, UGC35) used unbalanced classes.

The Opinion Mining subtask, also known as Sentiment Analysis, represents 62% of all tasks. Two primary studies (UGC11, UGC12) also evaluated the sentiment or opinion variation over time, also known as *Sentiment Drift*. Eighteen papers reported the usage of lexical resource to perform the sentiment analysis. The main used lexical resources were: SentiLex-PT, SentiWordNet, OpLexicon and Sentimeter-BR.

Table 5. Text Mining tasks and subtasks

Task	%	Subtask	%	Primary Studies
Classification	79	Language Identification	6.5	UGC04, UGC10
		Opinion Mining	74	UGC01, UGC02, UGC03, UGC06, UGC11, UGC12, UGC13, UGC15, UGC17, UGC18, UGC19, UGC21, UGC22, UGC25, UGC26, UGC27, UGC28, UGC29, UGC30, UGC32, UGC33, UGC34, UGC35
		Others	19.5	UGC05, UGC08, UGC09, UGC14, UGC16, UGC23
Information Extraction	13	-	-	UGC07, UGC14, UGC15, UGC20, UGC24
Summarization	2	-	-	UGC31
Topic Tracking	3	-	-	UGC09
Visual Text Mining	3	-	-	UGC31

4.4 *RQ4: what are the techniques, algorithms, methods and tools applied?*

69% of all primary studies performed at least one type of Natural Language Processing (NLP) (see Table 6). The main tools used for text preprocessing and NLP were the Python NLTK, LingPipe and Freeling. Two primary studies reported the use of the TreeTagger-PT for Part-Of-Speech (POS) tagging. For Named Entity Recognition (NER), the CRF tagger, FS-NER and GeoNames were adopted. Table 7 presents the algorithms or methods used in the text analysis step. Naïve Bayes and Weka appears as the most used classifier and most used tool, respectively. Python and Java were the most used programing language in this step.

Table 6. List of adopted pre-processing techniques used in primary studies

	%		Primary Studies
Applied	69	Stopword Removal	UGC01, UGC03, UGC09, UGC15, UGC16, UGC18, UGC21, UGC25, UGC29, UGC33
		Filtering	UGC01, UGC04, UGC09, UGC14, UGC16, UGC18, UGC25, UGC28
		Stemming	UGC01, UGC03, UGC09, UGC13, UGC18, UGC25, UGC33
		POS	UGC15, UGC19, UGC20, UGC25, UGC31, UGC32, UGC35
		NER	UGC06, UGC10, UGC13, UGC14, UGC24, UGC28
		Tokenization	UGC04, UGC10, UGC19, UGC31
		Sentence Splitter	UGC19, UGC22, UGC28, UGC31
		Lemmatization	UGC19, UGC20, UGC25, UGC35
		Chunk	UGC31
N/A	31		UGC05, UGC07, UGC08, UGC11, UGC12, UGC17, UGC23, UGC26, UGC27, UGC30, UGC34

Table 7. List of algorithms and methods used in primary studies

Algorithms/Methods	%	Primary Studies
Naive Bayes	43	UGC01, UGC02, UGC03, UGC04, UGC10, UGC16, UGC18, UGC21, UGC25, UGC29, UGC30, UGC33, Multinomial Naive Bayes {UGC12, UGC25, UGC26}
SVM	31	UGC05, UGC09, UGC13, UGC21, UGC23, UGC32, UGC33, SMO {UGC01, UGC28, UGC29, UGC30}
Decision Tree	14	UGC29, C4.5 {UGC30}, RF {UGC16, UGC21, UGC23}
Rule-Based	17	UGC10, UGC11, UGC12, UGC19, UGC20, UGC31
Pattern-Based	9	UGC06, UGC20, UGC22
N-grams	29	UGC02, UGC04, UGC08, UGC10, UGC23, UGC28, UGC29, UGC30, UGC32, UGC33
Others	51	k-Nearest Neighbor {UGC09, UGC21}, Neural Network {UGC33, UGC21}, Filtered Space Saving {UGC09}, Hoeffding Adaptive Trees {UGC11}, Incremental Lazy Associative Classifier {UGC11}, Latent Semantic Indexing {UGC15}, Map-reduce paradigm {UGC33}, OneR classification algorithm {UGC28}, Online Rule Extraction {UGC12}, Pareto-Efficient Selective Sampling, {UGC11}, Topic Fuzzy Fingerprints {UGC09}, Zipping classifier {UGC04}, Genetic Algorithm {UGC21}, Regular Expression {UGC03, UGC23, UGC28}

4.5 RQ5: *what are the characteristics of UGTC data sources and how they were evaluated?*

A total of 46 data sources were employed among the 35 primary studies. Social networks appear as main sources for UGTC in Portuguese (Table 8). Twitter represents more than 50% of all data sources. Text domain is varied, but Politics, Sports and Technology have greater interest. Two primary studies (UGC05, UGC10) reported the use of publicly datasets, both containing twitter data. The *precision, recall and f-measure* trio was used by almost half of the primary studies to evaluate their results. Eight primary studies reported the adoption of cross validation for

estimating the classifier performance. Mostly (66%) primary studies built manually their gold standard.

Table 8. UGTC Data Sources

Quantity	Data Source
25	Twitter
2	Booking.com, Buscapé, Portuguese newspapers, Tripadvisor, Folha de São Paulo
1	Apontador, Cinema com Rapadura, CinePlayer, e-bit, Emails, Facebook, Fórum, Google Play, MySpace, Omelete, Portuguese newspapers

5 Discussion

We could observe an increasing interest in opinion mining, partly due to its potential applications, such as: marketing, public relations and political campaign. Portuguese is spoken mainly in Portugal and Brazil, with Brazil having approximately 20 times the population of Portugal. Choosing a random Tweet in Portuguese, there is a 95% chance of it originating in Brazil [12]. Facebook and Twitter are important sources of UGTC, however the first one is less used in text classification as it often contains pictures and the analysis of the text by itself is not effective [13].

As most of UGTC in Portuguese comes from social networks, more than 90% of text is short, written in an informal way, with grammatical errors, spelling mistakes, as well as ambiguous and ironic. Although 69% of works have reported the use of NLP, none have reported the use of word sense disambiguation. Therefore, the most used term weighting scheme, the TF-IDF (term frequency – inverse document frequency), is considered less discriminative for text classification [14].

Even when good results are achieved, the used datasets are rarely published. This makes it difficult to implement improvements, as well as comparisons on which technique performs better for a particular dataset. Therefore, less than 50% of all 35 primary studies have fully answered the five research questions. Important data for comparison like text domain and type, class details and language variant were not available. We did not find studies that have reported the use of clustering task for UGTC in Portuguese, as well as a unique tool for all mining tasks.

There are some threats to the validity that are worthy of note: (i) it is possible that some relevant studies were not included throughout the searching process. This threat was mitigated by performing an extensive search, as well as, double-checking from two researchers; (ii) as studies were classified based on personal judgment, it is possible that some studies may have been incorrectly classified. To mitigate this threat, the classification step was executed for more than one researcher; (iii) digital databases do not have a compatible search rules and show some instability when presenting results. We mitigated this threat by running the search in several digital databases more than one time by different researchers.

6 Conclusion

This paper plots the landscape of current studies relating to the application of text mining techniques for UGTC in the Portuguese language. The strength of this paper is to promote growth in the research of text mining in the Portuguese Language. We think that the reported data on this paper may help researchers and practitioners to discover what has been achieved and where the gaps are in this field area.

The lack of some relevant data and published datasets make further analysis in the research area difficult. This work is part of an ongoing broader research as shown in the general research question (Section 1). We are mapping not only the use of text mining techniques for UGTC in the Portuguese language, but for all kind of texts. To increase coverage we plan to apply snowball techniques on included primary studies.

Acknowledgment

Ellen Souza is supported by FACEPE (IBPG-0765-1-0311).

References

1. Marine-Roig, E., Anton Clavé, S.: Tourism analytics with massive user-generated content: A case study of Barcelona. J. Destin. Mark. Manag. 1–11 (2015).
2. Delen, D., Crossland, M.D.: Seeding the survey and analysis of research literature with text mining. Expert Syst. Appl. 34, 1707–1720 (2008).
3. Hotho, A., Andreas, N., Paaß, G., Augustin, S.: A Brief Survey of Text Mining. (2005).
4. Tan, A.: Text Mining : The state of the art and the challenges Concept-based. Proc. PAKDD 1999 Work. Knowl. Disocovery from Adv. Databases. 65–70 (1999).
5. Pardo, T., Gasperin, C., Caseli, H., Nunes, M. das G. V.: Computational Linguistics in Brazil : an overview. Proc. NAACL HLT 2010 Am. 1–7 (2010).
6. Poblete, B., Garcia, R., Mendoza, M., Jaimes, A.: Do All Birds Tweet the Same ? Characterizing Twitter Around the World. Society. 1025–1030 (2011).
7. Petersen, K., Feldt, R., Mujtaba, S., Mattsson, M.: Systematic Mapping Studies in Software Engineering. (2007).
8. Kitchenham, B., Charters, S.: Guidelines for performing Systematic Literature Reviews in Software Engineering. Tech. Rep. EBSE-2007-01, (2007).
9. Hotho, A., Nürnberger, A., Paaß, G.: A Brief Survey of Text Mining. Ldv Forum. (2005).
10. da Silva Conrado, M., Felippo, A., Salgueiro Pardo, T., Rezende, S.: A survey of automatic term extraction for Brazilian Portuguese. J. Brazilian Comput. Soc. 20, 12 (2014).
11. Lu, W., Stepchenkova, S.: User-Generated Content as a Research Mode in Tourism and Hospitality Applications: Topics, Methods, and Software. J. Hosp. Mark. Manag. (2015).
12. Laboreiro, G., Bošnjak, M., Sarmento, L., Rodrigues, E.M., Oliveira, E.: Determining language variant in microblog messages. In: Proceedings of the 28th Annual ACM Symposium on Applied Computing - p. 902. ACM Press, USA (2013).
13. Evangelista, T.R., Padilha, T.P.P.: Monitoramento de Posts Sobre Empresas de E-Commerce em Redes Sociais Utilizando Análise de Sentimentos. (2013).
14. Takçı, H., Güngör, T.: A high performance centroid-based classification approach for language identification. Pattern Recognit. Lett. 33, 2077–2084 (2012).

Gender Classification of Twitter Data Based on Textual Meta-Attributes Extraction

José Ahirton Batista Lopes Filho[1] , Rodrigo Pasti[1], Leandro Nunes de Castro[1]

[1] Natural Computing Laboratory (LCoN), Graduate Program in Electric and Computer Engineering, Mackenzie Presbyterian University (UPM), Rua da Consolação 930, Higienópolis, São Paulo, SP, Brazil
{ahirtonlopes, rodrigo.pasti}@gmail.com, lnunes@mackenzie.br

Abstract. With the growth of social media in recent years, there has been an increasing interest in the automatic characterization of users based on the informal content they generate. In this context, the labeling of users in demographic categories, such as age, ethnicity, origin and race, among the investigation of other attributes inherent to users, such as political preferences, personality and gender expression, has received a great deal of attention, especially based on Twitter data. The present paper focuses on the task of gender classification by using 60 textual meta-attributes, commonly used on text attribution tasks, for the extraction of gender expression linguistic cues in tweets written in Portuguese. Therefore, taking into account characters, syntax, words, structure and morphology of short length, multi-genre, content free texts posted on Twitter to classify author's gender via three different machine-learning algorithms as well as evaluate the influence of the proposed meta-attributes in this process.

Keywords: machine-learning, classification, gender, social media, Twitter, extraction, meta-attributes, Portuguese language.

1 Introduction

Social Media are a group of services and applications built from the technological foundations of *Web* 2.0, which allow the exchange and creation of collaborative contents, also known as user-generated contents. More specifically, *Web* 2.0 refers to a new way that software developers and final users have found to use the World Wide Web. With it, contents and applications are no longer created or published individually, but in a collaborative manner [1].

Different techniques of image, sound, video, and text processing can be applied to find patterns, tendencies, and provide qualitative and quantitative measures for use in different areas, such as economy [2], politics and government [3], recommendation systems [4], and rumor control [5]. Besides, with the growth of the area in the past years, there is an increasing interest in the automatic characterization of social media users based on the informal content they generate.

Amongst the purposes of this task of automating the characterization of user's profiles in social media, is that of labeling them in demographic categories, such as age

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_97

[6], ethnicity, origin, and race [7]. Other attributes inherent to these users, for example, political preferences [8], personality [9], and gender [10], have also been studied, specially based on Twitter data analysis [11] [12] [13] [14].

Such preferences and opinions can be personalized from these data in different contexts, for example, supporting business applications, as in digital marketing; helping in the answer of important social science questions; in the detection and action against embezzlers and falsifiers; as well as in the protection against terrorism, amongst other crimes.

However, these uses still face an essential difficulty, found in the majority of social media: the anonymousness. Knowing that, in cyberspace, users often do not need to provide their real information, such as name, age, gender, and address as well as, in many cases of improper social media usage, authors often hide their addresses using anonymous servers, also their true identities, to avoid being discovered. In that sense, it is necessary to develop and investigate efficient methods to assist the forensic tracking of identity in cyberspace.

The present work provides an experimental methodology based on the use of a set of 60 textual meta-attributes to classify the gender (male/female) of authors of *tweets* in the Portuguese language, by employing three machine learning algorithms. Furthermore, attribute selection via χ^2 (Chi-Square) and Information Gain techniques are performed to analyze which attributes from this set excel in the classification of a *corpus* with the presence of neutral messages, as well as the impact of each set of meta-attributes in the obtained results.

The paper is organized as follows: Section 2 presents the Gender Classification problem; Section 3 presents the proposed methodology; Section 4 provides a brief discussion concerning the Experimental Results obtained with the use of the selected Supervised Classification Model, and, at last, in Section 5, the Conclusions and Future Works are presented.

2 Gender Classification in *Tweets*

A typical authorship attribution problem consists of attributing a text of unknown authorship to a candidate author, given a set of candidate authors. To do that, sample texts of unquestionable authorship are previously available to train the classifiers [15]. Since in gender classification tasks, especially for short and context-free texts (*tweets*), a prior set of candidate authors is not available, the majority of the existing models work with attributes inherent to users.

The gender classification task can be treated as a binary classification problem, i.e., given two classes, male and female, the task is to attribute an anonymous message to one of these classes, without knowing any candidate author [15]. It is important to mention that, when speaking of gender classification, other aspects must be observed, such as *sex* and *gender expression*.

The American Psychology Association conceptualizes *sex*, *gender* and *gender expression* in the following manner [16]: *Sex*, refers to the biological state of a human being and is usually classified as male, female, or *intersex*; *Gender*, refers to attitudes, feelings, and behaviors associated with the biological sex of a person in a given culture;

and *Gender Expression* refers to the way in which a person acts to communicate its gender in a given culture, for example, in terms of clothing, interests, and communication patterns.

The present work is based on the concept of language as a form of *gender expression*, rather than related with sex. For consistency purposes, male and female were used as the two possible genders. Therefore, the studied gender classification can be understood as the task of detecting if a certain social media user is of male or female gender by analyzing the content and behavior demonstrated on their messages, and, furthermore, there is an interest in investigating which of the analyzed meta-attributes, which are addressed in the next section, can be considered meaningful to gender classification.

The first efforts aimed at gender classification in Twitter [10] [11] focused, mainly, on the creation of meta-attributes based on the use of words or specific terms (psycholinguistic characteristics), such as *emoticons*, abbreviations, and affective expressions, information mostly gathered from blogs [10], along with the analysis of other data like user's name, full name, location, URL links, and description, obtained from Twitter itself [11].

Some challenges of this sort of classification are listed in [12], with highlights to the major usage of colloquialism, the simplification of writing, the existence of different stylistic tools created by the users, URLs, and the spread use of acronyms in the English language (LOL, BRB, etc.). As for [13], inferences for non-English languages began to be investigated, together with the exploration of new unique attributes.

Finally, in [14] there is the first investigation of Portuguese language users. However, as in previous works [10], specific words, identified as relevant to the context of the gathered messages, are used as meta-attributes, such as terms with male and female suffix. Nevertheless, this methodology may not be an adequate solution when the objective is to investigate profiles with few *tweets*, or whose language can be considered neutral, like in *corpus* with the presence of journalistic messages [15]. Besides, any approach that considers the user's name inspection [11] [13] is subject to failure, for, while in some cases this information can reveal gender, many users choose names, nicknames and aliases that do not convey this information.

3 GENEC: A Gender Expression Classification Methodology

The proposed system to classify gender expression in tweets is based on the study presented in [15], where the gender classification problem was divided into four main steps: the gathering of an adequate text message *corpus* (*tweets*) that will compose the database; the automatic extraction of the characteristic values (meta-attributes) from each *tweet* or set of *tweets*; the development of a classification model to identify the author's gender; and the selection of the most significant meta-attributes in gender identification (cf. Figure 1).

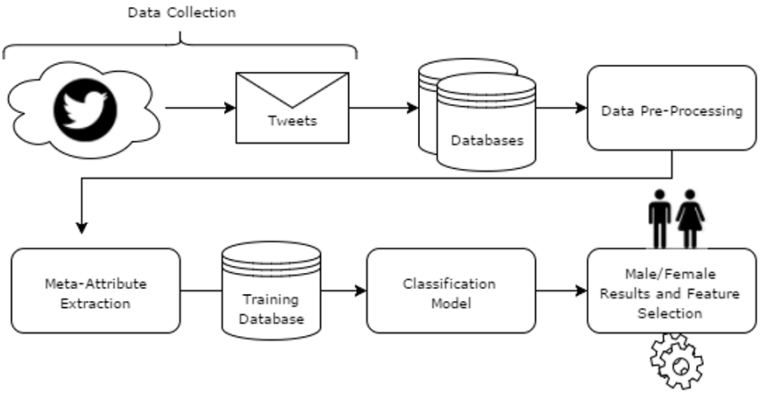


Fig. 1. GENEC: The Gender Expression Classification process.

3.1 Data Collection

A method using the *tweepy* module (https://github.com/tweepy/tweepy) was created in Python to access the Twitter API's as well as to create files containing the last 3,240 *tweets* of a set of 60 Brazilian journalist's profiles (30 male and 30 female). Those profiles were chosen because they are Twitter heavy users, with more than 2.000 published *tweets*, and whose *tweets* have both journalistic nature (neutral) as well as family affairs, day-to-day messages and personal opinions.

3.2 Pre-Processing

The pre-processing step in this work consists of, besides removing graphic accents and non-ASCII characters, using the processes of tokenization and *part-of-speech tagging* (*POS tagging*). The Mac-Morpho *corpus*, the largest POS *corpus* labeled in modern Portuguese, was used to analyze the relation between adjacent and related words in a sentence or paragraph, for the proper identification and classification of these words into categories such as adjectives, adverbs, articles, interjections, conjunctions, prepositions, verbs, etc.

3.3 Meta-Attributes Extraction

For the identification of gender expression in Portuguese *tweets*, the present work proposes the use of a set of 60 textual meta-attributes divided in the following groups:

1. Those based on *Characters and Syntax* (Table 1), stylistic characteristics that have already been used to solve authorship attribution problems;
2. Those based on *Words* (Table 2), which include statistic characteristics, known as vocabulary richness measures, such as Yule's K measure, Simpson's D measure, and Entropy;

3. Those based on *Textual Structures* (Table 3) that represent the way in which the author organizes the structure of a message; and
4. Those based on *Morphology* (Table 4), words that are used to express grammatical relations with other words within a sentence, or to specify the attitude or mood of the text or message author.

Table 1. Characters and Syntax based Meta-Attributes.

Name	Description
C_1	Total number of characters
C_2	Ratio between the total number of low case letters (a-z) and the total number of characters
C_3	Ratio between the total number of upper case letters (A-Z) and the total number of characters
C_4	Ratio between the number of digits and the total number of characters
C_5	Ratio between the number of white spaces and the total number of characters
C_6	Ratio between the number of tab spaces and the total number of characters
C_7	Ratio between the quotation marks (“) and the total number of characters
C_8	Ratio between the number of commas (,) and the total number of characters
C_9	Ratio between the number of colons (:) and the total number of characters
C_{10}	Ratio between the number of semicolons (;) and the total number of characters
C_{11}	Ratio between the number of simple question marks (?) and the total number of characters
C_{12}	Ratio between the number of multiple question marks (???) and the total number of characters
C_{13}	Ratio between the number of simple exclamation points (!) and the total number of characters
C_{14}	Ratio between the number of multiple exclamation points (!!!) and the total number of characters
C_{15}	Ratio between the number of simple periods (.) and the total number of characters
C_{16}	Ratio between the number of suspension points (...) and the total number of characters

Table 2. Word based Meta-Attributes.

Name	Description
W_1	Total number of words
W_2	Average number of characters per word
W_3	Ratio between the number of different words and the total number of words
W_4	Ratio between the number of words with more than 6 characters and the total number of words
W_5	Ratio between the number of words with 1 to 3 characters (short words) and the total number of words
W_6	Ratio between *hapax legomena* (word that appears only once in a whole text) and the total number of words
W_7	Ratio between *hapax dislegomena* (word that appears only twice in a whole text) and the total number of words
W_8	Yule’s K Measure
W_9	Simpson’s D Measure
W_{10}	Sichel’s S Measure
W_{11}	Honore’s R Measure

W_{12}	Entropy Measure
W_{13_28}	Ratio between the distribution of words size frequency and the total number of words

Table 3. Textual Structure based Meta-Attributes.

Name	Description
TS_1	Total number of sentences
TS_2	Total number of paragraphs
TS_3	Average sentences per paragraph
TS_4	Average words per paragraph
TS_5	Average characters per paragraph
TS_6	Average words per sentence
TS_7	Ratio between the number of sentences starting with low case letters (a-z) and the total number of sentences
TS_8	Ratio between the number of sentences starting with upper case letters (A-Z) and the total number of sentences
TS_9	Ratio between blank lines and the total number of paragraphs
TS_{10}	Average number of characters in non-blank lines

Table 4. Textual Morphology based Meta-Attributes.

Name	Description
TM_1	Ratio between the number of articles and the total number of words
TM_2	Ratio between the number of pronouns and the total number of words
TM_3	Ratio between the number of auxiliary-verbs and the total number of words
TM_4	Ratio between the number of conjunctions and the total number of words
TM_5	Ratio between the number of interjections and the total number of words
TM_6	Ratio between the number of prepositions and the total number of words

After the pre-processing step, the meta-attributes extraction module must then produce a characteristics vector for each *tweet*, or set of *tweets*, in order to represent the values of the different meta-attributes. For example, for the following *tweet* of the @realwbonner profile: "*Como dizem meus sobrinhos de Twitter, rimos litros. Embora eu não entenda como se possa medir o volume espacial de risos. Mas tudo bem*"; the first five output characteristic values, which will take part in the *tweet*'s representative vector, referring to the first five meta-attributes based on characters and syntax are: [134, 0.7761, 0.0298, 0.0, 0.1716].

3.4 Supervised Classification Model

From what was previously presented, it is clear that, after the development of a set of characteristics that can remain relatively constant for a large number of messages written by authors of the same gender, the gender classification problem may be addressed as a binary classification task [15], i.e., given a *tweet t*, or a set of concatenated *t tweets*, represented by a dimensional vector **v**, where *v* is the total number of meta-attributes, assign *t* to $Class_1$ if the author is male, or to $Class_2$ if he/she is female. That is, given a set of formerly known pre-classified messages, classifying-algorithms must be used to categorize such *tweets*.

Mathematically, from a classification model in the form of $y_i = f(\mathbf{v}_i)$, with $\{(\mathbf{v}_i, d_i)\}_{i=1}^{N}$ being the set of problem instances, and $\mathbf{v}_i = (v_{i1}, v_{i2}, \ldots, v_{iv}), \forall i$ as the set of meta-attributes representing the *tweet* with d_i the desired output (male or female class). With $y_i = (y_{i1}, y_{i2}, \ldots, y_{iN})$ outputs model, where $y_i \in \{+1, -1\}$ are class labels, so that $Class_1$, +1, is for messages with amle gender expression, or $Class_2$, –1, for messages with female gender expression; and *N* refers to the number of *tweets* in the *corpus*. Thus, each *tweet* in the corpus, or all concatenated *tweets* in a single *tweet*, are converted into a multidimensional characteristics vector *v*, with each characteristic contributing to classify the author of the *tweet* under the corresponding gender category.

Furthermore, to ensure that all meta-attributes are treated equally in the classification process, all of them are normalized over the [0,1] interval. Starting with this supervised classification model, this study aims to analyze the performance of three different classifyers (*Best First Tree* - BFTree, *Multinomial Näive Bayes*- MNB, and *Support Vector Machines* - SVM) for the suggested set of 60 meta-attributes. We also performed an investigation about the relevance of each meta-attribute by selecting some of them based on the χ^2 (Chi-Square) and Information Gain techniques.

The following experimental results were obtained by using classifiers implemented in WEKA [17] and the databases were acquired by filtering the group of *tweets* collected for each journalist's profile, excluding *tweets* which were not in Portuguese, *retweets* (RT's), *tweets* that were only mentions to other profiles (@), only link *tweets*, and *tweets* that were composed entirely of non-ASCII characters.

4 Performance Evaluation

To assess the performance of the proposed methodology (GENEC) approximately 187,950 *tweets* were collected, roughly 91,836 male and 96,114 female *tweets*, all from well-known Brazilian journalists. Those *tweets* were arranged in a way so that each file could correspond to a given profile, and that, after filtered, each row from each file represented a *tweet* written in Portuguese. Then, the most recent 100 *tweets* for each of the 60 profiles (30 male, and 30 female), in a total of 6.000 *tweets,* were arranged in two files: one composed of all *tweets* of each profile, which after pre-processing and meta-attributes extraction, turned into characteristic vectors *tweet* by *tweet*; and another composed of all *tweets* of each profile displayed in a concatenated way (like a full text), so that a single characteristic vector is created for each profile.

Table 5 presents the cross-validation (10 × 10-*folds*) results, when each of the methods were used for the three different algorithms, taking into account the following evaluation measures: Total Average Accuracy, that is, the number of instances correctly classified; and Precision, referring to the relative number of instances that truly belong to a class divided by the total classified instances as belonging to that specific class.

Table 5. Obtained results for gender classification.

Method	Database Size	Measures	BFTree	MNB	SVM
		Accuracy	63.5%	61.96%	**68.08%**

Tweet* by *Tweet	3000 (M) and 3000 (F)	Precision	0.599 (M) e 0.714 (F)	0.597 (M) e 0.656 (F)	0.674 (M) e 0.719 (F)
Concatenated *Tweets*	30 (M) and 30 (F)	Accuracy	**81.66%**	70%	68.33%
		Precision	0.794 (M) e 0.885 (F)	0.667 (M) e 0.75 (F)	0.69 (M) e 0.677 (F)

The data in Table 5 indicates that the *BFTree* algorithm has a good performance when compared to the other classifiers, especially for the concatenated tweets. However, SVM's performance is stable for both databases, showing results equivalent to those published in [14] [15] for a different problem, even when using more neutral language *corpus*. To assess the impact of the meta-attributes used in the classification task, attribute selection was made using the χ^2 (Chi-Square) and Information Gain techniques in conjunction with ranking, through cross-validation (10 × 10-*folds*), to the *tweet by tweet* and *concatenated tweets* databases. The meta-attributes significance ranking, in descending order, is shown in Table 6 (captions for each meta-attribute are better described in Tables 1, 2, 3 and 4).

Table 6. Meta-Attributes significance ranking.

Method	Techniques	Most Significant Meta-Attributes
Tweet by Tweet	χ^2 (Chi-Square)	W7, W9, W3, W10, W8, W13_1, W12, W6, C1, C7, TS5, TS10, W5, C13, C3, C15, C5, W2, W11, TS4, W1, TS6, C9, W13_2, C4, W13_4, C11, W13_7, TM1, TM6, W13_10, W13_5, W13_3, TM4, TM2, W13_6, W13_13, W13_8, W13_9, W13_15, C8, TS8, W13_12, W4, W13_11, TS7, C10, C2, TM5, TM3, C6, TS1, W13_14, W13_16, TS9, TS3, C12, C14, TS2, C16
	Information Gain	W9, W3, W7, W10, W8, W13_1, W12, W6, C1, C7, TS5, TS10, W5, C3, C13, C15, C5, W2, W11, TS4, W1, TS6, C9, W13_2, C4, W13_4, C11, W13_7, TM1, TM6, W13_10, W13_5, W13_3, TM4, TM2, W13_6, W13_13, W13_8, W13_15, W13_9, C8, TS8, W13_12, W4, W13_11, C10, TS7, TM5, C6, TM3, C2, TS1, W13_14, TS9, W13_16, TS3, C12, C14, TS2, C16
Concatenated *Tweets*	χ^2 (Chi-Square)	TS8, W3, W4, W5, W1, W2, W6, W10, C15, W9, W12, W11, W7, C16, W8, TM6, C5, C4, C3, C2, C13, W13_1, C14, C7, C6, C8, C12, C9, C11, C10, TS6, W13_2, TS5, TM5, TS4, TS10, W13_15, TS3, TS7, TS9, W13_13, TS1, TM1, TM4, TM3, TM2, TS2, W13_3, W13_16, W13_8, W13_14, W13_6, W13_5, W13_7, W13_4, C1, W13_9, W13_10, W13_11, W13_12
	Information Gain	TS8, W3, W2, W1, W4, W5, W6, W10, C15, W7 W9, W12, W11, C16, W8, TM6, C5, C4, C3, C2 C13, W13_1, C14, C7, C6, C8, C12, C9, C11, C10, TS6, W13_2, TS5, TM5, TS4, TS10, W13_15, TS3, TS7, TS9, W13_3, TS1, TM1, TM4, TM3, TM2, W13_3, W13_8, W13_16, W13_14, W13_6, W13_5,

		W13_7, W13_4, C1, W13_9, W13_10, W13_11, W13_12

To assess the importance of the different meta-attribute sets (characters and syntax, words, text structure and text morphology) for the gender expression classification problem, each of the four meta-attribute set was investigated separately and compared with that of all meta-attributes used in conjunction, using *BFTree* algorithm, as presented previously. The results presented in Table 7 shows that all meta-attribute sets contribute to the gender classification process and also, as seen in Table 6, the meta-attributes based on *words*, *characters* and *syntax* as well as *textual structure* tend to be important gender discriminators. Thus, the experimental results indicate that there are rather significant differences between users with male and female gender expressions also when using Twitter, even in the presence of neutral language.

Table 7. Obtained results for gender classification using the different meta-attributes sets.

Meta-Attribute Set	*Tweet by Tweet*	*Concatenated Tweets*
Characters and Syntax	62.45%	53.33%
Words	61.40%	51.66%
Textual Structure	63.15%	66.66%
Textual Morphology	57.38%	66.66%
All Meta-Attributes (Accuracy)	63.50%	81.66%

5 Conclusions and Future Works

This study aimed to analyze different algorithms and meta-attributes for the gender classification problem in social media, specifically on Twitter. To date, few studies were dedicated to such problem for tweets written in Portuguese. Moreover, it proposes a methodology and a set of meta-attributes, both based on the already structured area of authorship attribution, to deal with the gender expression classification problem.

As by-products, in addition to the GENEC methodology, a method for extracting tweets directly from Twitter's APIs and the subsequent automatic creation of *tweets* database for each user profile was developed, as well as a textual meta-attributes extractor, which builds, based on the previously created bases, feature vectors for each message or set of messages, taking advantage of already consolidated techniques such as tokenization and POS tagging.

From the use of such tools, together with classifier algorithms, one can see that the use of textual meta-attributes can be very important for the detection of writing style, and gender expression characteristics, for both genders. The experimental results also show that the use of *BFTree* can achieve good results, even in the presence of neutral messages. As future works, we intend to explore other Decision Trees and SVMs, using databases with more user profiles and *tweets*, as well as develop new meta-attributes based on psycholinguistics (such as dictionaries of negative, positive and neutral words), which can complement and improve the results shown here.

References

1. Kaplan, A. M., Haenlein, M.: Users of the World, Unite! The Challenges and Opportunities of Social Media. Business Horizons, 53, pp. 59 -- 68 (2010)
2. Bollen, J., Mao, H., Zeng, X.: Twitter Mood Predicts the Stock Market. Journal of Computational Science, 2(1), pp. 1--8 (2011)
3. Tumasjan, A., Sprenger, T. O., Sandner, P. G., Welpe, I. M.: Predicting Elections with Twitter: What 140 Characters Reveal about Political Sentiment. ICWSM, 10, pp. 178--185 (2010)
4. Pankong, N., Prakancharoen, S.: Combining Algorithms for Recommendation System on Twitter. Advanced Materials Research, 403, pp. 3688--3692 (2012)
5. Tripathy, R. M., Bagchi A., Mehta S.: A Study of Rumor Control Strategies on Social Networks. In: Proceedings of the 19th ACM International Conference on Information and Knowledge Management (CIKM '10). ACM, pp. 1817--1820 (2010)
6. Nguyen, D., Gravel, R., Trieschnigg D., Meder T.: How Old do You Think I Am? A Study of Language and Age in Twitter. In: Proceedings of the AAAI Conference on Weblogs and Social Media (ICWSM), pp. 439--448 (2013)
7. Bergsma, S., Dredze M., Van Durme B., Wilson T., Yarowsky D.: Broadly Improving User Classification Via Communication-Based Name and Location Clustering on Twitter". In: Proceedings of the Conference of the North American Chapter of the Association for Computational Linguistics, pp. 1010--1019 (2013)
8. Golbeck J., Hansen D.: Computing Political Preference among Twitter Followers. In: Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1105--1108 (2011)
9. Lima, A. C. E., De Castro, L. N. A Multi-Label, Semi-Supervised Classification Approach Applied to Personality Prediction in Social Media. Neural Networks, 58, pp. 122--130 (2014)
10. Rao D., Yarowsky D., Shreevats A., Gupta. M.: Classifying Latent User Attributes in Twitter. In: Proceedings of the 2nd. International Workshop on Search and Mining User-generated Contents (SMUC), pp. 37--44 (2010)
11. Burger J. D., Henderson J., Kim G., Zarrella G.: Discriminating Gender on Twitter. In: Proceedings of the Conference on Empirical Methods in Natural Language Processing (EMNLP), pp. 1301--1309 (2011)
12. Deitrick W., Miller Z., Valyou B., Dickinson B., Munson T., Hu W.: Gender Identification on Twitter Using the Modified Balanced Winnow. Communications and Network, Vol. 4 No. 3, pp. 189--195 (2012)
13. Ciot M., Sonderegger M., Ruths D.: Gender Inference of Twitter Users in Non-English Contexts. In: Proceedings of the 2013 Conference on Empirical Methods in Natural Language Processing, pp. 1136--1145 (2013)
14. Filho R. M., Carvalho A. I. R., Pappa G. L.: Inferência de Sexo e Idade de Usuários no Twitter. In: Proceedings of the III Brazilian Workshop on Social Networks Analysis and Mining (BraSNAM), pp. 200--211 (2014)
15. Cheng N., Chandramouli R., Subbalakshmi K. P.: Author Gender Identification from Text. Digital Investigation 8, 1, July, pp. 78--88 (2011)
16. American Psychology Association: The Guidelines for Psychological Practice with Lesbian, Gay, and Bisexual Clients, Adopted by the APA Council of Representatives. February 18-20 (2011)
17. Hall M., Frank E., Holmes G., Pfahringer B., Reutemann P., Witten I. H.: The WEKA Data Mining Software: An Update. SIGKDD Explorations, Volume 11, Issue 1 (2009)

Part IX
Human-Computer Interaction

Measure the usability of graphical user interface.

Altynbek Sharipbay[1], Alibek Barlybayev[1], Talgat Sabyrov[1]

[1]L.N.Gumilyov Eurasian National University, Astana, Kazakhstan
{Sharalt, Frank-ab, Sabyrov.Talgat}@mail.ru

Abstract. The goal of this paper is to measure the usability of interfaces. We have done an experiment using real users to estimate styles of components. As an example it has been chosen a graphical user interface of Web site. Web site is separated to 6 parts and has 5 evaluation criterions. Each user has given his mark for every style of every component by these criterions. In conclusion, considering the results of experiment we have shown the most comfortable and suitable user interface for majority of people.

Key words: GUI, usability, component, HTML, CSS, progressbar, interface, header, footer.

1. Introduction.

There are many steps of software development. One them is development of user interface. Developing comfortable user interface has become an important part of software development. Users require not only good software, but also very nice and intuitive user interface. It is very important to clearly design the graphical user interface (GUI) in this step. This work is done by interface designers. All of these designers have different views about usability of programs and create many types of GUI, but not each of them is comfortable to use. Also, there are types of software. The most used are web sites, mobile applications and desktop applications.

In this paper we are going to speak about the researches we have done to find out the way of designing very nice user interface for Web sites. There are many design tools. One the most popular is Moqups. To create a frontend of web sites is used two ways. The first is using Content Management System (CMS), it is the easiest way and it does not need special knowledge for this. The second is coding, using hypertext markup language (HTML) to create components of web site and cascading style sheet (CSS) to give a style for these components. This way is the hardest, but today we have frameworks to make it easy. For instance, we can use Twitter Bootstrap to develop adaptive web site.

Though we have many ways, tools and technologies to develop GUI, the problem is to create the one that can be comfortable for majority of people. Some researchers offered the principles of graphic design. Clayton Lewis and John Rieman offered to separate GUI to blocks in their article called “Task-centered user interface” in 1994 [1]. Maloney-Krichmar, D., Preece recognize the needs and the interests of the user and focuses on the usability of the design in 2004 [2]. Dumas & Redish offered

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_98

usability testing [3]. That is why we decided to involve real users in the testing and find out the most effective GUI.

1.1 Criterions and parts of web site usability measure.

To find out the most effective GUI we have done some experiments. These experiments contain different criterions to measure the usability of Web sites and these criterions are used in different parts of Web sites. The criterions are following: By style of texts, by style of links, by style of components used to make operations (for instance button, combo box), by style of component used to show operation execution, by images

Components mentioned above have been used in different blocks of web sites in different styles. We separated web sites to following parts: Header, Menu, News feed, List of images, Block of video, Footer.

There are also other parts of Web site, but these are presented in majority of Web sites, that is why we have chosen them.

We needed 5 users to estimate the usability of Web sites. The users do not have the same jobs, experience of Web site usage and lifestyle. All of these users have given their own opinion and mark for every part of Web sites and explained the conveniences of styles of components. The mark of every of component of every part will be between 1 and 10.

2. Experiment with real users

As it was mentioned we separated our web site to 5 parts and used different components with different styles. We also needed 5 users to estimate the usability of site. The marks of users will be given as tables and graphs.

2.1 Header

Table 1. Marks for text

	Title			Text		
	Small (8-20)	Middle (22-40)	Large (42-72)	Small (8-20)	Middle (22-40)	Large (42-72)
User 1	5	2	1	3	5	4
User 2	9	8	8	5	6	4
User 3	4	5	2	3	6	7
User 4	8	9	2	3	1	5
User 5	6	8	7	9	2	1

Font and color of texts depends on subject. According the researches font and color that are chosen not suitable to subject confused the users.

Table 2. Marks for link

	Blue text with underline	Button
User 1	2	3
User 2	4	5
User 3	7	9
User 4	10	5
User 5	4	9

Table 3. Marks for components that make operations

	Submit			Select	
	form	color	Change on hover	Pop	horizontal
user 1	Rectangle - 5	Isolation from background- 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 2	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 3	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 4	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 5	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2

Table 4. Marks for components that show execution of operations

	Horizontal progressbar	Round
user 1	2	5

user 2	5	5
user 3	6	8
user 4	1	7
user 5	6	8

Table 5. Marks for images

	Logotype			Others		
	Small (8-20)	Middle (22-40)	Large (42-72)	Small (8-20)	Middle (22-40)	Large (42-72)
user 1	5	2	1	3	5	4
user 2	9	8	8	5	6	4
user 3	4	5	2	3	6	7
user 4	8	9	2	3	1	5
user 5	6	8	7	9	2	1

2.2 Menu

Table 6. Marks for text

	Title			Text		
	Small (8-20)	Middle (22-40)	Large (42-72)	Small (8-20)	Middle (22-40)	Large (42-72)
user 1	5	7	1	8	5	1
user 2	4	4	3	9	4	1
user 3	6	8	2	8	6	2
user 4	6	8	2	9	1	2
user 5	5	8	5	9	2	1

The table of link is missed, because in menu majority of texts are links, those texts are presented in the table 6. Also, menu in most of web sites does not contain components that make operations.

Table 7. Marks for components that show execution of operations

	Horizontal progressbar	Round
user 1	8	6
user 2	6	5
user 3	9	7
user 4	6	5
user 5	5	5

Table 8. Marks for images

	Logotype			Others		
	Small (8-20)	Middle (22-40)	Large (42-72)	Small (8-20)	Middle (22-40)	Large (42-72)
user 1	7	2	1	9	5	3
user 2	9	4	5	8	6	4

user 3	4	5	2	3	6	6
user 4	8	6	2	7	1	4
user 5	8	8	8	9	2	1

2.3 News feed

Table 9. Marks for text

	Title			Text		
	Small (8-20)	Middle (22-40)	Large (42-72)	Small (8-20)	Middle (22-40)	Large (42-72)
user 1	9	4	1	7	2	1
user 2	9	5	2	8	3	1
user 3	4	6	2	9	3	1
user 4	8	5	3	5	2	1
user 5	6	5	5	6	4	1

Table 10. Marks for link

	Blue text with	Button
user 1	7	3
user 2	8	5
user 3	7	9
user 4	10	5
user 5	5	6

Marks for components that make operations are similar to marks on “header” part, which is given in table 3.

Table 11. Marks for components that show execution of operations

	Horizontal progressbar	Round
user 1	5	8
user 2	7	7
user 3	5	6
user 4	5	7
user 5	7	7

Table 12. Marks for images

	Head photo			Other		
	Small (8-20)	Middle (22-40)	Large (42-72)	Small (8-20)	Middle (22-40)	Large (42-72)
user 1	5	7	1	6	5	4
user 2	2	6	2	6	1	5
user 3	4	6	2	7	6	4
user 4	5	8	5	8	2	4
user 5	6	9	7	9	2	1

2.4 News feed

Table 13. Marks for text

	Title			Text		
	Small (8-20)	Middle (22-40)	Large (42-72)	Small (8-20)	Middle (22-40)	Large (42-72)
user 1	9	8	1	8	5	3
user 2	9	7	5	7	6	4
user 3	8	5	2	6	6	5
user 4	8	8	2	8	4	5
user 5	7	5	7	7	5	2

Table 14. Marks for link

	Blue text with	Button
user 1	5	10
user 2	6	9
user 3	7	9
user 4	10	5
user 5	4	9

Size of images depends on size of block. If we make size of images similar to size of block users give high marks, but if we do not, users give low marks.

Table 15. Marks for components that make operations

	Submit		
	Form	Color	Effect on hover
user 1	Rectangle - 3	Isolation from background - 7	Yes - 9
	Rounded corners - 6	Similar to background - 3	No - 2
user 2	Rectangle - 4	Isolation from background - 6	Yes - 9
	Rounded corners - 8	Similar to background - 4	No - 2
user 3	Rectangle - 5	Isolation from background - 8	Yes - 5
	Rounded corners - 7	Similar to background - 7	No - 2
user 4	Rectangle - 6	Isolation from background - 9	Yes - 6
	Rounded corners - 7	Similar to background - 5	No - 4

user 5	Rectangle - 4	Isolation from background - 5	Yes - 7
	Rounded corners - 8	Similar to background - 7	No - 5

2.5 Block of video

Table 16. Marks for text

	Title			Text		
	Small (8-20)	Middle(22-40)	Large(42-72)	Small(8-20)	Middle(22-40)	Large(42-72)
user 1	2	7	4	3	5	4
user 2	3	8	5	5	6	4
user 3	4	8	6	3	6	7
user 4	5	9	8	3	1	5
user 5	6	8	7	9	2	1

Table 17. Marks for link

	Blue text with	Button
user 1	5	6
user 2	6	5
user 3	4	5
user 4	5	6
user 5	5	5

Table 18. Marks for components that make operations

	Submit			Select	
	form	color	Change on hover	Pop	horizontal
user 1	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 2	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 3	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9

	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 4	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2
user 5	Rectangle - 5	Isolation from background - 8	Yes - 9	Count of elements less than 6 - 5	Count of elements less than 6 - 9
	Rounded corners - 6	Similar to background - 2	No - 2	Count of elements more than 6 - 9	Count of elements more than 6 - 2

Table 19. Marks for components that show execution of operations

	Horizontal progressbar	Round
user 1	4	8
user 2	4	7
user 3	5	7
user 4	2	5
user 5	9	5

2.6 Footer

In majority of web sites footer is related to header. That is why the marks for styles of all components in footer part are similar to marks in header part. The results of header are given in part 2.1.

Conclusion

We found out how important is to designing user interface of application. According to researches of some scientists we also defined the way of GUI effectiveness testing. We have done experiments with real users to find the usability of web site. Each of these users gave their marks to style of every component. According to results of this experiment we have chosen the most suitable styles for components, so we have created the most suitable interface for majority of people. The results of researches have given as tables. Also, we have proved how effective is to test usability by real users.

References

1. Lewis, C., Rieman, J.: Task-centered user interface design. (1993-1994)
2. Abras, C., Maloney-Krichmar, D., Preece, J.: User-Centered Design. In Bainbridge, W. Encyclopedia of Human-Computer Interaction. Thousand Oaks: Sage Publications. (2004)
3. Joseph, D., Redish J.: A Practical Guide to Usability Testing. (1999)

The role of touchscreens for learning process in special education

Diego Antonio Beltramone[1], Marcela Fabiana Rivarola[2], María Luz Quinteros Quintana[1]

[1] Rehabilitation Engineering Laboratory; Faculty of Exact, Physical and Natural Sciences; National University of Córdoba, dbeltramone@efn.uncor.edu, mluzqq@efn.uncor.edu
[2] School of Kinesiology and Physical Therapy; Faculty of Medicine; National University of Córdoba, licfabianarivarola69@gmail.com

Abstract. Nowadays touch technologies have become part of everyday life for many people. These technologies can be found in various scopes both, labor and education with great diversity of uses and applications. The massive use by various age groups is directly related to how intuitive they are for the user. Through a research project conducted by an interdisciplinary team, usability was assessed quantitatively and qualitatively on how children with disabilities have access to the use of various technologies intuitively or naturally promoting the incorporation of significant academic content developed in the school. The project Natural Interfaces conducted to results that served as the basis for the use of tactile interface as a special education facilitator element. Also establish them as a significant learning methodologies by substantial incorporation of new knowledge in a cognitive structure not arbitrary and based on prior learning way.

Keywords: Touchscreens, natural interfaces, intuitive interfaces, learning process, special education, educational tool.

1 Introduction

The new Information and Communications Technologies (ICT)[1] have been introduced massively in all facets of life. They have altered the everyday modes of communication and start being so fundamental to society that most areas of everyday social practice are affected by the information revolution.

In an electronically mediated world, being literate is about understanding how the different modes combine in complex ways to create meaning. Users have to learn to make sense of the obvious iconic systems in computer displays, which involved all the combinations of signs, symbols, images, words and sounds. The language is no longer exclusively grammar, vocabulary and semantics, but it has come to encompass a wide range of semiotic systems involved in reading, writing, viewing and speaking.

[1] At http://guzlop-editoras.com/web_des/comuinf/pld0985.pdf the reader can delve into the use of ICT in Education for People with Disabilities

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_99

What looks the same text on paper or on screen is different from the functional point of view.

Beyond understanding the new technologies, the world of technological design must interpret the needs of users. Among the latest trends in new designs, it has focused attention on achieving the massiveness of use. Since 1971, Dr. Samuel Hurst[2], by introducing touch screens, sought to introduce an interface with electronic devices more intuitive way or somehow more natural for the user [1]. The challenge that arose since then was to find a design that was massive, economical, versatile, and keep its main condition: usability [2], and therefore accessibility [3].

In education, there are many ways for teaching using touchscreen technologies. For example, some authors take advantage of them using tablets to teach writing through the repetition of write characters [4].

1.1 Determinants for the choice of technologies using learning styles

The existence of different ways for human information processing; the existence of preferences for different ways of perception (visual, auditory, tactile-kinesthetic, olfactory-gustatory); and the discovery of several biological, environmental and social conditions for learning have created a research and development field called "cognitive, teaching and learning styles". From this field they have been derived strategies to innovate teaching and learning practices and conceptions about one and other. One of the conceptual and methodological developments of this field of research is the model of diagnosis and pedagogical intervention based on the teaching and learning styles of Dunn, et al. (1983) Dunn and Dunn (1992); Dunn, Dunn and Price (1993), who developed a diagnostic methodology for identifying learning styles and to modify the teaching and learning process from the design of teaching strategies and educational environments based on the styles [5].

"The perspective of learning styles helps to develop intellectual skills and raise awareness about the cognitive functions that come into play in each of the three phases of the mental act: a) entry; b) development and c) output. It doesn't polemic about *what* to learn, but *how*. At some point this may be a constraint against the ever-present ideological practices, involving the maintenance of conditions of inequality and educational inequality in the constitution of the pedagogical discourse and the acquisition of its rules" [5].

Cognitive functions and mental input operations are recognized by several authors, including [6] as those providing the basis on which the following phases finish developing the full cognitive process, if something is not right in input phase will determine input deficits in the other two.

Given the importance this perceptual preference has as part of the input cognitive functions, it then influences the phase of development and information processing within the mental act, such kind of children with such perceptual preference, required to obtain the sensory register in order to that necessary information can be passed to the long-term memory and the ability to retain. Otherwise, poor cognitive function blurry and confused perception of the task or learning content occurs.

[2]More information at http://www.elotouch.com/AboutElo/History/

The same requirement applies to the structure, which refers to the need for clear and precise instructions to develop a learning activity or to perform a task. According to the knowledge of the perceptual preferences **these instructions should preferably be in the most permeable perceptual way that the person has**: visual, auditory, tactile or kinesthetic.

For teachers and special education experts as well as teachers and tutors of courses where students with disabilities are incorporated, it is very important to know assistive technologies, and make proper use of them. The device-user interaction or user-user interaction based on the use of such assistive technologies and accessible, usable and adaptive natural interfaces, can be instrumental in the educational development of students with special needs.

1.2 The HAAT model - application in the process of meaningful learning

The model of HAAT (known as HAAT by its acronym of Human Activity Assistive Technology) [7] was developed to analyse the complexities of someone (a person with a disability) doing something (an activity) somewhere (in a context), especially when the use of assistive technology is part of that context. In this model, Human refers to the person trying to perform an activity. The activity is the fundamental element of the model represents the act of daily life that the user wants to perform. Assistive Technology is included as the essential elements that allow humans to complete the activity in an adaptive way[3].

In our experience, the HAAT model contribution is valuable and we use it daily, creating custom technology or adapting technology for users with disabilities. *However, there are situations where several interfaces require a significant level of abstraction both temporo-spatial and symbolic thought which is not always present in all of users with disabilities*. For some of these users it is very complex to assimilate and interpret. For this sub-minority these adaptations are not recommended, make more expensive access and possibly they do not reach the expected results, as more layers of interface between the user and the device are generated, which increases the distance between them.

Currently there are technologies that enable more natural and intuitive interfaces, where there is a direct relationship between the user and the object to interact. Touch screens, where the user "plays what he sees" as an objective, seems to add an advantage over others. Additionally if, for example, a sound effect is generated at the same time, an essential effect in multimedia experience is achieved. This allows both users with greater predominance of visual memory that hearing, as those with higher prevalence of auditory than visual memory have a place. Thus, both individuals with auditory learning style as those with visual style are attended, according to the points raised by the Theory of Multiple intelligences [8] [9].

Meaningful learning is the process whereby new knowledge or information is related with the cognitive structure of the learner in not arbitrary and substantive or not literally way.

[3]More information at http://www.rehab.research.va.gov/jour/00/37/5/angelo.html

According to that some authors proposed, meaningful learning has two fundamental conditions:

1. Potentially significant learning attitude by the learner, what is willingness to learn significantly.
2. Presentation of a potentially significant item [10].

The first condition is inherent to the student, while the second has to do with the proposed material. By adding a different sensory stimulus -such as for example haptic (tactile) - information is reinforced by an additional auditory and visual pathway. This set of synchronized stimuli produces an effect on the user very important in integrating information to generate meaningful learning synthesis.

2 Background and Development

2.1 Natural Interfaces Project

The International Classification of Functioning, Disability and Health (ICF) defines the disability as a generic term that includes deficiencies, activity limitations and restrictions on participation [11]. Disability is understood as the interaction between those people that suffer from an illness condition (for example, not progressive chronic encephalopathy, motor sequel with neurological origin, Down syndrome, etc.) and personal and environmental factors (such as, inaccessible transportation and public buildings, lack of universal design and limited social support).

It is estimated that over 15% of the world's population is afflicted by some form of disability [12] while in Argentina the number arises to 12.9%. When these people want to access to a technological device (such as a personal computer or PC), usually they found interfaces that are not meant or designed for them.

During the years 2012 and 2013 we conducted a project entitled "In search of natural interfaces for people with disabilities" [13]. The main objective of this project was to find a technological medium as a facilitator of the integral development of students with sensory psychomotor disorders attending a special school in the city of Córdoba, Argentina, through the introduction and implementation of natural and intuitive interfaces for working with computers in education, providing educational and therapeutic equipment in the establishment of a complementary educational tool for the development of their daily activities. At the same time specific objectives were raised as the implementation of hardware and software interfaces to achieve the overall objective. During the project, a special analysis of the needs of the educational institution, with specific selection criteria for inclusion of recipients (students), and subsequent comparison of usability between different technologies applied was made.

2.1.1 Used Technologies

Six different technologies were initially chosen, some of them were familiar to the students by previous experiences:

01-Touchpad	02-Mouse	03-Kinect
04-All In One with touch screen (AIO)	05-Leap Motion	06-Tablet (Android) with 10-inches screen

2.1.2 Methodology

Specific tests were performed over 12 students between 8 and 12 years old. All students had similar profiles in relation to their disabilities, diagnosed with motor impairment with cerebral origin compromising the cognitive ability, mainly with difficulties in the acquisition of learning with abstraction. The criteria for selection of subjects was by analyzing the following items: Grade (in school); Shift (morning-evening); Motor impairment; Expressive Language impairment; Cognitive impairment (Comprehension); Cognitive impairment (Attention).

The following table was made for the analysis and assessment of the technologies:

Table 1. Student-technology relationship for analysis.

	01 Touchpad	02 Mouse	03 Kinect	04 AIO	05 Leap Motion	06 Tablet
Stud01						
…						
Stud12						

Two different types of analysis were performed:

- **Transversal Analysis by Technology** (vertical), compares the performance of all the students with the same technology.
- **Longitudinal Analysis by Student** (horizontal), compares the performance of each student with different technologies.

Tasks

In testing audiovisual recordings (filming) were taken in order to register the use of different technologies as interface to perform a specific simple task: To make a click on a specific place on the screen. Each test consisted of an assignment where students had to "hang an apple in a tree". Thus, subjects had to click on the apple and then click on the tree to accomplish the task.

Transversal Analysis by Technology

Tests with the selected students were carried out recording several videos with the performing and accomplishing clear and specific assignments with each one of the technologies. These assessments were performed by five observers, professionals' members and collaborators of this project, with similar criteria on the evaluation.

Following with the aim of this project, the fact that each technology generates an interface with the user was take into account and that interface can determine how natural its use was. That is why the following characteristics for the evaluation – indicators- were chosen: Possibility of Generating Fatigue (GF); Possibility of Generating Distraction (GD); Ease of Use (FU); User Flexibility (FB); User accuracy required (PN).

Each observer assigned preset values between 4 and 0 to the corresponding quantitative assessments None-Regular-Good-Very Good-Excellent in the first two characteristics, while the values used in the last three features were 0 to 4 corresponding to a qualitative assessments None-Regular-Good-Very Good-Excellent. After the evaluation by the five observers a sample of five students (n = 5)

was taken randomly and conclusions about the behavior of the technologies involved and what kind of interface generates with the user.

For the analysis of these data, the non-parametric Friedman test was used. This technique allows evaluation by comparing variances between applied technologies if statistically significant differences are evident.

The analysis was carried out by student and by technology, in order to assess all the technology's characteristics and its performance in relation to the student's profile.

In cases where statistically significant differences were observed we proceeded to test multiple comparisons of means. The software tool used for data treatment was InfoStat [14]. The software indicated after each analysis when they are not significantly different ($p <= 0.050$), denoting what technologies show similar behavior. Otherwise they act differently and obtained averages values are analyzed.

To summarize the results of this analysis we present the next two tables:

Table 2. Technologies that present the **most Natural Interfaces**

The Most Natural Interface					
Student	**GF**	**GD**	**FU**	**FB**	**PN**
1	06	01	04	All	04
2	04 and 06	06	04 and 06	All	04 and 06
5	All	04 then 02	02	All	02 and 06
10	All	All	T4	All	04, 06 and 02
12	04 y 06	06 then 04	06 and 04	03 and 06	01, then 06 and 04

Table 3. Technologies that present the **least Natural Interfaces**

The Least Natural Interface					
Student	**GF**	**GD**	**FU**	**FB**	**PN**
1	03	03 and 02	03 then 02	None	02 then 05 and 03
2	05, 01, 03 and 02	01	01, then 02 and 05	None	02 and 03
5	None	06	03	None	05 and 03
10	None	None	05	None	03 and 05
12	05, 01, 03 and 02	01	01, 02 and 05	01, 02 and 04	05, 02 and 03

From the analysis of all the technologies, their features and results of the performances of the students, one might conclude that the most natural technologies are Tablet (06), AIO (04) and Mouse (02) respectively. *This could indicate that touch interface technologies are those with a more "natural" interface*. We recognize that

the Mouse is a not tactile technology, however it shows a similar behavior with 06 and 04 that may be the result of previous knowledge of the users.

Longitudinal Analysis by recipient/Student

The recording of data in longitudinal analysis involves testing each student with every technology. There were 5 observers in total. Evaluation criteria of the observers was agreed and uniform in order to achieve an objective assessment.

The next step was to calculate the probability for each sum, given the number of observers. Because the information was recorded on a qualitative scale, it was characterized and quantified by a weight of 0 to 4. This weighting was in ascending or descending order, depending on the feature to record according to what is desirable as an ideal interface.

The next step was to make the product of the probability and weighting, resulting in a weighted probability of each feature. Each weighted by probability is then added feature, giving a value which took into account the sum of all observers for that feature. Subsequently they joined by all the features, giving a total valuation (called Points) per student per technology.

Finally, the sum of the ratings for all technologies by students was performed.

2.1.3 Natural Interfaces Projects' results

After the quantitative analysis, a contrast with the students' profiles (qualitative) were performed, in order to arrive to more integral conclusions.

1. **Touchscreen technologies obtained the highest score and recurrence** (04- and 06-tablet AIO). It is important to highlight that the students did not know or had contact with touch technologies previously, either at school or at home. These data were obtained through interviews with the teacher and the student academic history. This means that the students had an intuitive and natural interaction with touch technologies. This result is extremely important and will resume in the Discussion and Conclusions section.
2. There were students that obtained a high score at 01-Touchpad and 02-Mouse because they had previous experience, as they are the most widespread standard technologies.
3. The most recurrent technologies with lower scores are:
    - 02-Mouse with a recurrence of 3 over 12 students
    - 05-Leap Motion with a recurrence of 4 over 12 students, although with higher scores than 02-Mouse
    - 03-Kinect with a recurrence of 3 over 12 students presenting a higher score than 05-Leap Motion.

    From the results above one might initially conclude that these technologies are not very intuitive or natural, or require much attention, coordination, visual-spatial accuracy and / or abstraction by users (hence the lower score). This has a different explanation in the case of 02-Mouse where this technology obtained the highest score because users were more familiar with its use.
4. Students with better overall performance with moderate level of attention and previous experience in the use of technologies (digital competence).

Motor impairment is mild to moderate. The cognitive level of these students varies from mild to severe. The age range was between 8 and 12 years.
As an important fact, all the students have a basic level of symbolic thought. Everyone understood the motto. All of them showed a high motivation in the use of technology.

5. The student who had lower overall performance required continuous organization through verbal and gestural commands to avoid losing attention. Also presented a dysmetria that disrupts their movements and generated little precision when trying to reach something with your hands, therefore the student had to remain seated during and after the activity. It also presented a hearing disorder that also hindered the performance in the proposed activities. Compared with other students, it has a higher sensoperceptual and hearing impairment which affected the general organization and motor planning, impacting negatively on its cognition. Additionally, the student is less tolerance for frustration.
6. Students with better adaptability range have in common their high scores. These students have symbolic level of thinking (which greatly influences the use of technology, but require indicators and verbal reinforcement). They are in the process of literacy and have a background in the use of tools.
7. Students with lower level of adaptability have a very labile level of attention. They require constant external organization through verbal and / or gestural commands. Their levels of thought, for the pre-operative period[4]. From the point of view of motor functionality, they presented an unstable functional performance in upper limbs.

3 Discussion

The information and communications technology (ICT) can be understood as a dynamic concept. From the "person with disability– user" experience observed with the use of ICT, it is extremely important the user interface within the man-machine interaction, particularly human-computer. The tool can succeed or fail with the user according to how its interface was designed and implemented. *Additionally, they can even generate motivations that did not exist or arise unexpected capabilities of users.*

Accordingly, the initiative arose to determine what interfaces were easier to use or which are more natural and intuitive according to the user characteristics. Thus, in order to facilitate the use of a computer, an intrinsic motivation could be achieved from an extrinsic stimulus.

Accessibility means that people with disabilities can access content or services through assistive technologies, if necessary. Usability, however, understood in the field of ICT, means that people who use them do so successfully, using assistive technology, if necessary.

According to Jakob Nielsen (1993) "Usability is the quality of a system that is easy to learn, easy to use, easy to remember, fault tolerant, and subjectively pleasing" [15].

[4]More information at http://reeduca.com/piaget-periodopreoperacional.aspx

For a user with disabilities, the fact of facilitating access to information and communication through technology becomes a critical issue.

The ultimate purpose of this project can be summed up in a phrase attributed to Plato: "All things will be produced in superior quantity and quality, and with greater ease, when each man works at a single occupation, in accordance with his natural gifts, and at the right moment, without meddling with anything else"[5]. Thus, greater comfort for the user and optimum efficiency, specifically to focus energies on the task would be achieved. In addition, the learning curve for new devices could be optimized too.

All the people with disability are subjects of rights and among them is the right to learn and to participate in educational plans. For people with some kind of functional diversity, learning and communication can become a difficult task, but the proper use of certain non-invasive technologies support can resolve this difficulty and achieve speed, naturally, the process of inclusion.

4 Conclusions

Results from the Natural Interfaces project allowed us to infer that touch technologies would be the most intuitive and natural interfaces that encourage the incorporation of new learning for children 8-12 years of age with involvement in cognitive processes and acquisition program content with abstraction anchoring components in the structure of the previous knowledge of students. This can be reached by promoting new knowledge and experience, generating communication, cognitive and motor modifications. In this special school these features become the touch interfaces as facilitators to help enriching the teaching-learning tools and incorporate them as assist or support the teaching tasks set by the teacher team.

5 Future Projects

Due to the good results the project carried out, a decision to continue working in the same school was taken in order to ensure continuity of work and the need to incorporate technologies that were categorized as natural. It was possible to carry out an interdisciplinary project with the teachers of the school with a large acceptance and collaborative attitude to assess quantitatively and qualitatively the use of technology in the education of children with disabilities and identify technologies that propose a more natural interface.

Therefore, in 2014 and 2015 a project called "Implementation of natural interfaces in multi-sensory rooms" is being performed. As part of this new project the results of the previous project are applied, incorporating new technologies into the educational space of multisensory room as assistive tool for rehabilitation and education.

One of the hypotheses is that natural interfaces in a multi-sensory room -where users are being stimulated through different channels- the students could improve

[5] http://www.uky.edu/~eushe2/quotations/plato.html

communication in the classroom (teacher-student, student-student) and visual-motor coordination, as a result after a prolonged use.

References

[1] D. Wigdor y D. Wixon, Brave NUI World: Designing Natural User Interfaces for Touch and Gesture, Morgan Kaufmann, 2011.

[2] S. Krug, Don't Make Me Think: A Common Sense Approach to Web Usability (Voices That Matter), 3rd revised ed., New Riders, 2013.

[3] E. Rovira and B. Cuyás, Libro blanco de la accesibilidad, Barcelona: UPC, 2003.

[4] S. Sybenga and Y. Rybarczyk, "Using machine learning and image processing for character recognition: an application for teaching handwriting," in *28th International Conference on Computer Applications in Industry and Engineering*, San Diego, USA, 2015.

[5] B. Bernstein, La estructura del discurso pedagógico, Madrid: Morata, 1993, pp. 104-110.

[6] R. Feuerstein, Instrumental Enrichment, Baltimore: University Park Press, 1980, pp. 250-285.

[7] A. M. Cook and S. M. Hussey, Assistive Technologies: Principle and Practice, 2° ed., St. Louis: Mosby, 2002.

[8] H. Gardner, Frames of Mind: The Theory of Multiple Intelligences, Third ed., Basic Books, 2011.

[9] H. Gardner, Multiple Intelligences: The Theory In Practice, A Reader, First ed., Basic Books, 1993.

[10] M. L. Rodríguez Palmero, M. A. Moreira, M. C. Caballero Sahelices and I. M. Greca, La teoría del aprendizaje significativo en la perspectiva de la psicología cognitiva, Barcelona: Octaedro, 2008.

[11] World Health Organization, International Classification of Functioning, Disability and Health (ICF), World Health Organization, 2001.

[12] World Health Organization, "World Health Organization," 12 2014. [Online]. Available: http://www.who.int/mediacentre/factsheets/fs352/en/.

[13] D. Beltramone, S. Tula, M. Rivarola, M. Hidalgo, P. Tancredi, M. Quinteros Quintana, J. Diaz, A. Marcotti and J. Atea, "En búsqueda de interfaces naturales para personas con discapacidad," *IEEE Xplore Digital Library,* pp. 702-707, 2014.

[14] National University of Córdoba, "InfoStat - Statistical Software," [Online]. Available: http://www.infostat.com.ar/.

[15] M. L. Guenaga, "La accesibilidad y las tecnologías en la información y la comunicación," *Trans Dossier,* pp. 155-169, 2007.

A Neurocognitive Virtual Rehabilitation system for Children with Cerebral Palsy: a preliminary usability study

Sergio Albiol-Pérez[1,2], Edwin-Patricio Pruna-Panchi[2], Ivón-Patricia Escobar-Anchaguano[2], Marco-Antonio Pilatasig-Panchi[2], Luis-Enrique Mena-Mena[2], Janeth Segovia-Chávez[3], Aracne Bernis[4], Paulina Zumbana[5]

[1]Departamento de Informática e Ingeniería de Sistemas, Universidad de Zaragoza, Calle Ciudad Escolar S/N, 44003 Teruel, Spain
[2]Departamento de Eléctrica y Electrónica, [3]Departamento de Ciencias Exáctas, Universidad de las Fuerzas Armadas ESPE, Sangolquí, Ecuador
[4]Centro de Salud Lasso - Cotopaxi, Ecuador
[5]Hospital Instituto Ecuatoriano de Seguridad Social de Latacunga
{salbiol}@unizar.es
{eppruna, ipescobar, mapilatagsig, lemena, jpsegovia}@espe.edu.ec
{aracnebl}@gmail.com, {fisiorenacer87}@hotmail.com

Abstract. One of the main neurological disorders in children worldwide is cerebral palsy (CP). The main alterations are postural control, balance, and gait disorders, and difficulty in performing activities of daily living. Techniques in traditional rehabilitation are focused on therapies such as constraint-induced movement, strength training, and functional electrical stimulation. In the last few years, novel and customizable virtual systems have been incorporated in the rehabilitation of children with cerebral palsy, but there are few studies that have tested the usability of these systems. Therefore, the purpose of this paper is to test our tool in terms of usability, acceptance, and security. To do this, we analyzed the system usability questionnaire with subjects without neurological disorders. The results that we obtained show that our tool follows the standards of usability, security, and acceptance. Therefore, we will validate this novel system with children that have CP.

Keywords: Virtual Motor Rehabilitation, Children with Cerebral Palsy, Rehabilitation, Virtual Environments, Usability.

1 Introduction

Cerebral Palsy (CP) is one of the main disorders in childhood, with a prevalence of around 2.11 per 1.000 live births [1]. In the USA, approximately 1 in 303 children are diagnosed with CP each year [2]. Worldwide, approximately 10% of children have physical disabilities, which produce mental perturbation and decrease learning capabilities [3]. In Europe, there are approximately 2 cases of CP per 1000 live births [4], with a rate of 1.5 per 1000 live births every year from 1979-90 in Denmark [5].

CP is composed of a group of permanent disorders of movement and postural control that produce limitations in activities of daily living. These disorders occur in

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_100

fetal growth or the infant brain. These types of disruptions cause sensory and cognitive alterations [6], vision and hearing loss [7], attentional disturbances [8], problems interacting and communicating with people [9], behavioral disruptions (sleep, anxiety, and mood disorders) [10], epileptic attacks [11], and musculoskeletal component deficits (postural control, balance, gait, muscle contractures) [12].

With regard to motor abnormalities, there are different types of CP in childhood that we can classify based on the type of impairment and the area of the body (lower and/or upper limbs). These include the following: 1) spastic quadriplegia, which involves all four limbs, and mainly affects the upper limbs; 2) diplegia, which mainly affects the lower extremities and causes children with CP to have disorders in gait, producing limitations in toe-walking and in flexed knees; 3) hemiplegia, which is predominantly characterized by weakness in one-half of the body and motor and sensory disorders [13]. With regard to clinical symptomatology there are other symptoms in children with CP. These include: 1) spasticity, which produces excessive muscle contraction; and 2) ataxia, which produces balance disorders and decreased coordination of muscle tone.

The traditional techniques for recovering motor functionality and reducing symptoms in children with CP are the following: 1) constraint-induced movement therapy; 2) strength training; and 3) functional electrical stimulation.

One of the techniques that is used in the rehabilitation programs of Acquired Brain Injury (ABI) patients and children with CP is the Perfetti method [14]. This method is based on sensory retraining which focuses on joint position perception and includes motor and sensory inputs in the rehabilitation processes. It is based on retraining sensory motor control and focuses on joint position perception. To achieve this, the method has two training phases. The first phase is the *exploration task* in which the participants must perceive the different objects of the method with the assistance of the therapist. The second phase is the *identification task* in which the participants must recognize those objects. Cognitive and motor skills are required in both phases in order to receive proper training.

2 Related Work

Novel and customizable Virtual Reality Systems (VRS) have been tested in the rehabilitation processes of patients with neurological disorders (related to neuroplasticity in ABI Patients [15], [16] and children with CP), which have shown good results in motor performance. The use of these systems in the rehabilitation process to increase gross/fine rehabilitation in upper extremities in children with CP are a hot issue being research at the present time [17]. However, at the present time, there are few virtual systems that have been tested specifically for usability, security, and acceptance in rehabilitation processes [18]. Meldrun et al. [19] tested the Nintendo Wii Fit Plus system in patients with neurological disorders and they showed high outcomes of usability and acceptance according to the System Usability Scale questionnaire (SUS) used.

The purpose of the experiment presented in this paper is to test the usability of a novel tool called Virtual Rehabilitation Child (VRChild) in terms of usability and

acceptance. To do this, we first tested the VRChild system using the SUS questionnaire in a population of subjects without neurological disorders [20]. In the past we tested similar VRS with ABI patients and we obtained high results in terms of usability. Therefore, in conclusion, we feel confident that the usability results will also be high for patients with CP.

3 Methods

In this experiment, eighteen subjects participated in the sessions, ranging in age from 18 to 23 years old (mean age of 19.62±1.2). These participants (four males and fourteen females) were predominantly university students with no neurological disorders. Therefore, the exclusion criteria in our experiment were the following: presence of motor and cognitive alterations and having experience with and knowledge of Virtual Motor Rehabilitation systems.

3.1 VRChild System

Our system is composed of different exercises from the Perfetti method. The system uses a set of 9 wooden blocks of different colours and a tablet with an Android operating system. The tasks of the exercises are recognition tasks: 1) recognition of the length of wooden blocks/bars; 2) recognition of the height of wooden blocks/bars; 3) pattern recognition.The exercises begin with a setup screen in which the researcher selects both the exploration time and the identification time (Fig. 1a). Once these session times have been selected, a browsing screen is displayed which is set for half of the session time selected. Half of the session time is for the exploration task and the other half is for the identification task.

In the three exercises, the subject sits at a table that has a tablet and a selection of wooden blocks/bars. The subject has his/her eyes open, looking at the wooden blocks selected by the researcher and paying particular attention to the explanations for the exercises. In the exploration task for length and height recognition, the researcher tells the subject to look at the wooden blocks and to associate the different colours with the different lengths and heights. In the exploration task, the researcher guides the subject's fingers to adjust to the length or height of the wooden block. Next, in the identification task, the subject closes his/her eyes and the researcher randomly selects one of the wooden blocks and places it on the surface of the tablet. The researcher guides two fingers of the subject and asks him/her to identify the block by the color. Each block has an assigned code which is recognized by the computer program.

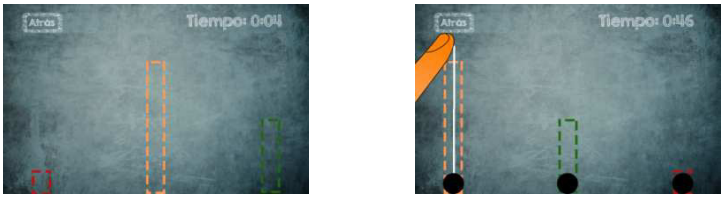
The wooden block can have a single pointer (Fig.1b) or two pointers (Fig. 1c) and can be placed in any position on the tablet. The subject recognizes the block by placing his/her fingers at each end of it as shown in (Fig 1d). White lines indicating the distance between the user's fingers and the block appear (Fig. 1e). Then, the system emits a sound cue based on the distance between the subject's fingers and the block. The playing time of this sound cue is proportional to the distance between the subject's fingers and the block.

a) b) c)

d) e)

Fig. 1. Sequence of screens designed to perform a length-recognition exercise

The exercises for length and height have some differences. In the exercises for length, only one block is used at a time. In the exercises for height, three blocks are used at a time. For example, (Fig 2a, 2b) shows how the three blocks are aligned at the bottom of the tablet screen. Later in the exercise, the same three blocks are shown to the subject again in random order and the subject must identify them a second time.



a) b)

Fig. 2. Sequence of screens designed to perform a height-recognition exercise

For the pattern recognition exercise, the only component is the tablet and no wooden blocks are used. The contour of a figure or shape is displayed on the screen (e.g., the letter T, or a flower, or a square). The subject must follow the contour of this figure (Fig 3a). As the subject traces the figure with his/her finger, a line appears on the screen. If the line drawn by the subject follows the contour, there is no sound cue. If the line drawn by the subject does not follow the contour, a sound cue is played and the distance between the figure and the subject's finger is shown on the screen (Fig 3 b). The playing time of this sound cue is proportional to the error in distance.

a) b)

Fig. 3. Sequence of screens designed to perform contour recognition exercise

4 Procedure.

We tested the VRChild system with each subject for 5 minutes. At the beginning, the researcher explained the objectives (to decrease motor and cognitive disorders) and the instructions (to get the subject used to playing with our system). Then, each of the two phases of the Perfetti method (the exploration and the identification tasks) for the three exercises was performed (see Fig. 4). Finally, the subjects completed a version of the SUS questionnaire in order to determine the usability of the VRChild system.

Fig. 4. Subjects and researchers testing the VRChild system.

5 Results

The SUS questionnaire shows good outcomes for the VRChild system, with a global result of (75.83±10.47). In [21], Bangor et al. determined that a result in an interval ranging from 70 to 85 in the SUS questionnaire is a good result. Therefore, we consider our preliminary outcomes to be very interesting and that they should be validated for children with CP. The results of the SUS questionnaire are shown in Table 1.

6 Discussion and Conclusions

This experiment was tested with subjects that have no neurological disorders. The results obtained show that VRChild has good acceptance and good usability. We are

confident that we will obtain similar results testing our tool with children who have CP because it was specifically designed with the assistance of clinical specialists.

Table 1. Results of the SUS questionnaire

Question	Result (N=18)	
	Mean	SD
Q1. I think I would like to use this Virtual Reality system frequently.	3.39	0.78
Q2. I found the Virtual reality system to be unnecessarily complex.	1.94	0.80
Q3. I thought that the Virtual Reality system was easy to use.	4.22	0.55
Q4. I think I would need the support of a technical person to be able to use this Virtual Reality system.	2.56	1.25
Q5. I found that the various functions in this Virtual Reality system were well integrated.	4.28	0.67
Q6. I thought there was too much inconsistency in this Virtual Reality system	2.00	0.77
Q7. I would imagine that most people would learn to use this Virtual Reality system very quickly	4.33	0.49
Q8. I found the Virtual Reality system to be very cumbersome to use	1.50	0.71
Q9. I felt very confident using the Virtual Reality system	3.78	0.81
Q10. I needed to learn a lot of things before I could get going with this Virtual Reality system	1.67	0.69
GLOBAL SCORE (total)	75.83	10.47

Therefore, we think that our groundbreaking system can be used in the rehabilitation processes of children with CP. At the present time, we are recruiting a statistical representative sample of children with CP which will confirm our preliminary results in the near future. The inclusion criteria are: 1) children with CP with reading, visual, and auditory comprehension; 2) age≥5 years old and ≤18 years old; and 3) comprehension of VRChild instructions. The exclusion criteria are: 1) patients with transcortical sensory aphasia; 2) patients with mixed transcortical aphasia; 3) patients with cognitive impairment (MEC-Lobo) < 23); and 4) the refusal to participate by children with CP.

Acknowledgments. The authors would like to acknowledge Ivan Verde Pita and Minerva Rodriguez for designing VRChild. This contribution was partially funded by the Gobierno de Aragón, Departamento de Industria e Innovación, y Fondo Social Europeo "Construyendo Europa desde Aragón" and Universidad de las Fuerzas Armadas-ESPE.

References

1. Oskoui, M., Coutinho F., Dykeman J., Jetté N., Pringsheim T.: An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. Dev Med Child Neurol. 55(6),509-19 (2013).
2. Chen Y.P., Lee S.Y., Howard A.M.: Effect of virtual reality on upper extremity function in children with cerebral palsy: a meta-analysis. Pediatr Phys Ther. 26(3):289-300 (2014).
3. Gladstone M: A review of the incidence and prevalence, types and aetiology of childhood cerebral palsy in resource-poor settings. Ann Trop Paediatr. 30(3), 181-96 (2010).

4. Himmelmann K., Hagberg G., Beckung E., Hagberg B., Uvebrant P.: The changing panorama of cerebral palsy in Sweden. IX. Prevalence and origin in the birth-year period 1995-1998. Acta Paediatr. 94(3):287-94 (2005).
5. Topp M., Uldall P., Greisen G.: Cerebral palsy births in eastern Denmark, 1987--90: implications for neonatal care. Paediatr Perinat Epidemiol. 15(3):271-7 (2001).
6. Reid, D.: Benefits of a virtual play rehabilitation environment for children with cerebral palsy on perceptions of self-efficacy: a pilot study. Pediatric Rehabilitation. 5(3), 141-148 (2002).
7. Marlow E.S., L.P. Hunt, Marlow N.: Sensorineural hearing loss and prematurity. Arch Dis Child Fetal Neonatal Ed. 82:2 F141-F144 (2000).
8. Nashner L.M., Shumway-Cook A., Marin O.: Stance posture control in select groups of children with cerebral palsy: deficits in sensory organization and muscular coordination. Exp Brain Res. 49(3):393-409 (1983).
9. Gunel M.K., Mutlu A., Tarsuslu T., Livanelioglu A.: Relationship among the Manual Ability Classification System (MACS), the Gross Motor Function Classification System (GMFCS), and the functional status (WeeFIM) in children with spastic cerebral palsy. Eur J Pediatr. 168(4):477-85 (2009).
10. Ryan J.M., Forde C., Hussey J.M., Gormley J.: Comparison of Patterns of Physical Activity and Sedentary Behavior Between Children With Cerebral Palsy and Children With Typical Development. Phys Ther. (2015).
11. Mezgebe M., Akhtar-Danesh G.G., Streiner D.L., Fayed N., Rosenbaum P.L., Ronen G.M.: Quality of life in children with epilepsy: How does it compare with the quality of life in typical children and children with cerebral palsy?. Epilepsy Behav. 52(Pt A):239-243 (2015).
12. Lowes L.P., Westcott S.L., Palisano R.J., Effgen S.K., Orlin M.N.: Muscle force and range of motion as predictors of standing balance in children with cerebral palsy. Phys Occup Ther Pediatr. 24(1-2):57-77 (2004).
13. Jaspers E., Desloovere K., Bruyninckx H., Molenaers G., Klingels K., Feys H.: Review of quantitative measurements of upper limb movements in hemiplegic cerebral palsy. Gait Posture. 30(4):395-404 (2009).
14. Perfetti C. Der aufbau der uegungen. In: Perfetti C (ed.) Der hemiplegische patient cognitive-therapeutische uegungen, first edition. Munich: Pflaum. 71–106 (1997).
15. Albiol-Pérez S., Gil-Gómez J.A., Llorens R., Alcañiz M., Font C.C.: The role of virtual motor rehabilitation: a quantitative analysis between acute and chronic patients with acquired brain injury. IEEE J Biomed Health Inform. 18(1):391-8 (2014).
16. Albiol-Pérez S., Lozano-Quilis J.A., Gil-Gómez H., Gil-Gómez J.A., Llorens R.: Virtual rehabilitation system for people with Parkinson's disease. 9th international conference on disability, virtual reality, and associated technologies (ICDVRAT), 423-427 (2012).
17. Chen Y.P., Kang L.J., Chuang T.Y., Doong J.L., Lee S.J., Tsai M.W., Jeng S.F., Sung W.H. Use of virtual reality to improve upper-extremity control in children with cerebral palsy: a single-subject design. Phys Ther. 87(11):1441-57 (2007).
18. Kalawsky RS. VRUSE--a computerised diagnostic tool: for usability evaluation of virtual/synthetic environment systems. Appl Ergon. 1999 Feb;30(1):11-25.
19. Meldrum D., Glennon A., Herdman S., Murray D., McConn-Walsh R. Virtual reality rehabilitation of balance: assessment of the usability of the Nintendo Wii(®) Fit Plus. Disabil Rehabil Assist Technol. 7(3):205-10 (2012).
20. Brooke, J.: SUS: a 'quick and dirty' usability scale. In P. W. Jordan, B. Thomas, B. A. Weerdmeester, & A. L. McClelland. Usability Evaluation in Industry. London: Taylor and Francis (1996).
21. Bangor A., Kortum P., Miller J.: Determining what individual SUS scores mean: Adding an adjective rating scale. Journal of Usability Studies, 4(3):114–123, (2009).

Acceptance and suitability of a novel virtual system in chronic acquired brain injury patients.

Sergio Albiol-Pérez[1,2], Edwin-Patricio Pruna-Panchi[2], Ivón-Patricia Escobar-Anchaguano[2], José-Gioberty Bucheli-Andrade[2], Marco-Antonio Pilatasig-Panchi[2], Luis-Enrique Mena-Mena[2], Janeth Segovia-Chávez[3], Aracne Bernis[4], Paulina Zumbana[5]

[1]Dpto. de Informática e Ingeniería de Sistemas, Universidad de Zaragoza, Calle Ciudad Escolar S/N, 44003 Teruel, Spain
[2]Departamento de Eléctrica y Electrónica, [3]Departamento de Ciencias Exáctas, Universidad de las Fuerzas Armadas ESPE, Sangolquí, Ecuador
[4]Centro de Salud Lasso - Cotopaxi, Ecuador
[5]Hospital Instituto Ecuatoriano de Seguridad Social de Latacunga
{salbiol}@unizar.es
{eppruna, ipescobar, jgbucheli, mapilatagsig, lemena, jpsegovia}@espe.edu.ec
{aracnebl}@gmail.com , {fisiorenacer87}@hotmail.com

Abstract. Acquired Brain Injury is one of the leading causes of death in the world. The main alterations are postural control, balance, and gait disorders, that limit activities of daily living. Therapies in traditional gross/fine rehabilitation of upper limbs are: constraint-induced movement therapy, hand splints, or fine motor coordination. Groundbreaking virtual environments have been tested in patients with neurological disorders with encouraging outcomes. However these systems have not been tested with specific and customizable questionnaires that focus on usability, dizziness, disorientation, or realism. Therefore, the aim of this paper is to validate the suitability evaluation questionnaire (SEQ) with our system, the Virtual Rehabilitation Sphero (VRSphero). To do this, we tested previously the SEQ questionnaire with subjects that did not have any cognitive impairment. Since the results show that these subjects did not have problems related to nausea, disorientation or dizziness, we plan to test our tool with chronic ABI patients.

Keywords: Virtual Motor Rehabilitation, Chronic Acquired Brain Injury, Rehabilitation, Virtual Environments, Usability, Suitability, Realism.

1 Introduction

Acquired brain injury (ABI) is damage that is suddenly produced in the encephalon, which generates permanent neurological impairments and reduces the functional capacity and the quality of life of people [1]. ABI is composed mainly of stroke and traumatic brain injury (the main reasons for disability in adults on a global level [2]). ABI is one of the leading causes of death worldwide with an incidence of 1.7 million people contributing to approximately 30% of all injuries associated with deaths in the

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_101

USA [3]. Approximately 80% of patients with ABI have motor disorders, which mainly affects the upper limbs [4]. These patients have no functionality in the paretic arm 6 months after stroke (approximately 30% to 66% of hemiplegic patients), with only 5% to 20% of these patients recovering normal functionality [5].

Traditional rehabilitation treatments in ABI patients for the upper limbs are the following: 1) constraint-induced movement therapy [6], which produces significant improvements in the affected arm; 2) hand splints [7], which reduce spasticity; and 3) improvements in fine motor coordination [8] with exercises related to activities of daily living.

In this context, there are different therapeutic exercises for improving the Quality of life (Qol) of ABI patients: 1) gait training [9], with improvements in the strength of the limbs; 2) specific treatments focused on integration in society; 3) aerobic training [10] to improve mood in ABI patients; and 4) exercises that encourage healthy behavior and self-esteem, in order to increase the Qol.

Novel and groundbreaking virtual systems have attracted the attention of the scientific community [11] with experiments and validation in patients with neurological disorders showing greats benefits in motor recovery.

Different devices and virtual environments have been tested in patients with different etiologies: the Sony PlayStation II Eyetoy® for the rehabilitation of older adults with disabilities [12]; optical low-cost sensors such as Kinect® for patients with multiple-sclerosis [13], stroke patients [14], patients with Parkinson's disease; low-cost commercial force platforms such as the Nintendo® Wii Balance Board® (WBB) for chronic ABI patients [15],[16], Guillain-Barré patients [17], or patients with Parkinson's disease [18]; or the Nintendo Wii for Parkinson's disease [19]. The use of novel low-cost devices such as Sphero 2.0® are a good complement to rehabilitation, exercises such as: pronation and supination are normal movements in therapeutic sessions, therefore, we used this device to carry out these types of movements. In [20], the authors implemented a virtual system that is composed of different sensors (Microsoft Kinect, Leap Motion, and Sphero) using a server-client model in five patients with upper limb hemiparesis. However, at the present time, there is no good system that uses all the functionality of this robot ball.

Usability in virtual motor rehabilitation is an important feature that clinical specialists need to test previously in the validation of patients with neurological disorders. To do this, we created the Suitability Evaluation Questionnaire (SEQ) and we validated it using the Active Balance Rehabilitation (ABAR) system in patients with different etiologies [21].

The aim of this paper is to test the SEQ in subjects that have no neurological disability. To do this, we have implemented a novel system, the Virtual Rehabilitation Sphero (VRSphero). Our tool focuses on gross and fine rehabilitation in chronic ABI patients with a level of spasticity from low to moderate. To decrease the spasticity disorder, exercises related to movements of pronation/supination are carried out. For this purpose we used VRSphero with a virtual environment based on instrumented activity of daily living.

2 Methods

In this trial, thirteen subjects participated in the first session, ranging in age from 19 to 23 years old (mean age of 19.54±1.2). The subjects (one male and twelve females) were university students with no neurological impairment. The inclusion criteria for selecting the subjects for our trial were the following: no motor or cognitive impairment and no previous knowledge or experience using Virtual Motor Rehabilitation systems.

2.1 The VRSphero System

VRSphero is a software tool that is designed and programmed using Unity technology. Thanks to our system, we can assist chronic ABI patients in gross/fine rehabilitation therapies. VRSphero is composed of a video-game in which the players take care of a garden (an instrumented activity of daily living), where the subjects must water different plants that appear randomly. Based on the quantity of water that the subjects provide, virtual plants grow or wither, as shown in Figure 1.

Fig. 1. Interface of the VRSphero system.

All of the game parameters are configurable via a graphical interface so that clinical specialists can define the degree of difficulty, the duration of the session, the number of seconds for the plants to grow or to wither. The results can be saved in Dropbox. The data from the game session and the movements made with the external device are stored in PDF files, which are then stored in the device memory running VRSphero in order to observe the evolution of the patient or studies. The files are also encrypted to protect the confidentiality of data. The files can be automatically and securely saved to Dropbox, so that the authorized clinical specialist can access this information. The implementation details are shown in Figure 2.

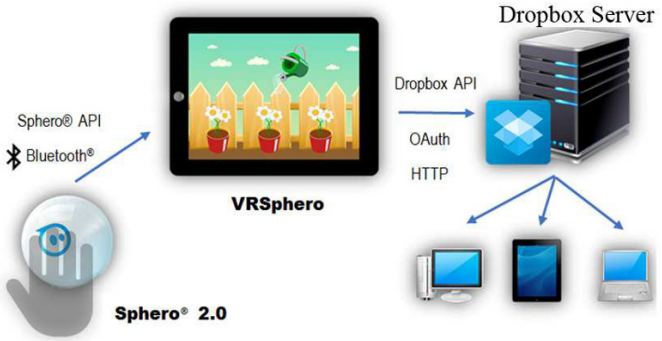


Fig. 2. System architecture of the VRSphero system

The Sphero device consists of an accelerometer and a gyroscope, and it is possible to obtain the values of *Roll*, *Pitch*, and *Yaw*. To perform the correct movement ABI patients must move the watering can along the x axis. We stored the normalized data sent by the accelerometer. The accelerometer of our robot ball in the idle state has 0 m/s on the x and y axes, and 9.8 m/s on the z axis due to gravity. To isolate this value and to calculate the new position of the watering can, Formula 1 must be solved. Value α is between 0 and 1 and it determines the cut-off frequency of the signal which will be transmitted. A value close to 1 indicates that the signal has been transmitted correctly. Finally, value α which we considered is approximately 0.9.

$$\text{NewX} + y = \alpha \times \text{PreviousX} + (1 - \alpha) \times \text{accelerationX axis.} \quad (1)$$

On the other hand, to show the effect of the incline of the watering can when the plants are being watered, the degree of the watering, the degree of Pitch on the x axis must be obtained, and, therefore, we obtained, thereby obtaining the final rotation on the z axis. To do this, Formula 2 must be solved.

$$\text{Rotation} = \text{Pitch-value} - \text{Previous-value-Pitch.} \quad (2)$$

3 Procedure

3.1 Interventions

We tested VRSphero with each subject for 10 minutes. At the beginning of the session, the researcher explained the purpose of our experiment (the gross/fine rehabilitation of upper limbs in chronic ABI patients) and gave a set of instructions to perform the correct movements. At the same time, the researcher activated Bluetooth communication to enable the personal tablet and the robot ball devices. The system shows the setup screen and the researcher selects the correct parameters. During the sessions, the participants played with the system performing the correct hand movements on the x and z axis, while the watering can watered the plants (see Fig. 3).

Finally, the participants answered the SEQ questionnaire in order to obtain the degree of satisfaction and usability and to determine if our system is safe for the rehabilitation process. The SEQ is composed of 14 questions, 13 of which are graded on a 5-point Likert scale and 1 last open question (It should be noted that Q13 was not answered by these subjects since Q13 is related specifically to ABI patients). The questions evaluated realism, enjoyment, feeling and whether or not the system was comfortable.

Fig. 3. Participants and researchers testing the VRSphero system.

4 Results

For the results obtained using VRSphero, the SEQ questionnaire shows good outcomes, with a global result of (31.15±8.27). The results obtained ranged from 26 to 35. The results of the test SEQ are shown in Table 1.

Table 1. Results of SEQ questionnaire

Question	Result (N=13)	
	Mean	SD
Q1. How much did you enjoy your experience with the system?	3.69	1.03
Q2. How much did you sense being in the environment of the system?	3.69	1.03
Q3. How successful were you in the system?	3.77	1.01
Q4. To what extent were you able to control the system?	3.92	0.76
Q5. How real is the virtual environment of the system?	3.38	0.96
Q6. Is the information provided by the system clear?	4.23	0.73
Q7. Did you feel discomfort during your experience with the system?	1.46	0.78
Q8. Did you experience dizziness or nausea during your practice with the system?	1.00	0.00
Q9. Did you experience eye discomfort during your practice with the system?	1.00	0.00
Q10. Did you feel confused or disoriented during your experience with the system?	1.00	0.00
Q11. Did you find the task difficult?	1.85	0.99
Q12 Did you find the devices of the system difficult to use?	2.15	0.99
GLOBAL SCORE (total)	31.15	8.27

5 Discussion and Conclusions

We tested a novel usability test that focuses on Virtual Rehabilitation systems in patients with neurological disorders. First, we validated our system with subjects that did not have disabilities and who complete the SEQ questionnaire. The results obtained show that the subjects enjoyed using VRSphero(Q1) and that they were able to control the system(Q4) and had received clear instructions before the session (Q6). These results demonstrate that the virtual motor rehabilitation sessions of ABI patients can be used for gross/fine rehabilitation upper extremities. This is because our tool specifically covers traditional actions such as movements of pronation and supination which are included in therapeutic sessions with ABI patients. The results of the questions that are related to specific items of the rehabilitation processes indicated that the subjects did not have dizzines/nausea(Q8), eye discomfort(Q9), disorientation(Q10), difficulty with the task(Q12), or difficulty of use(Q12), because our tool can be customized for each therapeutic session. These outcomes indicate that there should be no safety problems using VRSphero in the sessions of chronic ABI patients and that the ABI patients should be comfortable.

We are currently recruiting chronic ABI patients with the following criteria: outcomes on the modified Ashworth Spasticity Scale (ASS) <2 and close to zero; comprehension of instructions (the Mississippi Aphasia Screening Test (MAST ≥45); and no cognitive impairment (MEC-Lobo>23).

These preliminary results have encouraged us to validate VRSphero in chronic ABI patients. To do this, we will test our tool in chronic ABI patients using specific clinical tests: the Action Research Arm test (ARAT); the Wolf Motor Function test (WMFT); the modified Ashworth Spasticity Scale (ASS); and the Box and block test (BBT).

Acknowledgments. The authors would like to acknowledge Ivan Verde Pita and Minerva Rodriguez for designing the Game Engines. This contribution was partially funded by the Gobierno de Aragón, Departamento de Industria e Innovación, y Fondo Social Europeo "Construyendo Europa desde Aragón", and Universidad de las Fuerzas Armadas-ESPE.

References

1. Castellanos-Pinedo F., Cid-Gala M., Duque P., Ramírez-Moreno J.M., Zurdo-Hernández J.M.: Daño cerebral sobrevenido: propuesta de definición, criterios diagnósticos y clasificación. Rev Neurol. 54: 357-66 (2012).
2. World Health Organization. Neurological disorders: public health challenges. Geneva: WHO; 2006.
3. Faul M., Xu L., Wald M.M., Coronado V.G.: Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations, and Deaths 2002 – 2006. Atlanta: Centers for Disease Control and Prevention. (2010).
4. Chen H.F., Wu C.Y., Lin K.C., Chen H.C., Chen C.P., Chen C.K.: Rasch validation of the streamlined Wolf Motor Function Test in people with chronic stroke and subacute stroke. Phys Ther. 92(8):1017-26 (2012).

5. Kwakkel G., Kollen B.J., van der Grond J., Prevo A.J.: Probability of regaining dexterity in the flaccid upper limb: impact of severity of paresis and time since onset in acute stroke. Stroke. 34(9):2181-6 (2003).
6. Dettmers C., Teske U., Hamzei F., Uswatte G., Taub E., Weiller C.: Distributed form of constraint-induced movement therapy improves functional outcome and quality of life after stroke. Arch Phys Med Rehabil. 86(2):204-9 (2005).
7. Basaran A., Emre U., Karadavut K.I., Balbaloglu O., Bulmus N.: Hand splinting for poststroke spasticity: a randomized controlled trial. Top Stroke Rehabil. 19(4):329-37 (2012).
8. Mayer, N.H., Esquenazi, A., Childers, M.K.: Common patterns of clinical motor dysfunction. Muscle & Nerve 20(S6), 21-35 (1997).
9. Seif-Naraghi A.H., Herman R.M.: A novel method for locomotion training. J Head Trauma Rehabil. 14(2):146-62 (1999).
10. Bushbacher, R.M., Porter, C.D.: Deconditioning, conditioning, and the benefits of exercise. In R.L.Braddom (Ed.), Physical Medicine and Rehabilitation, Second edition ed., 702-726 (2000).
11. Burdea, G.: Keynote Address: Virtual Rehabilitation: Benefits and Challenges. 1st International Workshop on Virtual Reality Rehabilitation (Mental Health, Neurological, Physical, Vocational) VRMHR, pp.1-11, (2002).
12. Rand, D., Kizony, R., Weiss, P.T.L.: The Sony PlayStation II EyeToy: low-cost virtual reality for use in rehabilitation. Journal of neurologic physical therapy. 32,155-63 (2008).
13. Lozano-Quilis, J.-A., Gil-Gómez, H., Gil-Gómez, J.-A., Albiol-Pérez, S., Palacios-Navarro, G., Fardoun, H.M., Mashat, A.S.: Virtual Rehabilitation for Multiple Sclerosis Using a Kinect-Based System: Randomized Controlled Trial. JMIR Serious Games, 2(2), e12 (2014).
14. Kizony, R., Weiss, P.L., Feldman, Y., Shani, M., Elion, O., Kizony, R. et al.: Evaluation of a Tele-Health System for upper extremity stroke rehabilitation. Virtual Rehabilitation (ICVR), International Conference on. 80,86, (2013).
15. Cho K.H., Lee K.J., Song C.H.: Virtual-reality balance training with a video-game system improves dynamic balance in chronic stroke patients. Tohoku J Exp Med, 228, 69-74, (2012).
16. Albiol-Pérez S., Gil-Gómez J.A., Llorens R., Alcañiz M., Font C.C.: The role of virtual motor rehabilitation: a quantitative analysis between acute and chronic patients with acquired brain injury. IEEE J Biomed Health Inform. 18(1):391-8 (2014).
17. Albiol-Pérez S., Forcano-García M., Muñoz-Tomás M.T., Manzano-Fernández P., Solsona-Hernández S., Mashat M.A., Gil-Gómez J.A.: A novel virtual motor rehabilitation system for Guillain-Barré syndrome. Two single case studies. Methods Inf Med. 54(2):127-34 (2015).
18. Mhatre P.V., Vilares I., Stibb S.M., Albert M.V., Pickering L., Marciniak C.M., et al.: Wii Fit balance board playing improves balance and gait in Parkinson disease. PM R. 5(9):769-77 (2013).
19. Herz NB, Mehta SH, Sethi KD, Jackson P, Hall P, Morgan JC. Nintendo Wii rehabilitation ("Wii-hab") provides benefits in Parkinson's disease. Parkinsonism Relat Disord. 2013 Nov;19(11):1039-42.
20. Matos, N., Santos, A., Vasconcelos, A.: Kinteract: A Multi-sensor Physical Rehabilitation Solution based on Interactive Games. In Proceedings of the 8th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth '14). 350-353 (2014).
21. Gil-Gómez J.-A., Gil-Gómez H., Lozano-Quilis J.-A., Manzano-Hernández P., Albiol-Pérez S., Aula-Valero C.: SEQ: suitability evaluation questionnaire for virtual rehabilitation systems. Application in a virtual rehabilitation system for balance rehabilitation. In Proceedings of the 7th International Conference on Pervasive Computing Technologies for Healthcare (PervasiveHealth '13). 335-338 (2013).

Patient-Centred Transparency Requirements for Medical Data Sharing Systems

Dayana Spagnuelo* and Gabriele Lenzini

Interdisciplinary Centre for Security Reliability and Trust (SnT)
University of Luxembourg

Abstract. We compose, propose, and discuss several requirements to support transparency in Medical Data Sharing Systems. Transparency is a property that suggests openness and compliance with policies, practices, and processes employed to secure data, and it is believed to promote good quality of service in healthcare. Our requirements indicate how transparency can be realised on modern medical data sharing systems such as those managing electronic health records.

Keywords: Requirements, Transparency, Medical Data Sharing Systems.

1 Introduction

Medical data sharing systems are used by doctors, health care providers, and researchers to collect and share people's health information in digital form.

Information about patients is usually organised in Electronic Health Records (EHRs) and is strictly personal: EHRs carry highly sensitive data about a patient such as lab results, diagnosis, and health history. For this reason EHRs are expected to handle patient data by ensuring security and privacy. Regulations and laws have been billed to protect people's rights to have such properties put in place. In the Health Insurance Portability and Accountability Act (HIPAA), the Privacy Rule demands to document privacy policies and procedures and to notify individuals of uses of their health information, while the Security Rule requires specific protections to safeguard EHRs' security, including storing audit trails that record who has accessed what information. These and other similar requests refer to a transversal quality in security and privacy called *transparency*.

Transparency is invoked to implement people's right to have control over their data [20]. European Directives 95/46/EC and 2011/24/EU recommend transparency when they establish "the right for individuals to have access to their personal data concerning their health [..] also in the context of cross-border healthcare". The same does the incoming General Data Protection Regulation (GDPR) [5] when stating that data controllers are "obliged to provide easily accessible information, [..] and procedures and mechanisms for exercising a data

* Supported by FNR/AFR project 7842804 TYPAMED

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_102

subject's rights" (Art. 11, 12 and 13). Indeed, GDPR lists transparency as one of the driving principles in processing personal data.

For all these reasons transparency is considered a pro-ethical principle to promote accountability, improve service quality and outcomes, empower people's choices and demands for better services, and foster social innovation and economic growth [12, 8]. It has been defined as "the possibility to access information and evidences revealed through a process of disclosure" [22], as a practice "to inform users and make policies and processes openly available" [14], and as the "predisposition to increase responsibility and accountability" [9].

Either because required by law, or imposed by regulations, or suggested by ethical principles, transparency is a desirable quality to have in health care medical systems in order to defend patients' right to security and privacy. Although its benefits are discussed by a few papers [10, 9, 18, 20], there has been no establishment of technical requirements for transparency. Such requirements seems far from being simple, since defending patient's right must not be done only in appearance, like by making available logged data which no patient can interpret. This paper fills this gap: it discusses a definition of transparency for medical data sharing systems keeping a patient-centred perspective and presents the first list of requirements for transparency for health care system engineering.

2 Medical Data Sharing Systems

Several types of medical data sharing systems deal with EHRs: systems for eHospitals, for medicine and telemedicine, applications for wireless body area network, and systems used by bio-banks, pharmaceutical and insurance companies. They are all in the scope of this paper's research. However, to keep focus, we have implicitly referred to three systems in particular. The first is the *Integrated Telemedicine and Telehealth System* of the state of Santa Catarina, Brazil; it allows accessing medical examinations (e.g., ECGs, ECHOs, CATs, MRIs) at distance. The second is the *Visual Electronic Patient Record* of the Hospital São João, Portugal, a centralised data management system that collects clinical reports from the various hospital departments and lets them be accessed by authorised health professionals. The last one is the system developed by the Luxembourg Centre for Systems Biomedicine; it is available to doctors and researchers to collect and store questionnaires on personal and medical information of patients with the goal of studying the development of the Parkinson's disease.

3 Transparency in Medical Data Sharing Systems

Even though several works welcome transparency in health care (see §1), we have found none giving a clear definition of the concept or suggesting how to implement it. Instead, transparency has been discussed in web services and cloud computing. Here, researchers have developed Transparency Enhancing Tools (TETs), meant to inform users about how data are handled (see [6] and [11] for a survey), and discussed a few definitions of transparency.

One stands out for its clarity and for its utility in health care [7]. It separates *ex ante* and *ex post* transparency. Ex-ante transparency "*enables the anticipation of consequences before data are actually disclosed*". Ex-post transparency "*offers information about any consequences if data already have been revealed*" (FIDIS deliverable D7.12 as cited in [7]). Because of its simplicity and flexibility we adopt this definition and we adapt it to the health care domain, as follows:

Definition 1 (Transparency in Health Care). Ex-ante transparency *enables the patient to anticipate or to control what will happen to his/her medical and personal data.* Ex-post transparency *enable the patient to be informed or get informed about what happened to his/her medical and personal data.*

4 Methodology and Intermediate Results

Our methodology is organised in two phases. The first phase reviews the literature aiming at evidences to test this paper's *reason d'être* i.e., that transparency requirements are needed and missing in health care system engineering. The second phase establishes the requirements and discusses their relevance.

Phase 1: Testing the Relevance of the Problem. We browsed the state of the art for recent works (2003-2014) that contain "security" and "medical data sharing" in the title, abstract, keywords, and body. "Security" is a keyword that we expect to find in works addressing more specific security properties; "medical data sharing" is to restrict the research to this paper's topic. To search as extensively as possible, we browsed the literature with meta search engine, www.findit.lu: it cross-indexes a large number of digital libraries such as LNCS, the ACM Digital Library, IEEEXplore, ScienceDirect, Scopus, and Medline. From a first pool of 75 papers, we rejected those where security appears without being discussed and remained with 55 papers.

For reason of space we cannot comment all the findings (see our technical report for the details [21]) but, in short, of these 55 papers, 52 look at security in health care as a serious problem to address, and three see the need of transparency [14, 9, 18] or of other properties that, as accountability, link to transparency. However, there is no formalisation of it and no standard solution that makes a medical system compliant to it. Our research's goal seems justified.

Phase 2: Requirement Establishment. Instead of interviewing engineers of medical systems and lawyers expert in regulations (a task which was beyond our possibilities), to establish requirements for transparency we started from the existing research. We proceeded in five steps (see Figure 1): (1) *definition of sources*, where we review the literature in other domains searching for potentially applicable-to-transparency requirements, and where we collect papers that discuss technical features in medical systems that directly or indirectly are about transparency; (2) *extraction of requirements*, where we define the criteria to select/compose transparency requirements in preparation to have a preliminary

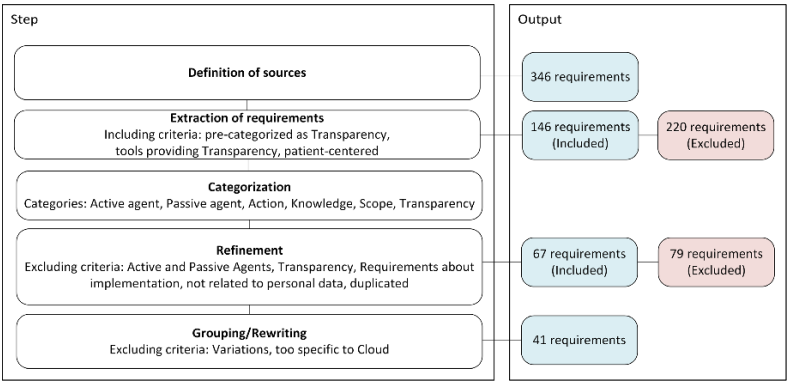


Fig. 1. Our second phase's 5 steps (left); No. requirements retained/rejected (right)

list; (3) *categorisation*, where we categorize our preliminary list of requirements according to whether they provide information or tools, to whether they concern privacy, accountability, or other security properties, and to whether they are ex-ante or ex-post; (4) *refinement*, where we review the requirements questioning their relevance in the healthcare domain; (5) *rewriting*, where we rewrite, restyle, and present our final list of requirements. We describe the five steps in detail.

Definition of sources. Our sources are papers and projects that mention transparency as a goal or as a subject of research and papers and projects about medical data security. In addition to the works we used in phase 1, we selected others by searching for "transparency" and "privacy" to find works discussing transparency but not necessarily in healthcare, and others more by searching for "security," "privacy", and "medical data", to find articles in healthcare that discuss properties linked to transparency. We also searched through papers cited in articles that survey the topic [19, 16].

We have found several publications on transparency, the majority belonging to the EU project A4Cloud (www.a4cloud.eu). Two deliverables of this project [15, 4]) comment 346 requirements for accountability. These requirements were elicited after several interviews with professionals, among which data protection experts. We decided to use this project's deliverables as our main source, since the requirements that they provide form a superset of potentially interesting requirements. To this, we added six papers (i.e., [17, 3, 13, 2, 1, 20]), discussing technical features for medical systems that match our definition of transparency.

Extraction of requirements. Because we had both a list of already well stated requirements for cloud computing and six scientific articles discussing security in medical data sharing systems, we set two different criteria for extracting requirements. (1) To select from the list of requirements those that were already tagged 'transparency': this because the requirements coming from the A4Cloud project were already labelled using combinations of accountability attributes,

among which "transparency". By applying this criteria we sieved a total of 126 requirements. (2) To identify sentences describing operations that patients are able to do, or are allowed to do, or have the right to do, as well as tasks executed by the medical system that concern a patient's records and affect the patient's right over them (e.g., break the glass and delegation of access rights). This criterion is meant to discern mainly patient-centred requirements. Words such as *can*, *should*, *might*, and *must* helped us spot key sentences. We extracted additional 20 requirements for a total of 146 requirements, written according to the RFC2119 to indicate the requirement levels.

Categorisation. The requirements resulting from the previous step have been classified according to six attributes that remind the syntactic categories used in the description of a requirement: "The [*Active Agent*] must/should/may provide a [*Passive Agent*] with an [*Instrument*] for a [*Transparency Scope*]". *Agents* are data providers, medical systems, consumers, data owners, the patients or a data broker. *Instrument* are pieces of information or tools that realize the "being transparent" in respect to a *Transparency Scope*, for instance compliance to policies, accountability, auditability. A further attribute, *Transparency Type*, specifies the requirement be ex ante, ex post, or other.

Refinement. We refined the set of requirements by removing (a) *requirements where the Active Agent is not "data provider"*, since data provider is (the subject managing) the medical data sharing system, the role we intend to let provide transparency. (b) *requirements where the Passive Agent is not the consumer*, since we are interested in requirements about data providers (medical systems) and data consumers (patients), excluding requirements about other roles not relevant or uncommon in the medical domain, such as data brokers; (c) *requirements that are not about ex ante or ex post transparency*; (d) *requirements about implementation*; and (e) *requirements that are not about personal data.* We also removed duplicates. This step reduced the pool of 146 requirements to 67 requirements (53 from A4Cloud and 14 from healthcare literature).

Regrouping/Rewriting. We clustered the requirements according to our categorisation. We did so to discover requirements that are in fact variations of the same concept expressed with slightly different words; in this case, we merged those variants into one new requirement. In this process we also identified and excluded requirements that were meaningless in healthcare, mainly because were tailored specifically to cloud computing. Finally, we removed requirements that were mere specialisation of others, leaving only those most general; they implicitly embrace the special cases.

5 Transparency Requirements for Medical Systems

Table 2 and Table 3 show 41 requirements, organised in ex ante and ex post. Due to space constraints, we did not included all the fields suggested by the

Software Requirements Specifications (SRS) standard, but reported only "identifier" (ID) and "Description". As ID, we gave a numerical code inspired by the Dewey Decimal Classification[1]. Dewey's Classification uses classes in reference to book's subjects; our relies on the attributes that we defined in our categorisation step. Table 1 lists the codes of our attribute elements. Each code is a three digits number that reminds the attributes classifying the requirement in: Transparency Type (the cipher in the position of the hundreds), Transparency Scope (the cipher in the position of the tens), Instrument (the cipher in the position of the units). There is no code for "Active Agent" and "Passive Agent": they are omitted for we consider implicit that every requirement is from "Active Agent" (medical system) to "Passive Agent" (patients). Requirements that would have the same identifier, because in the same class, are distinguished adding decimal ciphers to the code. So, for example "162.11 - The Provider must inform the Consumer on how to protect data or how data are protected" is the 11th requirement in the category Ex ante transparency (100) regarding Openness (60) on Information on processes (2).

Table 1: Category codes: attribute (left) and Value (right)

Type	Ex ante (100); Ex post (200)
Transparency Scope	Compliance with policies (10); Recoverability(20); Auditability (30); Accountability (40); Access Control (50); Openness (60); Privacy (70)
Instrument	Information about data (1); .. about processes (2); .. about events (3); Evidence/Proofs (4); Policy (5); Mechanisms (6)

5.1 Ex ante Requirements

According to Definition 1 ex ante transparency puts the patients in condition to anticipate and control what will happen to their data. Even though the ex ante transparency hints an active involvement of the patients, most of the requirements we have selected in this category involve them only passively by informing about data and processes (see Table 2). EHRs are normally created and manipulated by medical teams, and so patients are not always aware of what data the system has on them, of how data are handled and by whom are accessed. Without this pieces of information patients are not able to anticipate and control what is going to happen to their data. Requirements 161.1-2 and 162.1-13 support this believe. Requirements 156.1-3, 166, and 176, on the other hand, are requirements that directly address the problem of controlling data by providing patients with tools (mechanisms) to share and access their data.

While transcribing a few requirements we changed their recommendation level. Requirements 162.4-6 and 162.10, for instance, were originally mandatory (must). They were clearly conceived for users with some expertise in Information and Communication Technology (ICT). But in medical system, where users

[1] https://www.oclc.org/dewey/features/summaries.en.html

are patients commonly not experts in ICT, we relax these requirements to be recommended (should).

Table 2: Ex-ante Requirements.(S =medical data system; P =patient)

ID	Description
156.1	S must provide P with data sharing mechanisms.
156.2	S must provide P with mechanisms allowing the revocation of access rights.
156.3	S must provide P with mechanisms for the administration of access rights.
161.1	S must provide P with real time information on physical data storage and data storage location of different types of data.
161.2	S must inform P on how data are stored and who has access to them.
162.1	S must inform P from whom it purchases services, and about any "conflict of interest towards data.
162.2	S, in case of using services from third parties, must inform P about the existence of sub-providers, where they are located and whether they comply with the legal requirements of the country of P.
162.3	S must inform P how it is assured that data are not accessed without authorisation.
162.4	S should make available a document that describes the adopted mechanisms for securing data against data loss as well as data privacy vulnerabilities.
162.5	S should make available a document that describes the procedures and mechanisms planned in cases of security breaches on P's data.
162.6	S should make available the technical documentation on how data are handled, how they are stored, and what are the procedures for accessing them.
162.7	The P must be made aware of the consequences of their possible choices in an unbiased manner.
162.8	S must inform P about who is responsible for handling owned data.
162.9	S must inform P about storage in other countries and compliance issues related to this storage with respect to laws and regulations of both the other country and their own country.
162.10	S should inform P about the use of specific security mechanisms.
162.11	S must inform P on how to protect data or how data are protected.
162.12	In case of using services from third parties, S must inform P on the responsibilities of the different parties involved in the agreement.
162.13	S must inform P about who has the authority to investigate any policy compliance.
164	S must provide P with evidence of data collection practices.
165.1	S must make available a document explaining the procedures for leaving the service and taking the data out from the service.
165.2	S must make available a document that describes the ownership of the data.
165.3	S must provide P with disclosure of policies, regulations or terms regarding data sharing, processing and the use of data.
166	S must provide P with mechanisms for accessing, amending and correcting personal data.
174	S must provide P with evidence of separating personal from meta data.
176	S must provide P with mechanisms that allow to express binding privacy policies regarding the disclosure of data to third parties.

5.2 Ex post Requirements

According to Definition 1 ex post transparency is a way to inform the patients about what happened to their personal data. Because of that ex post is mostly composed by requirements about the system providing evidence to the patients on the way that data have been handled, and whether or not they have been handled in compliance to policies and regulations (see requirements 214, 224, 234.1-2, 254, 264.1-2).

Ex post category also includes requirements (like requirements 263.1-4) that inform patients about *events* that may endanger their data, like security breaches. The goal of these requirements is to inform the patients so that they are able to understand the impact of the event on their data, but not necessarily to find and blame the responsible for the event.

Almost all our requirements are either ex post or ex ante but two (i.e., requirements 162.1 and 262.1) can be defined as both, depending on how we interpret them: "S must inform the P from whom it purchases services, and about any conflict of interest towards data". When the information is given before the patient signs the consent and discloses data to the system, the requirement is clearly providing ex ante transparency. When the medical system purchases services from a new source, it is an ex post requirement for the patients who had already disclosed data.

Table 3: Ex post requirements (S =medical data system; P =patient)

ID	Description
214	S must provide P with evidence that policies, regulations and practices have been applied correctly.
224	S must provide P with evidence of the recovery from security attacks.
234.1	S must provide evidence of compliance with respect to extraterritorial legislative regimes.
234.2	S must provide evidence that the data is being maintained in the correct way.
236	S must provide P with audit mechanisms.
246	S must provide P with accountability mechanisms.
254	S must provide P with evidence regarding permissions history for auditing purposes.
261	S must provide detailed information on the data collected about P, and what information S has implicitly derived from disclosed data.
262.1	S must inform P from whom it purchases services, and about any conflict of interest towards data.
262.2	S must inform P if and when data is gathered, inferred or aggregated.
263.1	S, in case of security breaches, must inform P on what happened, why it happened, what the procedures S is taking to correct the problem and when services will be resumed as normal.
263.2	S must inform P when the authorities access personal data.
263.3	S must notify P in case the policy is overridden (break the glass).
263.4	S must provide P with timely notification on security breaches.
264.1	S must provide P with evidence of security breaches.
264.2	S must provide P with evidence that revoked consent has been executed.

5.3 Other Requirements

So far, we presented requirements matching directly Definition 1. But we have found other requirements that better qualify transparency. They are about informing about the existence of transparency tools: "*S must inform P about the availability of transparency tools*"; about the usability of the transparency tools: "*S must comply with a requirement in an understandable and usable way*"; and about preserving privacy while providing transparency: "*S must comply with a requirement without harming data privacy*".

The first is justified by the fact that a system cannot be considered truly transparent if its users are not informed about the transparency functionalities. The second is motivated by the fact that patients are generally non-technical users. Even though we are aware that providing usability in a satisfactory level is difficult, usability principles must be considered when designing transparency tools. The third is a concern raised by the fact that most of the requirements are dealing with personal data, and in so doing must not sacrifice an user's privacy.

These three requirements are modifiers of other requirements; in a sense, they are meta requirements. The three modalities can potentially be applied over the 41 identified requirements. If we do so, we obtain 41×4 requirements (for each original version we add three modalities). We can even give an ID to them if we assume the modality being a fourth attribute so encoded: *existence* (1000), *usability* (2000), and *preserve privacy* (3000). For instance, requirement 246 - "*S* must provide to the *P* accountability mechanisms" have three other modalities: 1246 - "[*S* must inform *P* that there are] accountability mechanisms"; 2246 - "*S* must provide *P* with [usable] accountability mechanisms"; 3246 - "*S* must provide *P* with accountability mechanisms [that do not disclose other private information]".

6 Discussion and Conclusion

Implementing the requirements we defined in this work will be technically challenging. We also expect difficulties due to internal regulations and some resistance if implementing them would mean change current practises. However, addressing these issues will be the goal of future research. Instead, here we comment on completeness and relevance of our requirements.

It is generally hard to have a complete list of requirements and our is not an exception. We know, for instance, that we overlooked technical requirements regarding *how* to implement transparency. We did so intentionally, since we aimed to identify the functional and not the technical features supporting transparency as a property. Even if we restrict the discussion to functional requirements it would be unrealistic claiming we are complete; but we think we have not missed any important requirement.

One can question that, while selecting our sources, we did not searched broadly enough. We searched for "transparency", "security" and "privacy", which we think are very general terms. In the incoming GDPR, transparency is

frequently related to security properties meant to give users feedback on their private data. So, for instance, even though we overlooked *accountability* or/and *auditability*, being them more specific than security, we indeed harvested works on those topics too. Despite, in medical systems, as we found in our phase 1 (§4), *privacy* is the property more likely to be related to with user-centric solutions.

One could also question that the best way to achieve completeness is to discuss with engineers working with medical systems and with health care professionals. We are considering this as a future work, at least within the network of the medical institutions we are in collaboration with. However, it must be reminded, the original list of 346 requirements that we "borrowed" from A4Cloud did emerge from a workshop where precisely those professional figures were asked for requirements also about transparency in the context of cloud computing. Moreover, we also extracted requirements from works debating patient-centric desirable features on medical systems (§4).

Besides, to build a list as complete as possible, we decided to add three meta requirements to our pool, exploring human aspects (usability), transversal security aspects (preserving privacy), and fairness aspects (knowledge of existence). They all capture better the spirit of transparency. We have thus indirect reason to believe that we have not missed much.

A similar argument gives us some guarantee about the relevance of our selection of requirements. However, although we chose carefully our sources, we cannot verify the relevance only by looking at the data we have. But, at least, if relevance is intended with respect to our definition of transparency (§3), we have some insurance because of our methodology: its selective and integrative steps were conceived to be compliant with that definition. However, if relevance is intended with respect to regulations, our methodology may not be sufficient to give full guarantee: it only gives best compliance with what we have found in the literature. But reaching legal compliance is a very difficult task in general, usually reached by compliance to standards; there are no standard yet for transparency. Even the incoming GDPR, which presents transparency as one of its driving principle for data protections, is not clear on the matter and, as far as we know, there is an alive discussion about how to be compliant to it. Our requirements constitute a reasoned first proposal that should be followed by discussions with health care specialists, patient associations and, regulators.

References

1. Aspects of privacy for electronic health records. *International Journal of Medical Informatics*, 80(2):e26 – e31, 2011. Special Issue: Security in Health Information Systems.
2. A. AL Faresi, D. Wijesekera, and K. Moidu. A Comprehensive Privacy-aware Authorization Framework Founded on HIPAA Privacy Rules. In *In Proc. of the 1st ACM International Health Informatics Symposium*, pages 637–646. ACM, 2010.
3. J. Benaloh, M. Chase, E. Horvitz, and K. Lauter. Patient Controlled Encryption: Ensuring Privacy of Electronic Medical Records. In *In Proc. of the 2009 ACM Workshop on Cloud Computing Security*, CCSW '09, pages 103–114. ACM, 2009.

4. D. Cruzes and M. Jaatun. D:b-2.4 requirements report deliverable, November 2014.
5. EU. Proposal for a Regulation of the European Parliament and of the Council on the protection of individuals with regard to the processing of personal data and on the free movement of such data (General Data Protection Regulation), 2012.
6. A. Ferreira and G. Lenzini. Can Transparency Enhancing Tools support patient's accessing Electronic Health Records? In *Proc. of the 3rd World Conference on Information Systems and Technologies*, 2015.
7. S. Fischer-Hübner, J. Angulo, and T. Pulls. How can Cloud Users be Supported in Deciding on, Tracking and Controlling How their Data are Used? In *Privacy and Identity Management for Emerging Services and Technologies*, volume 421 of *IFIP Advances in Information and Communication Technology*, pages 77–92. Springer Berlin Heidelberg, 2014.
8. Office for Civil Right of the Department of Health and USA Human Services. Privacy, Security, and Electronic Health Records, 2015.
9. R. Gajanayake, R. Iannella, and T. Sahama. Sharing with Care: An Information Accountability Perspective. *IEEE Internet Computing*, (4):31–38, July 2011.
10. K. W. Goodman, Berner E. S., Dente M. A., and *et al.*. Challenges in ethics, safety, best practices, and oversight regarding HIT vendors, their customers, and patients: a report of an AMIA special task force. *J. Am. Med. Inform. Assoc.*, 18(1):77–81, 2011.
11. H. Hedbom. A Survey on Transparency Tools for Enhancing Privacy. In *The Future of Identity in the Information Society*, volume 298 of *IFIP Advances in Information and Communication Technology*, pages 67–82. Springer Berlin Heidelberg, 2009.
12. N. Henke, T. Kelsey, and H. Whately. Transparency — the most powerful driver of health care improvement? *Health International*, pages 64–73, 2011.
13. J. Hu, H. Chen, and T. Hou. A hybrid public key infrastructure solution (HPKI) for HIPAA privacy/security regulations. *Computer Standards and Interfaces*, 32:274 – 280, 2010.
14. K. Kim, D. McGraw, L. Mamo, and L. Ohno-Machado. Development of a privacy and security policy framework for a multistate comparative effectiveness research network. *Medical Care*, 51:S66–S72, 2013.
15. N. Moe. D:b-2.1 workshop 1 results (requirements), March 2013.
16. F. Raizaebagha, K. T. Win, and W. Susilo. A systematic literature review on security and privacy of electronic health record systems: technical perspectives. *Health Information Management Journal*, 44(3), 2015.
17. L. Rostad. An initial model and a discussion of access control in patient controlled health records. In *In Proc. of the 3rd International Conference on Availability, Reliability and Security*, pages 935–942, March 2008.
18. P. Ruotsalainen, B. Blobel, P. Nyknen, A. Seppl, and H. Sorvari. Framework model and principles for trusted information sharing in pervasive health. *Studies in Health Technology and Informatics*, 169:497–501, 2011.
19. I. Señor and J. Fernández-Alemán. Security and privacy in electronic health records: A systematic literature review. *Journal of Biomedical Informatics*, 46(3):541–562, 2013.
20. O. Seneviratne and L. Kagal. Enabling privacy through transparency. In *Proc. of the 12th Annual International Conference on Privacy, Security and Trust*, pages 121–128, July 2014.
21. D. Spagnuelo and G. Lenzini. Security on medical data sharing (a literature review), March 2015. http://hdl.handle.net/10993/23241.
22. M. Turilli and L. Floridi. The ethics of information transparency. *Ethics and Information Technology*, 11(2):105–112, 2009.

A Web Platform of Serious Games for Cognitive Rehabilitation: Architecture and Usability Study

Rui Rocha[1], Paula Alexandra Rego[2,4], Brígida Mónica Faria[3,4,5], Luís Paulo Reis[1,4,6], and Pedro Miguel Moreira[2,4]

[1] DSI/EEUM - Departamento de Sistemas de Informação, Escola de Engenharia da Universidade do Minho, Guimarães, Portugal
[2] ESTG/IPVC - Escola Superior de Tecnologia e Gestão, Instituto Politécnico de Viana do Castelo, Viana do Castelo, Portugal
[3] ESTSP/IPP - Escola Superior de Tecnologia da Saúde do Porto, Instituto Politécnico do Porto, Gaia, Portugal
[4] LIACC - Laboratório de Inteligência Artificial e Ciência de Computadores, Porto, Portugal
[5] INESC-TEC - Instituto de Engenharia de Sistemas e Computadores, Tecnologia e Ciência, Porto, Portugal
[6] Centro ALGORITMI, Universidade do Minho, Guimarães, Portugal
gdrui_fafe@hotmail.com, paularego@estg.ipvc.pt, btf@estsp.ipp.pt, lpreis@dsi.uminho.pt, pmoreira@estg.ipvc.pt

Abstract. In recent years Serious Games have gained a new importance, very driven by the proliferation of video games and its application in diverse areas. Cognitive rehabilitation is a major area where Serious Games can assume a relevant role. Traditional cognitive therapies quickly become repetitive and discouraging for patients. To mitigate these problems, Serious Games based tools are necessary to create more dynamic rehabilitation processes, holding the attention of the patients throughout the process and motivating them during their road to recovery. This paper describes a web platform for Serious Games in cognitive rehabilitation that integrates a set of features that include natural and multimodal user interfaces and social features (collaboration, competition and handicapping) which can be used to augment the motivation of patients during the rehabilitation process. Results observed in a study with healthy subjects indicate that the platform offers good usability.

Keywords: Serious Games, Rehabilitation, Cognitive Rehabilitation, Natural User Interfaces, Games, Health Informatics.

1 Introduction

In recent years, Serious Games have gained a new importance, very driven by the proliferation of video games and its application in various fields such as military and health, among others. Although at present there is no single accepted definition of the term “Serious Games”, we use it when referring to computer games whose main purpose is the achievement of a specific goal, driven by the entertainment component and the game's ability to hold the attention of its user.

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_103

Cognitive rehabilitation is a major area where Serious Games assume a relevant role. Despite the literature review shows that Serious Games are most commonly used in physical rehabilitation therapy processes [1], several examples of serious games studies used for cognitive rehabilitation can be found. However, for most of these studies they are still prototypes in development or in testing phase [2-5].The main objective of cognitive rehabilitation is the improvement of cognitive skills affected as a result of suffered brain damage thus focuses mainly on returning patients to the maximum possible independence and the best possible functioning of their cognitive functions. These processes include cognitive faculties such as attention, concentration, memory, reasoning, problem solving, language and critical capacity, among others. Cognitive rehabilitation is used as a treatment for patients suffering from stroke [6] or brain injury. Just in the United States, every year 1.7 million people are victims of such injuries, mostly caused by falls (35.2%) and traffic accidents (17.3%) [7]. Thus, the cognitive rehabilitation processes are assumed to be fundamental in the lives and recovery of such patients.

Several studies on rehabilitation show that it is more effective when patients follow intensive training programs, oriented to the achievement of a goal and divided into specific tasks that require to be performed repetitively [8, 9]. It is noticed however that traditional cognitive therapies quickly become repetitive and discouraging for patients. On the other hand, highly motivated patients can perceive more easily that the therapy is the most important means for their recovery and try to play an active role throughout the rehabilitation process [10]. To mitigate these problems, Serious Games-based tools are necessary to create more dynamic rehabilitation processes, holding the attention of the patients throughout the process and motivating them during their road to recovery.

It is in this regard that Serious Games can play a key role in contributing to the increase of the motivational levels of patients, allowing a different perspective of the traditional processes of rehabilitation therapy. Thus, the introduction of Serious Games in these processes can help in motivating patients, increasing their interest in the exercises to perform. These games should then be defined taking into account characteristics that are able to stimulate and train cognitive functions as well as features that require some kind of motor activity in order to stimulate and attract the attention of patients [1, 11].

In a previous study we made a literature revision on Serious Games for cognitive rehabilitation and propose a set of features to be incorporated in the games [12]. Based on that, the main objective of this work is to describe a web platform for Serious Games in cognitive rehabilitation that integrates the proposed features.

The rest of the paper is structured as follows. Section 2 presents the importance of modalities of interaction in cognitive rehabilitation games and some of the main multimodal and natural interaction modalities present in these games. Following, section 3 describes the web platform for serious games, including the architecture and the integrated features. Section 4 describes the experiments with users and Section 5 presents results of user testing using the described architecture. Section 6 presents the major conclusions and some directions for future work.

2 Forms of Interaction

Many of the patients who use rehabilitation therapies in addition to cognitive difficulties, present various physical limitations [13, 14]. It is therefore essential to decrease the limitations of games with respect to usability and interaction with the use of user interfaces, as much natural as possible and according to a multimodal approach [15-18].

The multimodal term refers to the combination of multiple modalities, which in this particular case relates to the way the system receives its input / output [19]. Thus, the multimodal approach is a combination with more than one interaction technology, such as input or output [20] that should serve as facilitator of the interaction between humans and the computer [15]. A multimodal interface can incorporate different combinations of voice, gestures and facial expressions and other forms of interaction more conventional as mice and keyboards. The most common combination in the literature uses gestures and voice simultaneously [16]. In what concerns to the use of more natural forms of interaction, there is collaboration between different modes as a way of support in the signal recognition process. For example, capturing the lip movements can help in the speech recognition process [15]. Multimodal interfaces offer several advantages over more traditional user interfaces. Firstly they provide a more natural and friendly user experience. Similarly, a multimodal approach may be used in order to equip the system with redundancy which allows to open the use of the system to different people and in different circumstances [21].

Natural user interfaces are a type of interaction between humans and the machine based on the analysis of natural automatic behavior of humans. Human actions are interpreted by machines as commands that control system operations [22]. This means that humans are able to use the system with very little practice, since these behaviors are deeply rooted in their daily experiments, which reduces the cost of system use, and the time of learning and habituation to the system commands. These interfaces allow the user to interact with the system without being aware that it is using an intermediary interface, allowing in many cases this interaction to happen when there is no contact with any type of physical device [23]. The main objective of this approach is to interact with the computer the way we interact with the world [20]. To this end these interfaces are designed based on human behavior and using different interaction devices from traditional mice, keyboards or touch screens. This design allows for user interaction with the system through natural movements, which he performs in a daily basis, thus reducing the learning curve of the system controls, making it easier to handle and more intuitive [2, 23, 24]. The daily basis activities can be classified on basic (such as hygiene and personal care) and in instrumented activities of daily living (which include activities such as meal preparation, shopping, managing finances and housekeeping) [25].

Any physical limitation that these patients may have must be attenuated by a fusion between a multimodal approach and the use of natural user interfaces. Thus, the development of these games should include the use of technologies to encourage the use of the five human senses [26]. A multimodal natural approach enables a more flexible interactive environment, appealing, motivating and integrating through various interaction technologies. Relevant examples of the use of multimodal interfaces using the concept of an intelligent wheelchair can be found in [27-34].The

vision-based technologies are the most frequently identified in the literature. An overview of this type can be described as the interpretation of any human behavior that can be recognized as a visual signal [15]. Among the various existing technologies we highlight: the analysis of facial expressions [35], detection of body movements [36], gesture recognition [37] and tracking eye movement [38-40].

Several studies have been conducted on the use of these technologies in Serious Games. Conconi et al. (2008) [41] studied the applications of detection of movement and facial expression recognition, Flynn et al. (2007) [42] worked with tracking technologies of eye movements, Moussa et al. (2009) [35] tested the voice recognition while Saposnik and colleagues (2010) [43] conducted experiments with motion detection. Large companies of video games are increasingly focusing on these forms of interaction and these are increasing on the market. The Microsoft Kinect [44], the Nintendo Wii [45] and the Sony PlayStation Move [46], are just some of the devices most commonly commercially available.

3 Rehab+: A Web Platform of Serious Games for Cognitive Rehabilitation

A Web platform comprising a set of games adapted for use in cognitive rehabilitation has been developed. In this section we describe the development process of this solution - the platform Rehab+, the games that are part of it, the technologies used in its creation and the tests carried out in the validation.

3.1 Solution Architecture

The first step in the development of Rehab+ consists in defining features to be included in each of the games developed. It was decided that each game should contain rehabilitative features capable of stimulating at least one cognitive function, as well as some of the features proposed in this research as a way to improve the motivation of patients in relation to the rehabilitation process (use of natural interaction interfaces, social features as competition and collaboration, and handicapping).

The implementation of rehabilitation characteristics is a complex task. Not only because it depends on the limitations of each patient but because its design must be made effective by a multidisciplinary team composed of professionals from various fields such as physicians, psychologists and therapists, among others. In this work, it was decided to develop the games of the Rehab+ platform with similar rehabilitative features to an existing and established set of rehabilitation games, and then provide the Rehab+ games with the features proposed in our investigation.

In order to verify the existence of different reactions of individuals when faced with games that provide the proposed features, and other games that do not offer them, we decide to develop a game that does not provide any of the proposed features, and another version of the same game that includes some of the features proposed.

The Rehab+ platform houses all the games developed during this work, providing the solution that integrates all of the games in one place. This platform groups the games in two categories: single player and multiplayer. Figure 1 presents the architecture diagram of the Rehab+ platform, providing an overview of the integration of the proposed features in several developed games. Eight games were developed: memory, sorting, arithmetic and "noughts and crosses" (or Tic-Tac-Toe game).

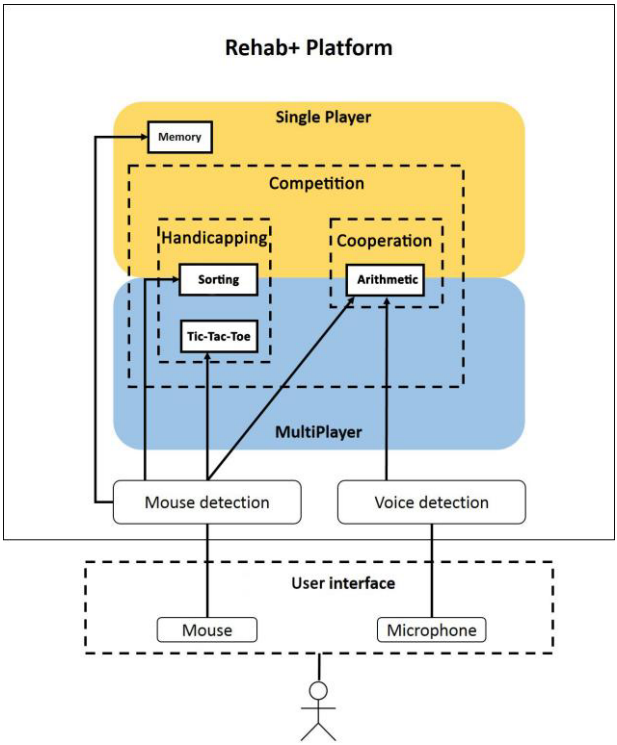


Fig. 1. Architecture Diagram of the Rehab+ Game Platform.

The memory game does not include any of the proposed features and is only available in single player mode. The sorting game, available in single player and multiplayer, covers competitive features and a handicapping system. The arithmetic game is available both in single player, and in multiplayer version, the later version being based on cooperative features, and the single player version also has the possibility of interaction using voice recognition. In the "noughts and crosses" game it was implemented a handicapping system. All the games have interaction via mouse.

3.2 Integrated features

In this investigation several innovative features were proposed whose main objective is to increase the motivation of patients during the rehabilitation process. These features were designed to make games more motivating, attractive and easy to

interact, by using a natural interaction interface and social characteristics, in particular: the competition, cooperation and the concept of handicapping. In the games developed for this research we tried to incorporate in the best possible way, the proposed features to meet the initial objectives. And as such, these games include all the features proposed. The games developed follow a competition and collaboration approach, and include a natural user interface to control the game (in this case, using voice commands). It was also implemented a handicapping system in two games.

User interface. All games developed enable interaction via a mouse or via a touch screen, if they are used in mobile devices. The use of this type of games should foresee possible motor difficulties for users. In this sense, it was included in one of the games that was developed an alternative mode of interaction. Through the use of a JavaScript library and the Google Chrome browser it is possible for users to interact with the game through voice commands, thus adapting the game to different profiles of users with varying abilities and difficulties/limitations. This form of interaction also requires the use of a microphone. In this work various types of microphones were tested, and similar results have been obtained. This type of natural user interface also allows users to interact with the system without the need to use an external device to the computer, since the built-in microphone on most laptops is sufficient to ensure a stable interaction. The major limitation of this user interface relates to its use in environments with a lot of background noise, making it difficult a correct detection of the necessary voice commands. In addition, it requires the use of a browser that allows voice interaction, which limits the choices for users and may require the installation of specific software. However, of the most used browsers on the market, Google Chrome is the only one to allow this type of interaction, and is also at the date of writing this document, the most used in the world [47]. Also to attenuate this obligation for using the Google Chrome browser is the fact that all the various existing browsers currently have a very similar operation, which does not require a major effort for learning and getting used to it.

Cooperation. Cooperation characteristics are part of a social approach to this kind of games, which aims to promote increased interaction between patients. Our proposed hypothesis is that this type of features enables patients to increase their motivational levels in relation to games and the rehabilitation process, from the companionship of their peers that are using the same games they too use. In this particular case, it is expected that, due the fact that patients are playing as a team, they will interact more, communicate more with their peers and create social bonds with their teammates, trying to avoid their isolation. These features were incorporated into the arithmetic game and were designed so that each user has a role in the completion of the task. Thus, each user plays a specific role to be played so that both can attain success as a team.

Competition and Handicapping. A competitive game approach exploits similar concepts to those of collaboration, in the extent that is expected that patients will be motivated by sharing their experience with their peers. The characteristics of competition assume that two users are confronted for reaching the best individual

result, not acting as a team but as opponents. It is therefore important to address the disparity difficulties of several patients. Different patients can have different problems and different types of limitations, and therefore when they confront themselves in these conditions, it is complicated, unfair and not motivating for them, which would prove to be contradictory to our purpose of the inclusion of these features. Thus, the concept of handicapping can be used in these situations since it seeks to equalize opportunities to win for each user.

4 User Testing

The tests described here were designed primarily to evaluate the usability and attractiveness of the games, to see if they are easy to play and interact, if it is easy to understand what is asked in each of them, if users like the games and if these are appealing. The user tests counted on a total sample of 58 subjects, 36 took part in the online test and 22 participated in tests in the classroom. An initial pre-test was done in classroom, with nine subjects in order to finalize the details of the tests and games. After this pre-test, some errors detected in the games were corrected.

It was developed a questionnaire that was applied to all subjects who participated in the test. In this questionnaire questions regarding multiplayer experiences were drawn for the participants online. The questionnaire has an initial section which aims to make a characterization of the sample (age, sex, and education, among others). Also it uses two validated instruments, commonly used in testing computer games: IMI (Intrinsic Motivation Inventory) and SUS (System Usability Scale). In the end, the questionnaire includes some questions that specifically address a comparison between the games modes and forms of interaction and an open response space to collect any comments that users want to express.

IMI is a multidimensional assessment tool that evaluates the subjective experiences of the participants in relation to the activity they experienced which, in this case, is in relation to all the gaming experience of activity and interaction with the Rehab+ platform. We adapted this instrument in order to use only one of their ranges, specifically the scale that measures the interest / satisfaction of the subjects in relation to the whole experience. The SUS is an instrument composed of 10 questions used to assess the usability of various products and services, hardware, software, among others. The questions in this instrument have been adapted to refer to the whole experience of interaction with the Rehab+ platform and the games that are part of it.

The tests were performed according to two different approaches: in classroom and online. The online tests contemplated only games in single player version, since it is impossible to control whether users actually played the games with other users or not, and also because for these games it is required a specific software for allowing the use of simultaneously two independent mice in the same computer. In this approach, each of the games has a small description that clarifies about the goal and the rules of the game and how to play it. In the tests realized in the classroom, subjects started to play alone all single player games, and then were grouped in pairs to test the multiplayer games. The tests began with a short explanation of the research and about the purpose of these games. Then each subject read and signed an informed consent, which

contained all the information regarding the research and testing in which they would participate. In what concerns the arithmetic game it was not defined any specific order for testing the two modes of interaction, which resulted in some participants experiencing first the interaction via mouse and others via voice commands.

In relation to the multiplayer version of the sorting game, all subjects experienced first the normal version and then the version with handicapping. It was not explained to the subjects nothing about the handicapping system before they played the games. In the questionnaire, all subjects were asked about the handicapping system, and if they noticed its existence during the game and all answered they did not notice.

It was shown for each subject how to interact with each game, and each one played the games during about 15-20 minutes before completing this questionnaire.

5 Results and Discussion

The questionnaires were analyzed using the IBM SPSS Statistics software, in which were inserted all the answers and the statistical analysis was performed.

The SUS questionnaire was used to evaluate the usability of the whole platform. There were significant differences ($P = 0.046 < 0.05$) with respect to age (<30 years, >30 years) of users, and the values of the questionnaire were significantly higher in participants with more than 30 years (39.78 vs. 27.61).

It was used in this research one scale of the IMI questionnaire, to assess the interest and satisfaction of individuals in relation to all the contact they had with the Rehab+ platform. The total result (86%) shows that users were satisfied with the platform and that it sparks their interest. Most users answered that they would like to use this platform often (74.2%) and 94.8% answered they liked to participate in this activity and that it was fun. The SUS instrument is quoted from 0 to 100. A score below 70 means that the system presents usability problems and more than 71.4 classifies the system as having good usability [48]. The results observed in this study (73.79) indicate that the platform has a positive assessment in relation to its usability. More specifically, it can be stated that the platform offers good usability.

6 Conclusions

We developed a web platform of Serious Games for cognitive rehabilitation that integrates social features (competition, cooperation and handicapping) and user interaction via mouse and voice commands. Some of the games can be played in multiplayer versions of two users. All versions can be played using the mouse and one version can use voice commands. The usability of the platform was evaluated resulting in a positive assessment. Tests were carried out on a sample of healthy subjects and without significant limitations. For future work we intend to validate these games in a population with limitations, either physical or cognitive, and to participate effectively in a cognitive therapy process where we can assess the virtues of these games as well as natural interaction interfaces, such as voice, used here, which can show to be more useful and functional to someone with motor difficulties.

Acknowledgments

This work has been supported by FCT - Fundação para a Ciência e Tecnologia in the scope of the projects: PEst-UID/CEC/00319/2015 and PEst-UID/CEC/00027/2015. The authors would like to thank also all the volunteers that participated in the study.

References

1. Rego, P., Moreira, P.M., Reis, L.P.: Serious Games for Rehabilitation: A Survey and a Classification towards a Taxonomy. 5th Iberian Conference on Information Systems and Technologies, vol. I, pp. 349-354, Santiago de Compostela, Spain (2010)
2. Rego, P.A., Moreira, P.M., Reis, L.P.: New Forms of Interaction in Serious Games for Rehabilitation. In: Cruz-Cunha, M.M. (ed.) Handbook of Research on Serious Games as Educational, Business, and Research Tools: Development and Design. IGI Global (2012)
3. Rego, P.A., Moreira, P.M., Reis, L.P.: A Serious Games Framework for Health Rehabilitation. International Journal of Healthcare Information Systems and Informatics (IJHISI) 9, 1-21 (2014)
4. Rego, P.A., Moreira, P.M., Reis, L.P.: Architecture for Serious Games in Health Rehabilitation. In: Rocha, Á., Correia, A.M., Tan, F.B., Stroetmann, K.A. (eds.) New Perspectives in Information Systems and Technologies, Volume 2, vol. 276, pp. 307-317. Springer International Publishing (2014)
5. Mendes, L., Dores, A.R., Rego, P.A., Moreira, P.M., Barbosa, F., Reis, L.P., Viana, J., Coelho, A., Sousa, A.: Virtual centre for the rehabilitation of road accident victims (VICERAVI). In: A.Rocha, J.C.-M., L.P. Reis, M.P.Cota,I (ed.) 7th Iberian Conference on Information Systems and Technologies (CISTI 2012), vol. I, pp. 817-822. AISTI, Madrid, Spain (2012)
6. Warlow, C.P., Gijn, J.v., Dennis, M.S., Wardlaw, J.M., Bamford, J.M., Hankey, G.J., Page, J.H., Sandercock, P.A.G., Rinkel, G., Langhorne, P., Sudlow, C., Rothwell, P.: Stroke: Practical Management. Blackwell Publishing (2008)
7. Faul, M., Xu, L., Wald, M., Coronado, G.: Traumatic Brain Injury in the United States: Emergency Department Visits, Hospitalizations and Deaths 2002–2006. Centers for Disease Control and Prevention, National Center for Injury Prevention and Control, Atlanta (GA) (2010)
8. Burke, J.W., McNeill, M.D.J., Charles, D.K., Morrow, P.J., Crosbie, J.H., McDonough, S.M.: Optimising engagement for stroke rehabilitation using serious games. The Visual Computer 25, 1085-1099 (2009)
9. Burke, J.W., McNeill, M.D.J., Charles, D.K., Morrow, P.J., Crosbie, J.H., McDonough, S.M.: Augmented Reality Games for Upper-Limb Stroke Rehabilitation. In: 2010 Second International Conference on Games and Virtual Worlds for Serious Applications (VS-GAMES), pp. 75-78. (2010)
10. Maclean, N., Pound, P., Wolfe, C., Rudd, A.: Qualitative analysis of stroke patients' motivation for rehabilitation. British Medical Journal 321, 1051-1054 (2000)
11. Krichevets, A.N., Sirotkina, E.B., Yevsevicheva, I.V., Zeldin, L.M.: Computer games as a means of movement rehabilitation. Disability and Rehabilitation 17, 100-105 (1995)
12. Rocha, R., Reis, L.P., Rego, P.A., Moreira, P.M.: Serious games for cognitive rehabilitation: Forms of interaction and social dimension. In: 2015 10th Iberian Conference on Information Systems and Technologies (CISTI) pp. 1-6. (2015)

13. Alankus, G., Lazar, A., May, M., Kelleher, C.: Towards customizable games for stroke rehabilitation. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 2113-2122. ACM, Atlanta, Georgia, USA (2010)
14. Ma, M., Bechkoum, K.: Serious Games for Movement Therapy after Stroke. IEEE International Conference on Systems, Man and Cybernetics, pp. 1872-1877, Suntec Singapore, International Convention & Exhibition Center (2008)
15. Karray, F., Alemzadeh, M., Saleh, J.A., Arab, M.N.: Human-Computer Interaction: Overview on State of the Art. International Journal on Smart Sensing and Intelligent Systems 1, 137-159 (2008)
16. Oviatt, S.: Multimodal interfaces. In: Julie, A.J., Andrew, S. (eds.) The human-computer interaction handbook, pp. 286-304. L. Erlbaum Associates Inc. (2003)
17. Rego, P.A., Moreira, P.M., Reis, L.P.: Natural User Interfaces in Serious Games for Rehabilitation: a Prototype and Playability Study. In: Rocha, Á., Gonçalves, R., Cota, M.P., Reis, L.P. (eds.) First Iberian Workshop on Serious Games and Meaningful Play (SGaMePlay'2011) - Proceedings of the 6th Iberian Conference on Information Systems and Technologies, vol. I, pp. 229-232, Chaves, Portugal (2011)
18. Rego, P.A., Moreira, P.M., Reis, L.P.: Natural and Multimodal User Interfaces in Serious Games for Health Rehabilitation. In: MASH'14: Multi-Agent Systems for Healthcare / AAMAS'14 - 13th International Conference on Autonomous Agents and Multiagent Systems. IFAMAAS, (2014)
19. Jaimes, A., Sebe, N.: Multimodal human-computer interaction: A survey. Computer Vision and Image Understanding 108, 116-134 (2007)
20. Jain, J., Lund, A., Wixon, D.: The future of natural user interfaces. CHI '11 Extended Abstracts on Human Factors in Computing Systems, pp. 211-214. ACM, Vancouver, BC, Canada (2011)
21. Faria, B.M., Reis, L.P., Lau, N., Soares, J.C., Vasconcelos, S.: Patient Classification and Automatic Configuration of an Intelligent Wheelchair. In: Filipe, J., Fred, A. (eds.) Agents and Artificial Intelligence, vol. 358, pp. 268-282. Springer Berlin Heidelberg (2013)
22. Ogiela, M.R., Hachaj, T.: Natural User Interfaces in Medical Image Analysis: Cognitive Analysis of Brain and Carotid Artery Images Springer International Publishing, Switzerland (2014)
23. Steinberg, G.: Natural user interfaces. ACM SIGCHI Conference on Human Factors in Computing Systems, Austin, Texas, USA (2012)
24. Blake, J.: The natural user interface revolution. Natural User Interfaces in .NET, pp. 4-35. Manning (2010)
25. Spector, W.D., Katz, S., Murphy, J.B., Fulton, J.P.: The hierarchical relationship between activities of daily living and instrumental activities of daily living. Journal of Chronic Diseases 40, 481-489 (1987)
26. Caschera, M.C., Ferri, F., Grifoni, P.: Multimodal interaction systems: information and time features. International Journal of Web and Grid Services 3, 82-99 (2007)
27. Faria, B.M., Reis, L.P., Lau, N., Moreira, A.P., Petry, M., Ferreira, L.M.: Intelligent Wheelchair Driving: Bridging the Gap Between Virtual and Real Intelligent Wheelchairs. In: Pereira, F., Machado, P., Costa, E., Cardoso, A. (eds.) Progress in Artificial Intelligence, vol. 9273, pp. 445-456. Springer International Publishing (2015)
28. Faria, B.M., Reis, L.P., Lau, N.: A Methodology for Creating an Adapted Command Language for Driving an Intelligent Wheelchair. J Intell Robot Syst 80, (2015)
29. Faria, B., Reis, L., Lau, N.: Adapted Control Methods for Cerebral Palsy Users of an Intelligent Wheelchair. J Intell Robot Syst 77, 299-312 (2015)
30. Reis, L., Faria, B., Vasconcelos, S., Lau, N.: Invited Paper: Multimodal Interface for an Intelligent Wheelchair. In: Ferrier, J.-L., Gusikhin, O., Madani, K., Sasiadek, J. (eds.) Informatics in Control, Automation and Robotics, vol. 325, pp. 1-34. Springer International Publishing (2015)

31. Faria, B.M., Silva, A., Faias, J., Reis, L.P., Lau, N.: Intelligent Wheelchair Driving: A Comparative Study of Cerebral Palsy Adults with Distinct Boccia Experience. In: Rocha, Á., Correia, A.M., Tan, F.B., Stroetmann, K.A. (eds.) New Perspectives in Information Systems and Technologies, Volume 2, vol. 276, pp. 329-340. Springer International Publishing (2014)
32. Faria, B.M., Vasconcelos, S., Reis, L.P.: Evaluation of Distinct Input Methods of an Intelligent Wheelchair in Simulated and Real Environments: A Performance and Usability Study. Assistive Technology: The Official Journal of RESNA 25, 88-98 (2013)
33. Faria, B., Reis, L., Teixeira, S., Faias, J., Lau, N.: Intelligent Wheelchair Simulator for Users' Training Cerebral Palsy Children's Case Study. In: 8th Iberian Conference on Information Systems and Technologies (CISTI). (2013)
34. Faria, B.M., Vasconcelos, S., Reis, L.P., Lau, N.: A Methodology for Creating Intelligent Wheelchair Users' Profiles. In: ICAART 2012 – 4th International Conference on Agents and Artificial Intelligence, pp. 171-179. (2012)
35. Moussa, M.B., Magnenat-Thalmann, N.: Applying affect recognition in serious games: The playmancer project. In: Egges, A., Geraerts, R., Overmars, M. (eds.) Motion in Games, pp. 53-62. Springer (2009)
36. Gerling, K., Livingston, I., Nacke, L., Mandryk, R.: Full-body motion-based game interaction for older adults. Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, pp. 1873-1882. ACM, Austin, Texas, USA (2012)
37. Chang, Y.-J., Chen, S.-F., Chuang, A.-F.: A gesture recognition system to transition autonomously through vocational tasks for individuals with cognitive impairments. Research in Developmental Disabilities 32, 2064-2068 (2011)
38. Ciger, J., Herbeliny, B., Thalmannz, D.: Evaluation of Gaze Tracking Technology for Social Interaction in Virtual Environments. In: Proceedings of the 2nd Workshop on Modeling and Motion Capture Techniques for Virtual Environments (CAPTECH04). (2004)
39. Jacob, R.J.K., Karn, K.S.: Eye Tracking in Human-Computer Interaction and Usability Research: Ready to Deliver the Promises. The Mind's eye: Cognitive The Mind's Eye: Cognitive and Applied Aspects of Eye Movement Research 573-603 (2003)
40. Mohamed, A.O., Silva, M.P.D., Courboulay, V.: A history of eye gaze tracking. Technical report, (2008)
41. Conconi, A., Ganchev, T., Kocsis, O., Papadopoulos, G., Fernandez-Aranda, F., Jimenez-Murcia, S.: PlayMancer: A Serious Gaming 3D Environment. In: International Conference on Automated solutions for Cross Media Content and Multi-channel Distribution (AXMEDIS '08). pp. 111-117. Institute of Electrical and Electronics Engineers (IEEE) (2008)
42. Flynn, S., Palma, P., Bender, A.: Feasibility of using the Sony PlayStation 2 gaming platform for an individual poststroke: a case report. Journal of Neurologic Physical Therapy 31, 180-189 (2007)
43. Saposnik, G., Teasell, R., Mamdani, M., Hall, J., McIlroy, W., Cheung, D., Thorpe, K., Cohen, L., Bayley, M.: Effectiveness of virtual reality using Wii gaming technology in stroke rehabilitation: a pilot randomized clinical trial and proof of principle. Stroke 41, 1477-1484 (2010)
44. Microsoft: Kinect for the Xbox 360. Available: http://www.xbox.com/en-US/kinect (2014)
45. Nintendo: Wii Console. Available: http://www.nintendo.com/wii/console (2014)
46. Sony: PlayStation Move. Available: http://pt.playstation.com/psmove/ (2014)
47. StatCounter: Página web de análise de serviços. Available http://gs.statcounter.com/#browser-ww-monthly-201409-201509-bar (2015)
48. Bangor, A., Kortum, P., Miller, J.: Determining what individual SUS scores mean: adding an adjective rating scale. J. Usability Studies 4, 114-123 (2009)

Blind Students' Learning Experiences – Challenges and Opportunities in Design for Inclusion

Graziela Sombrio[1], Lane Primo[1], Vânia Ulbricht[1], Vilma Villarouco[2]

[1]Universidade Federal de Santa Catarina, UFSC,
Programa de Pós Graduação em Engenharia e Gestão do Conhecimento – PPEGC/UFSC
Campus Universitário - Trindade
88.040-970 - Florianópolis, SC – Brasil,
[2]Universidade Federal de Pernambuco – UFPE
Programa de Pós Graduação em Design
{graziela.sombrio, lanepprimo, vrulbricht}@gmail.com, villarouco@hotmail.com

Abstract. This paper presents the results of a systematic review of the literature to identify how human-computer interaction (HCI) contributes for learning experience of blind students. The motivation for this study arises from the growth of the participation of students with disabilities in distance learning courses, the projection of increased development of learning objects and multimedia for use in these courses, therefore, requiring care for accessibility. The information gathered reveal thoughts about student's experience and have resulted in recommendations and proposals with a view to enhancing inclusion.

Keywords: Blind. Learning Experiences. Instructional Design. Human-Computer Interaction. Systematic review.

1 Introduction

Instituto Brasileiro de Geografia e Estatística (IBGE in Portuguese) 2010 demographic census shows that 23,9% of the Brazilian population has some sort of disability, which corresponds to around 45,6 million people and 35 millions of them are visually impaired [1].

In order to guarantee access to people with disability the same rights as the rest of the population, it is necessary to consider the recent technological advances. Under such perspective, the Human Computer Interaction (HCI) allows users with disability new experiences, including in Education.

In such context, Long Distance Education growing projections must be taken into consideration. In a survey carried by Brazilian Association for Distance Learning (ABED, in Portuguese) among 247 institutions 22% informed they intended, back in 2014, to invest in courses design and content production, such as videos, learning objects, games and others. This investment comes from the fact they identified a growing number of students with disability on their courses. To provide accessibility for those students, the institutions implemented changes in their materials, educational resources, learning objects and in their Virtual Learning Environment (AVA, in

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_104

Portuguese). Among the changes in the AVA are translations into Braille and into Brazilian Sign Language (LIBRAS, in Portuguese), access through keyboard, insertion of sub-titles [2].

In regard to Educational Technologies, the new interfaces are result of the objective to enhance interaction. Together with the use of media, technologies have a very important role in the teaching and learning processes. However, when the user has some type of disability, blindness, for instance, what was supposed to be a helpful tool can turn into a hindrance. When properly adapted and when used according to the existing recommendations, those tools facilitate the teaching and learning processes and also the peers interaction.

Accessibility must be considered along all the project phases, and according to [3], the e-learning accessibility systems must be focused on the students and meet their specific needs, according to their profile, knowledge and experiences.

Given these possibilities, the research problem arises: how HCI can contribute to blind people´s learning experiences?

This essay presents the results of a systematic review of the literature made in order to answer that question, from its outcomes presents recommendations and proposals for interaction design and instructional design roles in blind students´ learning development.

2 Methodology

Aiming to understand the state of art in regard to the HCI contribution to blind people education, it was made a systematic review of Scopus and Web of Knowledge database literature. Previous search was made using key-words *visually impaired*, *low vision*, *blind* combined with "*human-computer interaction*", *education*, *distance education*, *e-learning* and others. The search which listed the best results related to the question was made using *blind AND "human-computer interaction" AND education* key-words. As a result, 34 publications were found.

In the next phase, the search was through the titles of the essays. The repeated ones, those not available and those which did not bring any contribution to the objective of this essay were all discarded. It was considered different fields such as Psychology, Social sciences and others related with Education and HCI. In the end, 21 essays remained. Due to the fact that the technological changes are emerging, it was decided to study only the essays published from 2010 onwards. Therefore, eight essays remained for this research.

Other works were included given they were recently published and helped the research development. In the end, a wide picture of HCI contribution to blind people´s education was designed.

3 Results

The above mentioned works are inscribed in Computer Science field. Among those works, only one is from Brazil. On the next paragraphs, the results of the systematic

review which aims to answer "How human-computer interaction (HCI) can contribute to blind people´s learning experiences?" it will be presented.

From the analysis of the works came out the topics, which were in turn divided into categories, in order to find the points that would contribute to the study. The most cited key-words by the selected works' authors were: *human computer interaction, blind, assistive technology, visual deficiency* and *haptic system.*

Aiming to reflect upon Interaction Design and Instructional Design, experiences, audience profile, used technologies and how they were used, with the purpose to create a base for discussion were mapped. Table 1 presents blind people´s experience with education mediated by technologies.

Table 1. Blind people´s experience in education mediated by technologies.

Experience	Audience
Browsing and content search	Blind people from 18 to 74 years old [4]
Multimodal game	Blind and partially sight impaired children in Children Education [5]
New spaces recognitions and exploration	Blind people between 41 to 53 years old [6]
	Sight impaired and blind people between 19 and 36 years old [7]
Browsing and exploration of Virtual Learning Environment (AVA) in didactical situation	High school blind students (History) [8]
	Blind adults (Chemistry) [9]
	Congenital blind students between 14 to 17 years old and 14 years old with low vision impairment (Geometry) [10]
Multimodal exploration maps	Students and adults [11]

Source: elaborated by the authors

Table 2 lists the applied technologies and how they were used on the learning experience.

Table 2. Technologies and their application on blind people´s educational experience

Technologies	Application
Structured podcast [4]	Activities and learning material instructions
Multimodal game, including tactile and audio module [5]	Tactile sensorial approach (pieces on wood corresponding to the computer keyboard) and hearing approach (instructions through voice)
Sonorous and haptic interface [6] [11] [9]	Representation and recognition
Sensorial substitution device [9]	Recognition of real and virtual spaces. User receives sonorous signals when an obstacle gets closer.
Haptic (tactile) device for recognition of 3D objects [10]	Recognition of virtual objects

Source: elaborated by the authors

It was noticed the multimodal interfaces are present on the selected works. They are intended to allow the users complex experiences by offering information in

different modalities (tactile, sight, sound, speech)[12], which can be identified in the next paragraphs.

[4] presents podcasts as a possible tool to be used in education. They were used to guide on the learning virtual environment and as access as alternative media to learning materials. Its main feature is to get adapted to its users´ necessities and habits and also to facilitate learning at any time, any place and any pace. According to the authors, studies have shown the efficiency of podcast in education, given many students learn better by listening rather than by reading.

[4]´s conclusion after realizing a survey with users - mostly blind people and the rest with sight impairment - is that all of them prefer to listen to short structured podcasts instead of a long audio file. This is due to the fact that podcasts are simpler to be accessed, the titles on the sections make easier to search, among other factors that facilitate the user´s accessibility.

Application of sound and haptic interfaces applications are present on the works of [6], [11] and [9]. [6] created a virtual environment called BlindAid, which allows blind people do learn more easily by themselves on new environments. There are haptic devices that allow manual interactions with a virtual environment, which can be used in several fields of knowledge. According to the authors, the best succeed devices are those that simulate the virtual world through some kind of a handle similar to a cane exploring the real world. The BlindAid maps system to blind people consists of a software in a computer equipped with a haptic device and stereo headphone. [11]´s work discuss the user´s requisites to use accessible visual maps. The map´s design needs to meet three types of application: orientation and movement, exploration and localization of points of interest, and educational purposes – study of Geography, geometric forms and figures. The authors propose a multimodal user interface which contemplate the touch, gestures for choosing and the user´s actions; vibration to sign the system events, audio through sonorous signals for tips, or system situation and voice messages that can complement the visual information.

Multimodality is also a feature in educational games [5]. Lugram game was developed for children to have an initial contact with Geometry in a ludic manner. Along its development, during the prototype tests, voice commands and haptic devices were added to allow blind and sight disabled children to perform tasks,. Instead of a mouse, it was used a numerical keyboard and its keys corresponded to geometrical figures in several positions (squares, triangles and rectangles). These could be applied on the screen in a 3 lines and 3 columns matrix to form a drawing/picture. The blind players could get orientation from the sounds and voice messages to solve the proposed task. A haptic model made on wood was used to familiarize the players who did not have any experience with computer, so they could make the correlation between the haptic game and the numerical keyboard keys.

Virtual environments were discussed by [8], [9] and [7]. Based on WAI and W3C, [8] made a comparative analysis between two virtual learning environments (AVAs) in regard to their accessibility to blind users. It was found in those AVAs that their graphic structure interfaces were elaborated following the organization logic with accessibility resources, which explained the blind students´ difficulty to browse and explore the AVA. [9] presented the result of *Listening to Complexity* (L2C) experiment. It is a learning environment assisted by computer for blind students that uses the representation based on sounds to simulate a chemistry system. The

mediations based in sound give information in real time about an object´s speed, localization and interaction with other objects. The authors related that the blind participants showed improved conceptual scientific knowledge, improved reasoning system, perception of speed and of representations of elements. Among the advantages, for allowing visual and sounds representations, it can be used by people with normal sight and blind people in a collaborative learning processes.

In regard to environment, according to [7], when transferring information from real environment to virtual world, it is possible to create facilities for users, including those with sight problems. As example it is mentioned Google Street-View, that allows its users to know an environment even before visiting it. The authors understand that it is much safer for a blind person to learn how to navigate through a virtual world before going into the real one. The work analyses the use of a sensorial substitution device, a virtual white cane (*EyeCane)*, which when detects an obstacle bigger than 5 metres produces a sound. The closer the obstacle the more frequent is the sound. As result, it shows that the simple sonorous feedback is enough to allow blind people to perform tasks which before was not possible, and together with other tools can make their lives a little bit easier.

In regard to devices, [10]´s work is about haptic assistive technology for 3D virtual objects recognition, used to recognize basic three-dimensional objects in the field of Geometry. The authors had the participation of different partners (teachers, parents, blind and not blind students), who helped in the design and development of the educational environment. Falcon console was used to allow blind users to interact with virtual environment through the sense of touch on the educational game known as *Haptic-Audio Learning Environment (iHALE)*.

Despite several positive aspects present on the works, there are points to be put into equation, namely: resources available in few idioms [5], no generic tools for accessibility [7], virtual environments are not accessible to visual PCDs [7]; screen readers do not read images, graphics and tables [7]; incomplete or non-existent information causing confusion and disorientation [7]; sensory substitution devices require long time training [7]; disorientation when there are too many elements on the screen [9]; technologies cost is high [11]; maps and figures are not available for haptic format [11].

The authors´ contributions show the potentialities the technologies can bring to the student´s learning experience. They also represent challenges to be faced by interaction and instructional designers and their teams when developing projects aimed at inclusion.

4 Accessible Interaction Design and Instructional Design – Inclusion Opportunities

The selected works addressed several topics that can be unfolded within human-computer interaction field. For this essay, the cutoff point is related to some aspects about the development of accessible interaction and instructional design projects focused on blind students experience, taking as starting point the weaknesses

presented and also focusing on the multimodal characteristics mentioned sometimes as an strategy and sometimes as an attribute of the tool in [6], [11], [5], [9], [7], [10].

4.1 Concept of Experience in Interaction Design and in Instructional Design

Interaction and Instructional Design projects have their own development methodology. In order accessible projects succeed it is necessary to understand the different processes, as well as the experiences and their approach on the contexts of Interaction Design and Instructional Design.

[12, p.8] define Interaction Design as "projecting interactive products to support the way people communicate and interact in their daily lives, be it at home or at work". The focus is on how to create experiences for the user that go beyond the human-computer interaction. Among the user´s experience aspects to be taken into consideration when designing a product or service are usability, functionality, aesthetic, content, *look and feel* and emotional and sensorial appeals. In the present study, the product is educational, involving a course project and its by-products: learning objects, digital resources, educational materials, among others.

A Interaction Design project is made of the following phases: (1) mapping the requisites for the user´s experience; (2) projection of alternatives to meet the requisites; (3) prototipation of alternative designs which will be communicated and evaluated; (4) evaluation of the experience in the process [12]. In Instructional Design, for the development of a project one of the most used models is ADDIE - Analysis, Design, Development, Implementation and Evaluation [13]. It is understood that during both processes there are aspects and requisites involving human-computer interaction to be taken into consideration in regard to PCDs inclusions.

About the *experience* in Instructional Design, [13] sustains that it is only possible to provide a significant learning experience when educational solution is interactive, which means, when there is an interface that makes interaction possible. In other words, to make possible activities that demand the student´s interaction with contents, tools and other people. According to the author, interaction is related to "people´s behavior in relation to other people and to the systems" [13, p. 107]. When explaining about the interaction with the contents, the author states instructional conversation is the type of communication which presents the reasons, evidences, arguments and justifications to help students during the learning process. Instructional conversation, according to the author, has its proper language for each domain of knowledge and it must be addressed properly within the multimedia digital contents. At this point, attention must focused on accessibility to make sure it will contribute to blind students´ learning experience.

4.2 Blind Students´ Learning Aspects

To understand which challenges disabled students have to face and what helps them to learn can help when choosing media and technologies to be used when elaborating mediated learning situations. This way it is possible to enhance learning in *in loco* and in distance studies.

Visually impaired students use sound and haptic resources to interact with the world. That is why they use the other senses more often. Sensory information help students to build a mental representation of space, people and objects with which and whom they interact with. On Table 3, it is shown the sensory relation, the captured information and in what it can help the student´s interaction with the world:

Table 3. Senses and information captured by a person with visual deficiency

Sense used	Captured information	Help
Tactile	Access to reading and Braille writing; Tactile aesthetic: texture, form and size.	composition of analytical form
Hearing	Environment sound and speechs	space representation and recognition of what is transmitted to the out world
Smell and palate	People and environment odours and aromas; Tastes	Recognition of personal references and social ties

Source: elaborated by the authors, adapted from [14]

Tactile and sonorous stimuli widen the students´ interaction with the contents to be studied. It is important to pass on information that maps the characteristics, routes, space and actions to be performed to make possible for these students to bond and have references in order to act autonomously and independently. To study using a PC, tablet or smart phone, the visual disabled student can use assistive technologies, like amplifiers, screen reader, depending on the disability. However, not all virtual environments are prepared for the screen readers to reproduce the texts using voice. This requires the instructional and interaction designers and developers to come up with alternatives that make available equivalent contents or alternative contents.

4.3 Learnt Lessons

The literature review raised up challenges, but it also signaled suggestions for improvement that can be considered learnt lesson and are listed on Table 4, according to their similarities.

Table 4. Compilation of improvement suggestions – lessons learnt by the authors.

Topic	Indication of improvements
Games	Take care of ergonomy when developing educational games [5]
	To use gamification for blind people education [7]
Information	To insert sounds in a clear way to turn possible to discern the function or type of alert/message [9]
	To limit the quantity of information that can be integrated to one only hearing [9]
	To provide control conditions for the user to explore the tool or environment [9]
	To insert help and back keys [6]

	To assure the presence of information [7]
	To complement information for sensory perception – localization and features to allow the student to create a mental picture of the object [10]
	To state the information in a very clear manner [9]
	To include tips to complement the tactile information [11]
	To provide appropriated feedback [9]
Evaluation	Do not consider only time as efficiency factor [8]
Access	To check the possibilities of multimodalities [11]

Source: Elaborated by the authors

In conclusion, the suggestions for improvement can be applied on both Interaction and Instructional Designs. It is up to the multidisciplinary team, responsible for the projects, to be aware, sensible and committed to the success of students´ experiences.

There are developers initiatives toward the elaboration of orientations, in an effort to widen the access to digital contents. World Wide Web Consortium (W3C) and Global Learning Consortium (GLC) created recommendations, among them Web Accessibility Initiative – World Wide Web Consortium (WAI-W3C) and IMS GLC – Accessibility Guidelines (IMS GLC-ACC). Other contributions came from researchers. One of them comes from [15], who elaborated a set of Guidelines for Creation of Accessible Learning Objects. The Guidelines were put together from the convergence of three documents – Principles of Universal Design (for web content) + Recommendations on Accessibility for Creation of Online Content (W3C-WCAG 2.0 and W3C-WCAG 1.0) + Development Guide for accessible learning applications (IMS-ACC Guide). The purpose is to make available alternative options to turn the medium (still images, images on movement, tables, texts, audios and graphics) accessible to disabled students. These medium compose the learning objects, which, in their turn, are part of educational experience.

4.4 Interaction Design and in Instructional Design – Accessibility Proposals

As a result of this study, the recommendations presented below may help on development of projects that provide significant learning experience for disabled students emerged from a series of factors: challenges, concepts of experience, visually impaired students´ learning potentialities and learnt lesson, as well as the experiences listed on Table 1 – exploration and recognition; multimodal technologies and their use (guide, represent and recognize) presented on Table 2.

Interaction Design: (1) To include disabled people representatives during the phases of collection of requisites for user´s experience, prototyping and experience evaluation on the process; (2) To verify the Guidelines for Creation of Accessible Learning Objects for medium (still images, moving images, tables, texts, audios and graphs) used in the proposed device; (3) To make available control options in a format accessible to PCDs, including time and speed; (4) To make available keys or Help options; (5) To consider cognitive, emotional and social aspects during the prototype and process evaluations.

Instructional Design: (1) To include disabled people representatives during the Analysis, Design, Implementation and Evaluation phases; (2) To check Guidelines for Creation of Accessible Learning Objects for medium (still images, moving images, tables, texts, audios and graphs) during the elaboration of learning objects and resources, including educational materials; (3) To approve virtual learning environments which have accessibility criteria; (4) To make more flexible procedures, deadlines/times and types of delivery to contemplate the students´ potentialities; (5) To include in the didactic planning tips strategies, alternatives and pedagogical orientations related to accessibility.

It is important to highlight the propositions do not exhaust the topic, given each project has its own characteristics. They aim to sensitize the development teams when elaborating accessible projects.

5 Final Considerations

This essay presented the results of a systematic literature review, aiming to identify how human-computer interaction can contribute to the learning experience of blind students. In the analysis of selected works, the main points were categorized and resulted in information about experiences, audience profile, technologies, potentialities, frailties and suggestions for improvements. These aspects were the pillars for proposed actions to be implemented on the processes of Interaction Design and Instructional Design.

Although it is necessary to improve the Interaction Design and Instructional Design processes and their teams must be aware of the recommendations and guidelines on accessibility, the conclusion is that the human-computer interaction has a very relevant role for the disabled students´ learning experiences. For future studies, it is suggested to approach other aspects of the learning experience, like the emotional and social ones. As researchers, we hope we have somehow contributed because we do believe that technologies and education are potent to enhance inclusion.

Acknowledgments. We want to thank professors, collaborators and students of the discipline of Instructional Design, from Santa Catarina Federal University Knowledge Engineering and Management Master and Doctorate programme**.**

References

1. Brasil. Secretaria de Direitos Humanos da Presidência da República (SDH/PR). Secretaria Nacional de Promoção dos Direitos da Pessoa com Deficiência (SNPD): Cartilha do Censo 2010 – Pessoas com Deficiência. SDH-PR/SNPD, Brasília (2010)
2. ABED, Associação Brasileira de Educação a Distância: Censo EAD.BR 2013 - Relatório Analítico da Aprendizagem a Distância no Brasil, pp. 109. Ibpex, Curitiba, (2014)
3. Buzzi, M. C., Buzzi, M., Leporini, B.: Accessing e-learning systems via screen reader: an example. In: Human-computer interaction. Interacting in various application domains, pp. 21—30. Springer-Verlag Berlin Heidelberg (2009)

4. Buzzi, M. C., Buzzi, M., Leporini, B., Mori Giulio: Educational Impact of Structured Podcasts on Blind Users. In: Lecture Notes In Computer Science, pp.521--529. Springer Berlin Heidelberg (2011)
5. LučiIć, B., Ostrogonac, S., Sedlar, N. V., Sečujski, M.: Educational Applications for Blind and Partially Sighted Pupils Based on Speech Technologies for Serbian. The Scientific World Journal, 1--14, (2015)
6. Schloerb, D. W., Lahav, O., Desloge, J. G., Srinivasan, M. A.: BlindAid: Virtual environment system for self-reliant trip planning and orientation and mobility training. In: IEEE Haptics Symposium, pp.363-370. IEEE, Massachusetts (2010)
7. Maidenbaum, S., Chebat, D. R., Levy-Tzedek, Amedi, A.: Depth-To-Audio Sensory Substitution for Increasing the Accessibility of Virtual Environments. In: Universal Access In Human-computer Interaction. Design And Development Methods For Universal Access, pp.398--406.Springer-Verlag Berlin Heidelberg (2011)
8. Silva, A. L.: Comparative analysis of accessibility for blind digital environments for learning management for distance education. In: Iberian Conference on Information Systems and Technologies, pp. 1--5, IEEE Santiago de Compostela (2010)
9. Levy, S.T., Lahav, O.: Enabling people who are blind to experience science inquiry learning through sound-based mediation. Journal of Computer Assisted Learning, 28, 499--513 (2011)
10. Petridou, M., Blanchfield, P., T. Brailsford.: Involving the user with low or no vision in the design of an audio-haptic learning environment for learning about 3D shapes: The first approach. In: 3rd Computer Science and Eletronic Engineering Conference (CEEC). University of Essex, UK (2011)
11. Buzzi, M. C., Buzzi, M., Leporini, B., Martusciello, L.: Making visual maps accessible to the blind. In: UAHCI'11 Proceedings of the 6th international conference on Universal access in human-computer interaction: users diversity, vol. Part II, pp. 271—280 (2011)
12. Rogers, Y., Sharp, H., Preece, J.: Design de interação: além da interação humano-computador. Bookman, Porto Alegre (2013)
13. Filatro, A.: Design instrucional na prática. Pearson Education do Brasil, São Paulo (2008)
14. Quevedo, S. R. P., Ulbricht, V, R.: Como os cegos aprendem. In: Ulbricht, V. R., Vanzin, T. Villarouco, V.:Ambiente Virtual de Aprendizagem Inclusivo, pp. 153—188. Pandion, Florianópolis (2011)
15. Macedo, C. M. S.: Diretrizes para criação de objetos de aprendizagem acessíveis. Tese para obtenção do título de Doutor no programa Pós Graduação em Engenharia e Gestão do Conhecimento – PPEGC, da Universidade Federal de Santa Catarina. Florianópolis (2010)

Gamification approaches to learning and knowledge development: a theorical review

Raul Inácio Busarello[1], Vania Ribas Ulbricht[1], Luciane Maria Fadel[1], Andiara Valentina de Freitas e Lopes[2]

[1]Federal University of Santa Catarina, Technological Center, Postgraduate program of Engineering, Management and Media of Knowledge, Florianópolis City, SC, 88040-900, Brazil
[2]Federal University of Pernambuco, Undergraduate program of Graphic Expression, Recife City, PE, 52171-900, Brazil

Abstract. The article presents an outline of theoretical discussion about gamification concepts on the learning process and knowledge generation. As methodology, we did three systematic reviews in Scopus and Web of Knowledge databases. We identified that whem gamification applied in the learning process it have positive effects in student engagement and knowledge mediation. Gamification focuses efforts on students' inner motivations and learner autonomy in a controlled environment, where the contents of specific areas subdivided and treated as stage in a surrounding context by cognitive, social and emotional correlating. Also for us the games, concepts are complementary parts in the gamification process.

Keywords: Gamification, learning, knowledge generate, systematic review, theorical discussion

1 Introduction

The knowledge generation is amplified when stimulated the person's motivation and creativity [1][2]. In addition, new technologies corroborate effective teaching process [3]. Thus, it becomes effective use of innovative media storytelling to generate motivating environments for teach [4]. We identify efficient that use of hypermedia storytelling in knowledge generation favor the individual experience to a range of experience effectively, emotional and investigative [5][6]. Those experiences are fundamental to memory, communication and knowledge construction [7].

We have been creating learning object-based hypermedia comics focusing accessible [8] which is efficient for learning. However, after object application we identified that artefact motivational aspects need to a reviewed. Our premise is incorporating gamification mechanisms into a learning object can aggregate in the motivation process and student interaction with, promoting the process of knowledge generation. We based it becouse gamification is a systematic: to solve problems, to increased motivation and to engagement of certain public in [9][10]. In addition, a learning object may be any media content, digital or analog format, if it used for

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_105

educational purposes and since it is a well-defined and measurable object [11]. Furthermore, we understand gamified environments can contribute to creation of motivational contexts based on exciting challeng games, rewards the dedication and efficiency and provide a space for leaders appear spontaneously. As an example of the gamification in the current practices, the *NMC Horizon Report: 2014 Higher Education Edition* [12] points out the games and gamification as important Digital Strategies within the Educational Technology for the coming years. The report is part of the *NMC Horiozon Project*, which focuses on research on global education and aiming to identify and describe emerging technologies that have the potential to influence the way of learning and creative research in higher education for years to come.

We checked that games agents as character, competition and rules may have a direct effect on learning motivation [13]. We understand these agents can exploited by creating a learning object based on a non-linear storytelling. When the students immersed in a storytelling work they are willing to abide the rules of that new universe, and it involves navigation and competition aspects [6]. Those elements enable individual greater experience into a fictional universe. Additionally, other aspects of gamification can incorporated in a learning object [14] [15], such as repeat trials, fast feedback cycles levels increasing difficulty, continuous increase in skills, different possible ways and different engagement levels.

In this context, this article's purpose is to present an outline of the theoretical discussion about gamification concepts on the learning process and knowledge generation. As methodology, we did three systematic reviews in Scopus and Web of Knowledge databases. The systematic reviews contributes to the implementation of strategies for limiting the biases of search and selection of scientific works, where the researcher should critically evaluate the materials collected, summarizing the research relevant to a particular topic [16].

2 Systematic Review

To survey theoretical framework we did three systematic reviews between July 2014 and January 2015. The first one was conducted in Scopus database (www.scupus.com) in July 2014 and it sought to identify *which learning object elements based on fictional hypermedia comics linked the gamification possibilities, are effective for deaf and not deaf people's motivation and knowledge generation.* The object was to seek guidelines that would help in the learning object construction proposed by us. The research variables contemplated: *In: Article Title, Abstract, Keywords; All documents; 2004 e 2014; AND; areas: Live Sciences, Health Sciences, Physical Scieces, Social Sciences & Humanities*. The keywords that guided the research were: *gamification, game, comics, learning, learning object, deaf e deaf student*. That research resulted in the sum of 276 documents and we read summaries of 16 articles. Of these, 11 have been read fully and 2 used as part of the theoretical foundation.

The second and third systematic reviews occurred in January 2015 and we did it in distinct databases: Scopus database (www.scopus.com) and Web of Science database

(webofknowledge.com). The question for both revisions included: *Wich are papers address the concepts gamification use in hypermedia comics for accessible learning?* Keywords searched: *gamification, learning, learning object, comics, hypermedia, accessibility e deaf student.*

Research in the Scopus database used as variables: *In: All Fields; All documents; 2005 e 2015; AND; areas: Live Sciences, Health Sciences, Physical Scieces, Social Sciences & Humanities.* Of the 732 articles identified, 41 were selected for reading the summaries. Of these, 3 were used to complete reading and 2 used the theoretical framework. Of these, the article closest to our issue is a paper published by us [17]. The articles cutting is due to the remoteness of the goal of the proposed research.

To search in Web of Science database we used as variables: *TS no início e AND; 2005 e 2015.* Of the keywords combinations set out only the addition of *gamification and learning* keywords have number of positive documents. We found 89 articles, where 26 had been read fully and 7 selected to contemplate the theoretical review. We included in the review more 9 works, including articles and books, which were often cited as primary sources.

Based on these reviews and more relevant works was possible to theoretical reflection to the next session.

3 Gamification Concept

Gamification principles arousal positive emotions and explore skills, linked to virtual or physical rewards while performing a given task. Therefore, it applied to situations and circumstances requiring the creation or adaptation of the user experience to a product, service or process [10]. Gamification can be applied to activities where is necessary to stimulate the individual's behavior and to creation or adaptation of user experience to a product, service or process. Its use contributes to creating a unique environment, with efficiency in the individual attention retention [18].

We understood that environments that interact with users' emotions and desires are effective for the individual engagement. Through gamification mechanisms, it can align the interests of object creators with the users' motivations. The development of new products and systems must take into consideration the trend of the contemporary society is increasingly interested in games. In this reality, the involvement of any public must based on reward structures, reinforcement and feedback, supported by mechanical and systematic that enhance the involvement of the individual [9]. In addition to providing pleasure, the play act contributes for develop cognitive skills, stimulate attention and memory [19].

The games are able to promote playful and fictional contexts with individuals, through storytelling, images and sounds, and it favoring the generation process and relationship with knowledge [20]. In the storytelling aspects, the games allow the individual to live experience in a fictional context controlled [21]. Gamification appropriates games elements for use in environments, products and services do not necessarily focused on games, but with the intention to promote motivation and stimulate the individual's behavior. Those elements [22] are traditionally use in games or fun activities in order to promote engagement and learning, culminating in positive

behaviors to these practices. Another approach shows gamification [23] as the act of experiencing an experience where interaction takes place from the object, the tools and the context. The human brain needs the common games experiences [24], solving puzzles and receive response as stimuli activate the dopamine system in the person's brain. In addition, in a game the individual has the opportunity to overcome challenges and miss, but not permanently. That is, the player will always have the opportunity to redo the task, seeking its success. This serves as a motivator for a constant search for new and improved ways to find solutions.

Based in research and practical focus of the elements related to the term gamification, we put conceptually that: ***Gamification*** *is a system used to solve problems through raise and maintaining engagement levels by incentives to the individual's intrinsic motivation. Uses playful scenarios for simulation and exploration of phenomena with extrinsic goals, supported by elements used and created games.*

4 Gamification in learning and knowledge generate

The generating knowledge process is motivating when the activity becomes fun, as in a game [25]. In a context of learning, we can use gamification of several ways, as including storytelling to change the context of a routine activity and thereby encourage the subjects' behavior [26]. Its encourage individuals to learn and perform tasks before tedious, by a motivating way. For example, the gamification strategies uses has great potential in educational processes [27] which are often unmotivated students in learning activities. Gamification can induce motivation in tedious routines [15].

One of gamification bases is the use of game elements in another contexts [25], once it contribute in learning practical combining fun elements with instructional design and motivational and interactive systems. The gamification essence is not on technology [22], but about an environment, that promotes diversity of learning paths and decision-making and reward systems of the subjects. Always it aiming to raise student motivation levels and engagement in the process. However, gamification has been successfully incorporated into digital platforms on a commercial basis [20].

We identified gamification is based on psychological theories that uses motivational models in its basis [27]. Therefore, it is necessary to recognize that motivation in that system covers the individual's *cognitive*, *emotional* and *social* areas [20].

Cognitive Area: it establishing a complex set of rules from oriented tasks and smaller steps. These steps are developed as expertise cycles composed of short quick tasks where the individual repeatedly attempts to search its conclusion. This process based on trial and error raises the skill level necessary so that individual can solve that particular cycle. This is justified with the flow theory [28] where the individual motivational flow occurs in the balance point of the relationship between necessary skills and learned to levels of challenges encountered and confronted the system. For the individual's involvement in this process is necessary that system provide subject necessary information, so that person develops the appropriate conhecimeno and he or

she has the ability to interact along the systematized experience. In the case of creating and building a gamified system for learning and generating knowledge must enable the individual to have freedom to choose which tasks carried out, and when, resulting in non-linear structure pivotally sequences activities. Cognitive area denotes the person autonomy [24], once the skills and subject preferences are decisive for the tasks choices.

Emotional Area: in an environment that stimulate game thinking there are complex rules system that individuals should dominate, and the experience depends on the person's autonomy of this subject. Emotional area denotes one's competence and focuses primarily on the success and failure concepts [20]. An example is when player's task is completed as expected, resulting in a positive emotion simply because that individual has been able to overcome certain difficulties. To increase the person's positive feelings the game's systematic assumes that success in carrying out tasks should be recognized immediately by the players. Conversely, the execution of tasks may contribute to player's increased anxiety. To some extent, it is interesting that this anxiety to be exploited, however, in many cases, this can turn into frustration and hence the player output from system. To avoid this, all tasks should be designed to support players' skills at any level.

Social Area: its individual interaction while them using the system [24]. This dimension addresses both, socialization such as collaboration, and competition from the social point of view. Stimulate competition can generate as much constructive results as destructive [26]. Competition is constructive when it is a fun experiences and when it are structured to raise the positive relationships relationships participants. Conversely, competition becomes destructive when the result of the competition is detrimental to at least one of the members. Competitions examples that harm intrinsic motivation may be the games with children who are encouraged to "punch" other competitors and when individuals are forced to position themselves as personally connected to rival competitors. It is not clear if the scoreboards' use generate positive or negative feelings, once this strategy always highlights a single winner and losers. However, from the social point of view, the ease with which scores compare players tend to stimulate the negative competition, especially when applied in the process of knowledge generation.

For learning by gamification, it stresses that those concepts must be used in the design of educational ideas and learning objects, seeking to make them motivating. Environments that interact with the emotions and desires of users [9] are effective in raising engagement levels. Through gamification mechanisms it can align the interests of artifacts and objects creators with the users motivations users. We should attention to the fact that certain extrinsic rewards can destroy the intrinsic motivations, affecting the individual motivational aspect. For example, if the individual does not pass a certain action on the environment, is utmost importance that the image intrinsic motivations are preserved. However, one should be cautious when using extrinsic motivations to improve the level of intrinsic motivation [26].

Efforts in competitions for get rewards tend to decrease intrinsic motivation. It can happen when the individual is motivated to perform a certain task and and for him or

her is given specific and tangible reward already expected for that person. Thus that individual will require more rewards in next actions. In general, by offering rewards expected for people already interested in a given subject or context, can make them change the motivation of "already want to conduct" for the motivation of "going to do to win the reward". However, those individuals who receive a reward for performing an uninteresting activity, can making the practice more interesting. Extrinsic rewards are less effective than the intrinsic [29], however, both motivation kinds are determinants to individual's behavior.

The complicating factor in creating gamification's environments and devices is how effectively stimulate the intrinsec and extrinsec motivation, both together as separately [17]. The effective intrinsic and extrinsic combination increases motivation level and engagement of the student. It shows that the gamification use should viewed with caution. On the one hand, can assist in motivating the student who is bored in the educational task. On the other hand, can damage student motivating's levels who was already motivated for such activity. These aspects are possible to balance by ARCS Model [22] - attention, relevance, confidence and satisfaction - that can applied to measure the motivation of a device or gamified system for learning:

Attention: is the beginning for winning the attention of the student. Includes:

- *Perception:* where the excitement seeking attention through specific meanings, related examples, use of inconsistencies and conflicts or elements of surprise;
- *Consultation:* it considers that excitement comes from the curiosity stimulation by submitting questions and problems that students are interested in solving, or from the stipulation of rules to run the experiment;
- *Variability:* are options available elements to keep the attention.

Relevance: it established from four methods:

- *Goals Guidance:* where from the illustration of the objective importance described as a topic will help the student at the time and in the future;
- *Combination of education's reasons of students:* from that can be achieved, risks taken and affiliation relationships;
- *Familiarity:* explains how the domain knowledge is related to that the student also knows;
- *Modeling of learning outcomes for new knowledge.*

Confidence: implies the achievement of students' expectations success. Students tend to motivate themselves when they realize that they can learn from the material. Make it evident the expectation of learning at the beginning of an experience that can contribute to confidence building. Individuals who feel confident believe they are controlling their own path to success and in this case, the existence of feedbacks and reinforcements help this feeling.

Satisfaction: to continue struggling students need to feel that the learning object has any value. Thus enabling the application of knowledge and skills in the activity favors the visualization of the content of learning being apply. In addition, new topics positively encourage learning as a strategy can contribute to increasing the intrinsic motivation of students.

In addition, there three fundamental elements which make motivational games based systems [22]. These are challenge, fantasy and curiosity.

- The *Challenge* dependent on goals that have uncertain outcomes. That is, an environment is not challenging if the individual has sure how should or should not be to reach certain goal. The challenge is associated with the perception of the individual, factor that influences the way we perceive the parts of the system. Depending on that perception can understand a given system attribute as a motivator or not.

- The *Fantasy* translated as an environment that evokes mental images of things not present at the actual experience of that individual involved. To develop instructional environments must consider extrinsic and intrinsic Fantasies: the first concern is to work with something external to fantasy. It only depends on the skills used in games, for exemple win a game show. The intrinsic costumes presented as elements within the fantasy world, making the individual perceive this as natural. For example is when a player should have to negotiate with Indians to cross a forest. In this case, negotiation is internal to the fantasy, because it is within the game. Furthermore, it provides two types of advantages: cognitive and emotional.

- The *curiosity* is stimulated when presented good levels of complex information in an exciting environment. It divided into sensory and cognitive components: the first involves attention values and appeal to changing sensory stimuli of the environment; the second invoked when there is the expectation of high levels of cognitive structures. That awakened when students believe that their knowledge structures are incomplete or inconsistent, motivating them to learn more, resulting in the improvement of their cognitive structures. Engage the curiosity should take into account that the feedbacks are surprising and constructive.

The person's actions within the game are not the same out of it [21]. This difference based on the individual's feeling about his understanding of the game, where there is a beginning and a well-defined order, where rules for performance are conscious, explicit and clear objectives. Thus, the subject defines their actions with reference at the end goal of the game itself. In contrast, in situations out of the game these same elements are difficult to identify. The games trigger repeated judgment's cycles of the player, game behavior and feedback [29]. These cycles relate to a dependancy circle with the intent to: 1. search the desired behavior of the student; 2. enabling students' first experience emotional and cognitive reactions desajáveis; 3. each result of interaction with the system and the feedbacks generated by the game.

In addition, the first contact with the environment, individuals make judgments about the games, trying to answer whether this is fun, interesting and engaging. These judgments are based on:

Interest: expressed in the educational context, the preference in the execution or related to any specific activity.

Satisfaction: this feeling is subjective, but is associated with the sense of accomplishment of something that occurs in the relationship between individual skills and challenges in the tasks.

Tasks involvement: are set the level of attention or depth in which the subjects are focused and are picked up by a given activity. These topics are related to the degree of immersion experienced by the individual in the environment and can be determined by factors control, sensation, distraction and realism. The improvement in the learning process is related to the increase in the quality of cognitive engagement of the individual.

Confidence: instructional environments based games favor the student can complete tasks without mistakes and failures have serious consequences, as in the real world. Still, structure levels of progressive difficulty, allows the subject to become familiar with the environment and the rules, developing skills in complex tasks. These stimulate increased confidence in the environment, especially in complex, stressful and dangerous tasks.

Initial trials of the system are responsible for determining the direction, intensity and quality of the individual's behavior. The more students are motivated - form of behavior, more involved and interested in will perform the tasks. Motivated students present as characteristic enthusiasm, focus and engagement [29]. Besides, they are interested in what they do and feel pleasure from it, despite the task performed not necessarily be easy, persistence is another feature-motivated.

5 Final Thoughts

This article aims to present a theoretical gamification concepts discussion applied in the learning process and knowledge generation. Thus, we understand that gamification comprises motivational strategies applied to problem-solving situation. Uses for it bases and common systematic of game concepts and storytelling theories. The main purpose is to involve the individuals' full experience, transporting them to a fictional universe where the intention is to facilitate and accelerate the generation and application of knowledge by the individual. Moreover, gamification is always a practical element, far beyond simple entertainment.

As applied in the learning process, the gamification have positive effects, both in student engagement, as in the better mediation between knowledge and person. Educational psychology is base of gamification where especially focuses efforts on learner autonomy in a controlled environment, where the contents of specific areas are subdivided and treated as a stage in a surrounding context by correlating cognitive, social and emotional. In the learning process, the gamification should focus activities in exploring the students' inner motivations. In this case, the simple application of basic mechanics of game in the process could lead to negative results. Throughout everyday situations, one should invest in curiosity, satisfaction and confidence of student within process.

The common games elements as storytelling, goals, rules, feedback, challenges, incentives and the ability to control contribute to the construction of the possibility of experience within the gamified environment, promoting the voluntary participation of the individual. Thus, the mechanical and dynamic applications, shared with the games, contributing in the participation process of gamified system. We show that not the games' attributes that gamified a system, but these attributes are complementary parts in the gamification process.

References

1. Tuncel, G., Ayva, O.: The utilization of comics in the teaching of the "human rights" concept. ScienceDirect. Procedia Social and Behavioral Sciences 2 (2010)
2. Lazzarich, M.: Comic Strip Humour and Empathy as Methodological Instruments in Teaching. Croatian Journal of Education, Vol: 15: 153-189 (2013)
3. Novaes, M. H.: O que esperar de uma educação criativa no futuro. Psicologia Escolar e Educacional, Volume 7 Número 2 155-160 (2013)
4. Weller, M. J.: The use of narrative to provide a cohesive structure for a web based computing course. Journal of Interactive Media in Education (2000)
5. Brockmeier, J., Harré, R.: Narrativa: Problemas e Promessas de um Paradigma Alternativo. Psicologia: Reflexão e Crítica, 16(3), pp. 525-535 (2003)
6. Murray, J. H.: Hamlet no holodeck: o futuro da narrativa no ciberespaço. São Paulo: Itaú Cultural: Unesp (2003)
7. Gordon, A. S.: Fourth Frame Forums: Interactive Comics for Collaborative Learning. ACM 1-59593-447-2/06/0010. MM'06, October 23–27 (2006)
8. Busarello, R. I.: Geração de conhecimento para usuário surdo baseada em histórias em quadrinhos hipermidiáticas. Dissertação apresentada para a obtenção ao título de Mestre no Programa de Pós-graduação em Engenharia e Gestão do Conhecimento, área Mídia e Conhecimento, da Universidade Federal de Santa Catarina. Florianópolis, SC (2011)
9. Zichermann, G., Cunningham, C.: Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps. Sebastopol, CA : O'Reilly Media, Inc. (2011)
10. Vianna, Y., Vianna, M., Medina, B., Tanaka, S.: Gamification, Inc.: como reinventar empresas a partir de jogos. MJV Press : Rio de Janeiro (2013)
11. Macedo, C. M. S.: Diretrizes para criação de objetos de aprendizagem acessíveis. Tese para obtenção do título de Doutor no programa Pós Graduação em Engenharia e Gestão do Conhecimento – PPEGC, da Universidade Federal de Santa Catarina. Florianópolis (2010)
12. Johson, L., ADMAS BECKER, S.; ESTRADA, V.; FREEMAN, A. NMC Horizon Report: 2014 Higher Education Edition. Austin, Texas: The New Media Consortium (2014)
13. Schmitz, B., Klemke, R., Specht, M.: Effects of mobile gaming patterns on learning outcomes: a literature review. Journal Technology Enhanced Learning (2012)
14. Li, W., Grossman, T., Fitzmaurice, G.,: Gamified Tutorial System For First Time AutoCAD Users. UIST '12, October 7–10, Cambridge, Massachusetts, USA (2012)
15. Simões, J., Redondo, R. D., Vilas, A. F.: A social gamification framework for a K-6 learning platform. Computers in Human Behavior. Instituto Superior Politécnico Gaya, Portugal: [s.n.] (2012)
16. Galvão, C. M., Sawada, N. O., Trevizan, M. A.: Revisão Sistemática: recurso que proporciona a incorporação das evidências na prática da enfermagem. Rev Latino-am Enfermagem, maio-junho; 12(3):549-56 (2004)
17. Busarello, R. I., Fadel, L. M., Ulbricht, V. R., Bieging, P.: Construction Parameters for Hypermedia Comics to Learning Based on the Gamification Concept In: International

Conference on Design and Emotion (9th : 2014 : Colombia), 2014, Bogotá. The colors of care : 9th International Conference on Design & Emotion. Bogotá - Colômbia: Ediciones Uniandes, v.1. p.616 – 622 (2014)
18. Campigotto, R., McEwen, R., Demmans, C.: Especially social: Exploring the use of an iOS application in special needs classrooms. Journal Computers & Education, Virginia, v. 60, p. 74–86 (2013)
19. Furió, D., González-Gancedo, S., Juan, M. C., Seguí, I., Costa, M.: The effects of the size and weight of a mobile device on an educational game. Journal Computers & Education, Virginia, v. 64, p. 24–41 (2013)
20. Domínguez, A., Navarrete J. S., Marco, L., Sanz, L. F., Pagés, C., Herráiz, J. J. M.: Gamifying learning experiences: Practical implications and outcomes. Journal Computers & Education, Virginia, v. 63, p. 380–392 (2013)
21. Collantes, X. R.: Juegos y viedojuogos. Formas de vivencias narrativas. In Scolari, C. A.: Homo Videoludens 2.0. De Pacman a la gamification. Col·leccio Transmedia XXI. Laboratori de Mitjans Interactius. Universitat de Barcelona. Barcelona (2013)
22. Kapp, K. M.: The gamification of learning and instruction: Game-based methods and strategies for training and education. San Francisco: Pfeiffer (2012)
23. Seaborn, K., Fels, D. I.,: Gamification in theory and action: A survey. Human-ComputerStudies 74, 14–31 (2015)
24. Clementi, J. A.: Diretrizes motivacionais para comunidades de prática baseadas na gamificação. Dissertação submetida ao Programa de Pós-Graduação em Engenharia e Gestão do Conhecimento da Universidade Federal de Santa Catarina para a obtenção do Grau de Mestre em Engenharia e Gestão do Conhecimento. Florianópolis (2014)
25. Amory, A., Naicker, K., Vincent, J., Adams, C.: The use of computer games as an educational tool: identification of appropriate game types and game elements. British Journal of Educational Technology. Vol; 30 N°4, 311-321 (1999)
26. Hanus, M. D., Fox, J.: Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. Computers & Education 80, 152-161 (2015)
27. De-Marcos, L.; Domínguez, A., Saenz-de-Navarrete, J., Pagés, C.: An empirical study comparing gamification and social networking on e-learning. Elsevier. Computers & Education 75, 82–91 (2014)
28. Csikszentmihalyi, M.: Flow: The Psychology of Optimal Experience. HarperCollins e-books. New York (2008)
29. Garris, R., Ahlers, R., Driskell, J. E.: Games, Motivation and Learning: a research and practice model. Simulation & Gaming, Vol. 33 No. 4, December, 441-467 (2002)

An Affective Learning Ontology for Educational Systems

Samantha Jimenez[1], Reyes Juarez-Ramirez[1], Víctor H. Castillo[2], and Alan Ramírez-Noriega[1]

[1] Universidad Autónoma de Baja California samantha.jimenez@uabc.edu.mx, reyesjua@uabc.edu.mx, alan.david.ramirez.noriega
[2] Universidad de Colima victorc@ucol.mx

Abstract. In recent years, education is characterized by promoting independent study through computational tools, such as Intelligent Tutoring Systems. It is important these educational systems consider affective aspects because it improves the learning process. However, the literature reports that there is no an affective model to guide the design of affective educational systems. For that reason, this work introduces a novel affective learning ontology that examines student, tutor and dialogue issues. Also, this paper presents an assessment of which elements of our ontology are taken into account in education systems such as Intelligent Tutoring Systems. We believe the findings from this research will serve as a useful reference for the design of educational systems such as Intelligent Tutoring Systems.

Keywords: Affective Learning, Ontology, Educational Systems.

1 Introduction

In recent years, education is characterized by promoting independent study, this form of studying has been supported by technology systems, such as [25]: Management Learning Systems (MLS), Adaptive Hypermedia Systems (AHS) and Intelligent Tutoring Systems (ITS). It is important that these educational systems taking into account not only the cognitive abilities and capabilities that students possess or need to acquire through learning processes, but also their affectivity [3]. By affectivity in learning, we mean the response gave by a tutor, with a behavior or dialogue, which produces a benefit in the student taking into account student's needs (emotions, attitude, motivation, among others) [11].

To date, affective research works have focused on the detection of emotional states student during the tutoring [15, 13, 16, 22, 24]. It should be noted that research about this area has progressed providing to computers the ability of recognize the affective state of the student. However, the question then arises what about the affectivity that the educational systems should provide to the student in order to bring an affective learning?

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3_106

Several authors purposed learning ontologies that include some affective factors. For example, [27] presents a method which is based on an Ontological Approach to elicit student's emotion during the learning process. In the same way, [7] designed an approach to modeling the affective state of a student. The model represents the learning process used by the student including the affective state. On the other hand, [4] purposed an ontology that include the different types of emotions, moods and behaviors that students experience in the e-learning environments. However, these approach does not answer the research question about how the educational system has to bring affective feedback?

In this work, we want to build an ontology as a knowledge representation system of the affective domain in learning. Moreover, it will allow us to support the design of educational systems based on affective learning. Additionally, the ontology is constructed in relation to a context of use, because the ontology specifies a conceptualization of the world or a way of perceiving it. In our case, our ontology seeks to conceptualize virtual learning environments, for example ITS, from the affective domain's point of view.

This paper is organized as follows. Section 2 describes the affective learning ontology's design. Section 3 shows an ontology's mathematical evaluation. Section 4 discuses which elements of the ontology are used in ITS. Finally, Section 5 presents our conclusions.

2 Affective Learning Ontology

The design of affective learning ontology was guided by methontology, in conceptualization's phase [17]. This stage consists of the following steps: 1) Build the glossary of terms, 2) build the taxonomy, 3) state the relations, make the concept's dictionary and 4) the ontology's evaluation.

Glossary of Terms First, we build a glossary of terms that includes all the relevant terms of the domain. There are three relevant actors in learning [33]: student, tutor and dialogue. Based on literature review [26, 35, 5, 31, 21, 3], we analyzed the student's, teacher's and dialogue's characteristics that are necessary for achieving affective learning. Table 1 presents the terminology concepts extracted from the literature.

Table 1. Terminology glossary.

Actor	Concepts
Student	Motivation, objectives, learning style, cognition, emotional Intelligence
Teacher	Authenticity, reliability, friendly attitude, latency, immediacy, respect, individual support, emotional intelligence
Dialogue	Corrective, gestures, voice tone, eloquent, courteousness, active listening, words, empathy, connectors

To achieve the affective learning domain we need to analyze which elements of the student should be taken into account to create a suitable environment for learning. It is important to consider student's motivation, objectives, cognition, learning style, and the emotional intelligence. A teacher needs to be sensitive to these aspects of the student. First, the teacher takes into account student's needs, and then he need to interact with the student in an appropriate and friendly manner.

In a perfect scenario, the teacher must be authentic, reliable, uses his emotional intelligence to express a friendly attitude and respect to the student. The student needs individual support with latency and immediacy. The dialogue plays a significant role in teacher-student interaction, it must be eloquent, corrective, empathic and courteousness [21]. The dialogue uses words, gestures and voice tone to express affectivity.

Taxonomy The second step consisted in the taxonomy design. A taxonomy is usually only a hierarchy of concepts, i.e., the only relation between the concepts is generalization-specialization relation or parent/child, or subClass/superClass. Figure 1 shows our fourth level taxonomy.

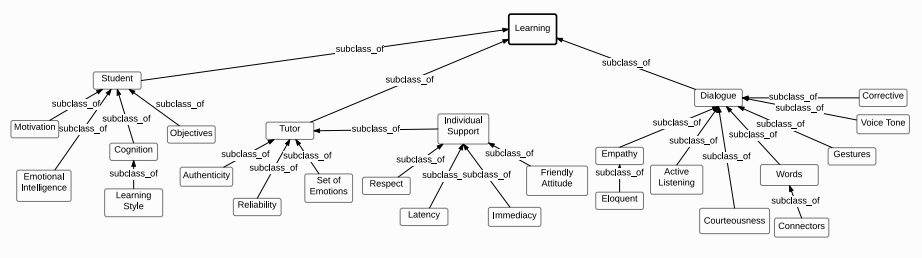


Fig. 1. An ontology learning taxonomy.

We classified the affective domain in three levels. Learning is the first level in the taxonomy. Then, there are three subdomains the student, the tutor and the dialogue. The concepts listed in Table 1 are subclasses of each subdomain are the third and fourth level.

In an ontology, arbitrary complex relations between concepts can be expressed too. For that reason, in the next step we state the relations.

Relations There are three significant relationships in ontologies: 1) subsumption relation (subclass of, this relationship creates the taxonomy); 2) mereology (part of, represents how objects combine to form composite objects) and 3) semantic relation (describe the expression power of the language). Our proposed ontology comprises semantic relationships. In this way the Table 2 defines the relationships used in the affective learning ontology.

Table 2. Relationship's descriptions.

Relation	Definition	Formal Representation
contributes	a concept is involved in achieving another concept	$\forall x C_{(x2)} \overrightarrow{contributes} C_{(x1)}$
must_have	a concept has other concept necessarily	$\forall x C_{(x1)} \overrightarrow{must\_have} C_{(x2)}$
has	a concept has a direct relationship with other concept	$\forall x C_{(x1)} \overrightarrow{has} C_{(x2)}$
brings	a concept offers another concept	$\forall x C_{(x1)} \overrightarrow{brings} C_{(x2)}$
part_of	a concept is a fraction of another concept	$\forall x C_{(x2)} \overrightarrow{part\_of} C_{(x1)}$
uses	a concept uses other concept	$\forall x C_{(x1)} \overrightarrow{uses} C_{(x2)}$

The formal representation describes how should be read the relation between two concepts, where $C_{(x1)}$ is a subsumption (father) and $C_{(x2)}$ is a subsumed (son). For example, $\forall x C_{(x1)} \overrightarrow{uses} C_{(x2)}$ the $C_{(x1)}$ uses the $C_{(x2)}$.

The next step consists into bringing a definition of each ontology's concept.

Dictionary of Concepts Once, the taxonomy and relationships have been determined, we must specify which are the properties that describe each concept of the taxonomy.

In this section, we expose a set of definitions which integrates our affective learning ontology. Table 3 shows the concepts related to student's domain. On the other hand, the terms associated with the tutoring domain are described in Table 4. Finally, Table 5 presents the concepts related to the dialogue's domain.

Table 3. Student's concepts definitions.

Concept	Definition	Relation
Student	Is the person who acquires knowledge [26].	$student \overrightarrow{has} learning$
Motivation	Is an emotional state, having a strong reason to act or to accomplish something [35].	$student \overrightarrow{has} motivation$
Emotional Intelligence	Is the ability of [5]: a) perceive emotions, b) use emotion, c) understand the emotions, d) managing emotions.	$student \overrightarrow{has} EmotionalIntelligence$
Objectives	Are goals that students are trying to achieve [35].	$student \overrightarrow{has} objectives$
Cognition	Is the analysis of the processes to acquire, store, retrieve and use knowledge [31].	$student \overrightarrow{has} cognition$
Learning Style	A preference shown by the student for learning [35].	$learning\_style \overrightarrow{part\_of} Cognition$

Finally, we integrated all the aspects listed above, the taxonomy of the semantic relationships between the concepts described earlier to form the affective learning ontology. The graphical representation if this ontology is shown in Figure 2.

3 Ontology's Evaluation

Assessing the quality of an ontology is necessary for recognizing areas that might need more work. The quality of ontologies can be determined in different dimen-

Table 4. Tutor's concepts definitions.

Concept	Definition	Relation
Tutor	Is the person who gives systematic support to the student [26].	$tutor\overrightarrow{_{contributes}}learning$
Reliability	Is a key factor that contribute to building a sense of communication in learning [3].	$tutor\overrightarrow{_{has}}reliability$
Authenticity	Is the ability to behave taking into account feelings [21].	$tutor\overrightarrow{_{has}}authenticity$
Emotional Intelligence (EI)	Is the ability of [5]: a) perceive emotions, b) use emotion, c) understand the emotions, d) managing emotions.	$tutor\overrightarrow{_{has}}EI$
Individual Support (IS)	Is the process of close interaction between tutor and student [21].	$tutor\overrightarrow{_{brings}}IS$
Respect	States that the students are worthy people and should be treated with respect [21].	$IS\overrightarrow{_{must\_have}}respect$
Friendly attitude (FA)	Is a kind disposition of the tutors that make ease the communication and contribute to building a sense of communication in learning [3].	$IS\overrightarrow{_{must\_have}}FA$
Immediacy	Is a characteristic that suggest the promptness to bring feedback to students [3].	$IS\overrightarrow{_{must\_have}}Immediacy$
Latency	Is the time required of the student to respond, be patient [21].	$IS\overrightarrow{_{must\_have}}Latency$

Table 5. Dialogue's concepts definitions.

Concept	Definition	Relation
Dialogue	Is a powerful tool that supports the interaction between the professor and the student [26].	$dialogue\overrightarrow{_{contributes}}learning$
Corrective	Is the action of correct student's mistakes [21].	$dialogue\overrightarrow{_{must\_have}}corrective$
Courteousness	Is showing good manners, verbally and nonverbally [21].	$dialogue\overrightarrow{_{must\_have}}courteousness$
Active Listening	Includes in a teacher speech a student's phrase [23].	$dialogue\overrightarrow{_{must\_have}}ActiveListening$
Empathy	Is the ability to understand student's felling and response according to them [21].	$dialogue\overrightarrow{_{must\_have}}empathy$
Eloquent	Is the action of give positive feedback to the student [21].	$eloquent\overrightarrow{_{part\_of}}empathy$
Voice Tone	Is a particular quality, way of sounding, modulation, or intonation of the voice [23]. The tone of voice helps to give meaning to communication.	$dialogue\overrightarrow{_{use}}voice\_tone$
Gestures	Are movement of the face that is expressive of an idea or emotion [23].	$dialogue\overrightarrow{_{use}}gestures$
Words	Are the information transmitted during a dialogue [23].	$dialogue\overrightarrow{_{use}}words$
Connectors	Are the words used to link two sentences among others [23].	$words\overrightarrow{_{has}}connectors$

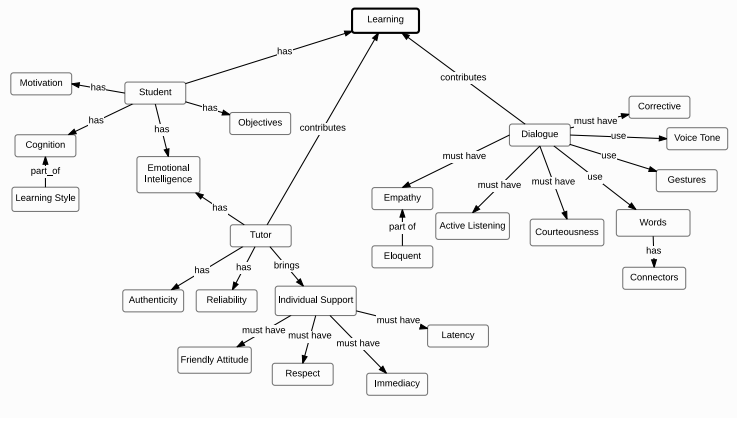


Fig. 2. Affective learning ontology.

sions, in this work we used the OntoQA for the evaluation [36]. This evaluation cannot states if the ontology design correctly models the knowledge, but these metrics can indicate the richness, width, depth and inheritance of the ontology schema [36].

- **Relationship Richness:** This metric reflects the diversity of relations and placement of relations in the ontology. The RR is given by the following equation:

$$RR = \frac{|P|}{|SC|+|P|} = \frac{|25|}{|0|+|25|} = 1$$

  If an ontology has an RR close to 0, that would indicate that most of the relationships are class-subclass relationships. In contrast, an ontology with an RR close to 1 would indicate that most of the relationships are other than class-subclass (semantic relationships). Our affective learning ontology has a $RR = 1$, which indicates that our ontology has relationship richness.
- **Attribute Richness:** In general we assume that the more attributes that are defined the more knowledge the ontology conveys.

$$AR = \frac{|att|}{|C|} = \frac{|0|}{|26|} = 0$$

  Affective learning ontology has 0 attributes and 26 classes. In our ontology each element detected in literature represent a concept, for that reason we do not integrated attributes into classes.
- **Inheritance Richness:** The number of subclasses (C_1) for a class C_i is defined as $\left|H^C(C_1, C_i)\right|$.

$$IR_s = \frac{\sum_{C_i \in C} \left|H^C(C_1, C_i)\right|}{|C|} = \frac{|1|+|5|+|5|+|4|+|1|+|1|+|8|}{26} = 0.96$$

  An ontology with a low IRS would be a very specific type of knowledge that the ontology represents (vertical nature). While our ontology with a high IRS would be of a horizontal nature, which means that ontology represents a wide range of general knowledge.

The mathematical evaluation allows us to establish the richness of our ontology considering attributes, classes and relationships. However, we need to assess which elements of our ontology are taken into account in education systems. For that reason we conduct a systematic literature review in ITS domain, the results are presented in the next section.

4 Discussion

We conduced a systematic literature review to confirm which elements of the ontology are used in ITS, and we expected that some of the affective learning

Table 6. Emotional and affective states of the students during the learning process.

Elements	[18]	[19]	[13]	[20]	[2]	[14]	[28]	[30]	[38]	[24]	[22]	[8]	[16]	[1]	[9]	[10]	[32]	[15]	[39]	[6]	[34]	[29]	[12]	[37]	No. papers
Objectives												x	x							x					3
Cognition	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Emotional		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	23
Motivation	x	x	x	x	x	x		x	x	x	x		x	x				x	x	x				x	16
Learning Style	x	x																							2
Authentic	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Reliability																									0
Emotions					x		x							x		x			x	x		x	x	x	9
Friendly Attitude					x		x							x		x			x	x		x	x	x	10
Individual Support	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Respect	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Latency		x		x																					2
Immediacy	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	24
Corrective	x																								1
Empathy					x		x							x		x			x	x		x	x	x	9
Eloquent	x	x	x	x							x													x	6
Active Listening																									0
Courteousness																									0
Affective Words																									0
Gestures					x		x							x		x			x	x		x	x	x	9
Voice Tone			x									x		x											3
No. Element	9	10	9	9	11	7	10	10	7	7	8	8	8	12	6	10	6	7	11	12	6	10	10	12	

ontology's elements are considered on the design of ITS. However, we also expected that the ontology purposed some new elements to the design of these systems. Table 6 shows the results.

ITS are increasingly aware of the user's profile not only considering aspects such as cognition, learning styles and student's objectives, also take into account emotions and motivation of the student in their tutoring process.

For their nature, the ITS bring individual support, and they are authentic. The development of these systems considers latency because ITS are aware of the user's actions. One of the main benefits of the ITS is the immediacy, unlike other systems, the interaction with an ITS is in real time. The authors know that it is important that ITS simulate a friendly and respectful attitude, for that reason they integrated animate pedagogical agents with gestures [2, 1, 10, 28, 39]. However, they do not consider aspects such as reliability.

On the other hand, the dialogue of ITS is empathic and eloquent [2, 1, 10, 28, 39]. However, they had a weak classification of words. The word is classified only into three groups: positive, neutral and negative. They do not use emotional and thoughtful words to communicate with the students. Also, the ITS are not active listeners.

According to our literature review, we can determine that researchers have a significant tendency to include student's characteristics such as affective states in ITS [14, 13]. Research has progressed providing to computer systems similar abilities to recognize an emotional expression such as expert teacher does. The ITS reported in the literature, are based on the detection of these factors during the tutoring. These researchers are getting closer to imitate human tutors.

The literature review describe that our affective learning ontology's elements are used by the current ITS reported in the literature. However, some items are not applied in ITS although learning literature states that are necessary to have an affective learning. As we above describe, affectivity improves student motivation and some cognitive processes, eventually it supports his learning process.

These findings suggested that our purposed ontology has enough elements to represent the affective learning, however, educational systems, such as ITS, not considered all of the ontology's elements.

5 Conclusions and Future Work

In this paper, we introduced our affective learning ontology based on the literature review. This ontology represents the affective domain in learning what do tutors needs to bring an affective feedback to the student, how the dialogue can improve the tutoring and which elements of the students need to be considered by the educational systems.

The mathematical evaluation states that our affective learning ontology has relationship richness. Moreover, this assessment indicates that our ontology has a horizontal nature, in other words, this ontology represent a generic domain. We need to work on the integration of attributes to the classes.

Also, this work presents a comparative study of which elements of the ontology are considered in the related work of the ITS. The results reveal that every day more ITS are aware of the needs of students considering cognition, learning style, emotional intelligence, objectives and motivation [14, 13]. However, these systems have a very simple dialogue structure, ie, do not take into account emotional aspects to improve the ITS's dialogue.

It is well known that the ITS can not replace human tutors. However, we can improve the user experience with these systems making them more effective and affective taking into account the elements of the purposed ontology.

This work is the basis for some lines for future research, such as: 1) developing a heuristic evaluation of ontology and update the ontology based on this assessment, 2) implementing the ontology in an ontology's language, 3) developing a formal representation of the ontology, and 4) designing an ontology-based guidelines for affective ITS design.

References

1. Alepis, E., Virvou, M.: Automatic generation of emotions in tutoring agents for affective e-learning in medical education. Expert Systems with Applications 38(8), 9840–9847 (2011)
2. Ammar, M.B., Neji, M.: The affective tutoring system. Expert Systems with ... 37(4), 3013–3023 (Apr 2010)
3. Angelaki, C., Mavroidis, I.: Communication and Social Presence: The Impact on Adult Learners' Emotions in Distance Learning. European Journal of Open, Distance and E-learning 16(1), 78–93 (2013)
4. Arguedas, M., Xhafa, F., Daradoumis, T.: An Ontology about Emotion Awareness and Affective Feedback in Elearning. 2015 International Conference on Intelligent Networking and Collaborative Systems pp. 156–163 (2015), http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=7312065
5. Armour, W.: Emotional intelligence, student engagement, teaching practice, employability, ethics curriculum. Investigation in university teaching and learning 8(2004), 4–10 (2012)

6. Arroyo, I., Woolf, B.P., Burelson, W., Muldner, K., Rai, D., Tai, M.: A Multimedia Adaptive Tutoring System for Mathematics that Addresses Cognition, Metacognition and Affect. International Journal of Artificial Intelligence in Education 24(4), 387–426 (2014)
7. Balakrishnan, A.: On Modeling the Affective Effect on Learning. Multi-disciplinary Trends in Artificial Intelligence pp. 225–235 (2011), http://link.springer.com/chapter/10.1007/978-3-642-25725-4_20
8. Banda, N., Robinson, P.: Multimodal Affect Recognition in Intelligent Tutoring Systems. In: Fourth International Conference, ACII 2011. pp. 200–207. Springer Link, Memphis, TN, USA (2011)
9. Barón-Estrada, M.L., Zatarain-Cabada, R., Zatarain-Cabada, R., Barrón-Estrada, A.: Design and Implementation of an Affective ITS. Research in Computing Science 56(August), 60–68 (2012)
10. Baylor, A.L., Kim, S.: Designing nonverbal communication for pedagogical agents: When less is more. Computers in Human Behavior 25(2), 450–457 (2009)
11. Bloom, B.: Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain. Addison Wesley Publishing Company, 2nd editio edn. (1984)
12. Chen, J., Luo, N., Liu, Y., Liu, L., Zhang, K., Kolodziej, J.: A hybrid intelligence-aided approach to affect-sensitive e-learning. Journal of Computing (2014), http://link.springer.com/10.1007/s00607-014-0430-9
13. D'Mello, S., Olney, A., Williams, C., Hays, P.: Gaze tutor: A gaze-reactive intelligent tutoring system. International Journal of human- ... 70(5), 377–398 (May 2012)
14. D'Mello, S.K., Graesser, A.: Language and Discourse Are Powerful Signals of Student Emotions during Tutoring. IEEE Transactions on Learning Technologies 5(4), 304–317 (Oct 2012)
15. D'Mello, S.K., Graesser, A.: Multimodal semi-automated affect detection from conversational cues, gross body language, and facial features. User Modelling and User-Adapted Interaction 20(2), 147–187 (2010)
16. Duffy, M.C., Azevedo, R.: Motivation matters: Interactions between achievement goals and agent scaffolding for self-regulated learning within an intelligent tutoring system. Computers in Human Behavior 52, 338–348 (2015)
17. Fernández-López, M., Gómez-Pérez, A., Juristo, N.: Methontology: from ontological art towards ontological engineering. Assessment SS-97-06, 33–40 (1997)
18. Ferreira, A., Atkinson, J.: Designing a feedback component of an intelligent tutoring system for foreign language. Knowledge-Based Systems 22(7), 496–501 (Oct 2009), http://www.sciencedirect.com/science/article/pii/S0950705109000070
19. Forbes-Riley, K., Litman, D.: Benefits and challenges of real-time uncertainty detection and adaptation in a spoken dialogue computer tutor. Speech Communication 53(9-10), 1115–1136 (Nov 2011), http://www.sciencedirect.com/science/article/pii/S0167639311000318
20. Forbes-Riley, K., Litman, D.: Benefits and challenges of real-time uncertainty detection and adaptation in a spoken dialogue computer tutor. Speech Communication 53(9-10), 1115–1136 (Nov 2011)
21. García, B.: Las Dimensiones Afectivas de La Docencia. Revista Digital Universitaria 10, 1–14 (2009)
22. Grafsgaard, J.F., Wiggins, J.B., Boyer, K.E., Wiebe, E.N., Lester, J.C.: Embodied affect in tutorial dialogue: Student gesture and posture. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 7926 LNAI, 1–10 (2013)

23. Ibarra, L.M.: Aprende fácilmente con tus imágenes, sonidos y sensaciones. Garnik Ediciones, México, 6ta edn. (2011), www.garnik.com
24. Jaques, N., Conati, C., Harley, J., Azevedo, R.: Predicting Affect from Gaze Data During Interaction with an Intelligent Tutoring System. In: 12th International Conference, ITS 2014. pp. 29–38. Springer Link, Honolulu, HI, USA (2014)
25. Juárez-Ramírez, R., Navarro-Almanza, R., Gomez-Tagle, Y., Licea, G., Huertas, C., Quinto, G.: Orchestrating an Adaptive Intelligent Tutoring System: Towards Integrating the User Profile for Learning Improvement. Procedia - Social and Behavioral Sciences 106, 1986–1999 (Dec 2013)
26. Kopp, K., Britt, M., Millis, K., Graesser, A.: Improving the efficiency of dialogue in tutoring. Learning and Instruction 22(5), 320–330 (Oct 2012)
27. Leontidis, M., Halatsis, C., Grogoriadou, M.: An Ontological Approach to Infer Student s Emotions pp. 89–100 (2009)
28. Lin, H.C.K., Wu, C.H., Hsueh, Y.P.: The influence of using affective tutoring system in accounting remedial instruction on learning performance and usability. Computers in Human Behavior 41(0), 514–522 (Dec 2014)
29. Motola, R., Jaques, P., Axt, M., Vicari, R.: Architecture for animation of affective behaviors in pedagogical agents. Journal of the Brazilian Computer Society 15(4), 3–13 (2009)
30. Munoz, K., Noguez, J., Kevitt, P.M., Lunney, T., Neri, L.: Work in progress: Towards an emotional learning model for intelligent gaming. Frontiers in Education Conference (FIE), 2010 IEEE pp. T3G–1 –T3G–2 (2010)
31. Navarro, M.R.: Procesos cognitivos y aprendizaje significativo. Comunidad de Madrid Consejeria de Educación, Madrid, España (2008)
32. Neviarouskaya, A., Prendinger, H., Ishizuka, M.: User study on AffectIM, an avatar-based Instant Messaging system employing rule-based affect sensing from text. International Journal of Human Computer Studies 68(7), 432–450 (2010)
33. Pagano, C.M.: Los tutores en la educación a distancia . Un aporte teórico. Revista de Universidad y Sociedad del Conocimiento 4(2), 1–11 (2008)
34. Ray, A.: Biophysical Signal Based Emotion Detection For Technology Enabled Affective Learning. In: 2015 IEEE International Conference on Electrical, Computer and Communication Technologies (ICECCT). pp. 1–6 (2015)
35. Rica, U.D.C., Pedro, S., Oca, M.D., Rica, C.: The Emotional Intelligence , its importance in the learning process. Educación 36(1), 1–24 (2012)
36. Tartir, S., Arpinar, I., Moore, M., Sheth, a., Aleman-Meza, B.: OntoQA: Metric-Based Ontology Quality Analysis. IEEE Workshop on Knowledge Acquisition from Distributed, Autonomous, Semantically Heterogeneous Data and Knowledge Sources pp. 45–53 (2005)
37. Theng, Y.L., Aung, P.: Investigating effects of avatars on primary school children's affective responses to learning. Journal on Multimodal User Interfaces 5(1-2), 45–52 (2012)
38. Vanlehn, K., Burleson, W., Echeagaray, M.E.C., Christopherson, R., Sanchez, J.G., Hastings, J., Pontet, Y.H., Zhang, L.: The Affective Meta-Tutoring Project: How to motivate students to use effective meta-cognitive strategies. 19th International Conference on Computers in Education, Chiang Mai, Thailand pp. 1–3 (2011)
39. Woolf, B.P., Arroyo, I., Cooper, D., Burleson, W., Muldner, K.: Affective tutors: Automatic detection of and response to student emotion. Studies in Computational Intelligence 308(Shute 2008), 207–227 (2010)

Author Index

A
Abramova, Veronika, 331
Abreu, Pedro Henriques, 869
Aguilar, Jose, 993, 1003
Alan, Ramirez-Noriega, 169
Alarcón, Pedro-Pablo, 797
Albiol-Pérez, Sergio, 1057, 1065
Alexandre, Claudio, 931
Alfalahi, Alyaa, 123
Almeida, Pedro, 253
Alonso, Igor Aguilar, 317
Alonso Rorís, Víctor M., 297, 659
Al-Qirim, Nabeel, 187, 431
AlShamsi, Asma Sultan, 431
Alvarado, Daniel, 717
Alvarez, Fernando, 759
Álvarez Sabucedo, Luis M., 297
Amorim, Paulo, 889
Amundin, Stefan, 777
Andrade, Thiago, 787
Araújo, Cristiana, 401
Araujo, Maria Valeria, 817
Ayres, Fausto, 369
Azevedo, Américo, 455

B
Báez, Andrés, 717
Balsa, João, 931
Barão, Alexandre, 59
Barba-Guamán, Luis, 797, 993
Barlybayev, Alibek, 1037
Barta, János, 223
Bauza, Cristian García, 243
Beltramone, Diego Antonio, 1047
Bernardino, Jorge, 253, 331, 767
Bernis, Aracne, 1057, 1065
Bolaños, Constantino, 717
Bonifaz, Edison Fernando, 467
Botega, Leonardo Castro, 145
Brandstetter, Pavel, 671
Brito, Alisson, 911
Bucheli-Andrade, José-Gioberty, 1065
Busarello, Raul Inácio, 1107

C
Cabral, Bruno, 767
Cacho, Andrea, 817
Cacho, Nélio, 787, 817
Caldeira, Filomena, 157
Camska, Dagmar, 411
Caro, Edmundo Tovar, 317
Carreteiro, Paulo, 59
Carvalho, Maria Sameiro, 951, 973
Cassio, Arthur, 817
Castillo, Víctor H., 1117
Castro, Dayvid, 1015
Castro, Jaelson, 609
Cevallos, Rosario Estefania Sanchez, 629
Chamba-Eras, Luis, 993, 1003
Chaves, Leonardo Grandinetti, 351
Cifuentes, Virginia, 243
Coelho, Jazon, 787, 817
Cognini, Riccardo, 579
Coneglian, Caio Saraiva, 145, 307
Corbellini, Alejandro, 919
Cordero, Jorge, 993, 1003
Correa, Roddy, 691
Correia, Anacleto, 379
Correia-Neto, Jorge S., 69
Costa, Ana Paula Cabral Seixas, 3
Costa Lima, Gabriel A., 835
Costa, Marco, 983
Cota, Manuel Pérez, 567
Crisóstomo, João, 749
Cunha, Tiago, 869, 879

D
D'Amato, Juan P., 243
de Barros, Rafael S.V., 835
de Campos, Sílvia Regina Machado, 25

Á. Rocha et al. (eds.), *New Advances in Information Systems and Technologies*,
Advances in Intelligent Systems and Computing 444,
DOI 10.1007/978-3-319-31232-3

de Carvalho, Rodrigo Baroni, 351
de Carvalho, Victor Diogho Heuer, 3
de Castro Botega, Leonardo, 307
de Castro, Leandro Nunes, 1025
da Cruz, Maria Aparecida Lopes, 503
de Freitas e Lopes, Andiara Valentina, 1107
Degrigny, Christian, 961
de Lima Júnior, Joel Alves, 69
de Moraes, André Fabiano, 179
de Oliveira, Pedro P.B., 707
De Santo, Alessio, 263
da Silva, Celmar Guimarães, 835
da Silveira, Denis Silva, 47
de Vasconcelos, José Braga, 59
del Salto, Victor Hernandez, 629
Dong, Chau S.T., 671
dos Santos, Henrique Manuel Dinis, 503
Drias, Habiba, 113
Duarte, Francisco, 681

E
Enciso, Liliana, 287, 797
Escobar-Anchaguano, Ivón-Patricia, 1057, 1065
Escobar, Suzana Alves, 213
Estaregue, Daniela, 787

F
Fadel, Luciane Maria, 1107
Fael, Paulo, 681
Faria, Brígida Mónica, 101, 1085
Faria, José, 455
Farias, Hiarley, 817
Ferreira, Adelino, 681
Ferreira, Filipe, 455
Ferreira, Jonathan Emannoel, 341
Figueira, Alvaro, 89
Figueredo, Mickael, 817
Filho, José Ahirton Batista Lopes, 1025
Fiorese, Adriano, 341
Flores, Claudia Paola Cartuche, 359
Fortuna, Paula, 89
Fragoso, Bruno, 379
Freitas, António Paulo, 557
Fusco, Elvis, 307

G
Garbajosa, Juan, 287
Garcia, Alexander, 201
Garcia, J. Esparteiro, 827
García, Víctor Hugo Medina, 79
Gaspoz, Cédric, 263, 961
Giraldo, Germán Andrés Méndez, 79
Godoy, Daniela, 919
Gomes, Jorge, 547
Gómez Alvarado, Héctor F, 359
Gonçalves, António, 379
Gonçalves, Joaquim, 567
Grañeda, José M., 157
Granja, Fernando Molina, 467
Grosjean, Marcel, 961
Guamán, Daniel, 691
Guamán, Franco, 691
Guedes, Gabriela, 609
Guerrero, Javier Sanchez, 441
Gusmão, Claudio Alexandre, 213
Gusmão, Cristine, 1015
Gusmão, Rodrigo, 157

H
Habib, Sami, 901
Henkel, Martin, 389
Henriques, Pedro R., 401
Henriques, Roberto, 25
Heredia, Edmundo Cabezas, 467
Hoch, Ralph, 589
Hwang, Ting-Kai, 943

I
Ienco, Dino, 879
Inzunza, Sergio, 649

J
Jaramillo, Danilo, 691
Jimenez, Samantha, 169, 1117
Jin, Bih-Huang, 39, 943
Jorge, Luís, 749
Juárez-Ramírez, Reyes, 169, 649, 1117
Junior, Valdir Amancio Pereira, 145, 307

K
Kaindl, Hermann, 589
Kanter, Theo, 777
Khennak, Ilyes, 113
Kisly, Dmitry, 951, 973
Klemm, Reinhard, 807

L
Lazo, Marcos, 243
Leão, Marcelo Brito Carneiro, 69
Lenzini, Gabriele, 1073
Le, Thanh Manh, 233
Librelotto, Giovani R., 401
Lima, Fabiano, 511
Lima, Joselice Ferreira, 213
Lino, Adriano, 855
Li, Yung-Ming, 39, 943
Loiola, Emiliano, 787

Longo, Mathias, 739
Lopes, Frederico, 787
Lopes, Isabel, 493
López, Gustavo, 717
López, Mariana, 717
Lourenço, João Ricardo, 767
Lucas, José, 817

M
Maia, André, 869
Maluleka, Simon Motlatsi, 481
Marani, Michelangelo, 579
Marimuthu, Paulvanna N., 901
Marques, Ana Luísa, 455
Marquez, Jack, 201
Martinez, Alexandra, 717
Martínez, Silvia Elena Malo, 359, 441
Martini, Ricardo G., 401
Martins, Jair, 511
Mateos, Cristian, 739, 919
Matos, Rui, 379
Medeiros, Francisco, 369
Medeiros, Juliana, 369
Meidanis, João, 835
Mejía, Jezreel, 421
Mena-Mena, Luis-Enrique, 1057, 1065
Mendes, Eder, 369
Mendes, Luiz, 817
Mendonça, Dener Guedes, 213
Mendonça, Marcel, 787
Meneses, Filipe, 101
Merino, Mateo Ramos, 297, 659
Montemanni, Roberto, 223
Moraes, Thiago, 889
Mora, Rodrigo, 717
Moreira, Pedro Miguel, 1085
Moura, Arnaldo Vieira, 835
Moura, Brunna, 787
Muñoz, Mirna, 421

N
Nascimento, Ademir Macedo, 47
Netto, Dorgival, 599
Neves, João, 157
Neves, José, 157, 845
Novais, Paulo, 845

O
Oliveira, Adriano L.I., 1015
Oliveira, Maychell, 787
Oliveira, Pedro, 493
Oliveira, Thiago, 911
Oliveira, Tiago, 845

P
Paiva, Ana C.R., 827
Pasti, Rodrigo, 1025
Pedrini, Helio, 889
Peña, Adriana, 421
Pereira, José Luís, 557, 619, 983
Perez, Jesus, 759
Perjons, Erik, 389
Persson, Magnus, 777
Petkovic, Dušan, 13
Pilatasig-Panchi, Marco-Antonio, 1057, 1065
Pires, Francisco, 331
Pitarma, Rui, 749
Placeke, Jan, 411
Poleto, Thiago, 3
Polzonetti, Alberto, 579
Poncelet, Pascal, 879
Popp, Roman, 589
Primo, Lane, 1097
Prolo, Carlos, 817
Pruna-Panchi, Edwin-Patricio, 1057, 1065

Q
Quezada, Pablo, 287, 797
Quintana, María Luz Quinteros, 1047
Quintero, José Fernando López, 79
Quiquerez, Brice, 263
Quirós, Steve, 717

R
Rahman, Hasibur, 777
Rahmani, Rahim, 777
Ramírez, Heltton, 421
Ramírez-Noriega, Alan, 649, 1117
Rathmair, Michael, 589
Re, Barbara, 579
Rego, Carlos Moreira, 101
Rego, Paula Alexandra, 1085
Reis, José Luís, 275
Reis, Luís Paulo, 101, 1085
Reyes, Alex Paúl Ludeña, 629
Reyes, Juarez-Ramirez, 169
Rivarola, Marcela Fabiana, 1047
Rocha, Álvaro, 59, 567, 855
Rocha, Josemary, 369
Rocha, Rui, 1085
Rodrigues, Tomy, 879
Rodriguez, Ana, 739
Romão, Mário, 547
Rosário Martins, M., 157
Rosselet, Antoine, 961
Ruxwana, Nkqubela, 481
Rybarczyk, Yves, 731

S
Saadeldin, Mohamed, 639
Sabucedo, Luis Álvarez, 659
Sabyrov, Talgat, 1037
Sá, Filipe, 567
Samantha, Jimenez, 169
Sanches, Mathues Ferraroni, 145
Sánchez, Manuel, 993
Sánchez, Natalia Soledad Bustamante, 441
Sandim, Miguel, 89
Santos Gago, Juan M., 297, 659
Santos, Ana, 369
Saul, Ventura, 523
Schiaffino, Silvia, 919
Segovia-Chávez, Janeth, 1057, 1065
Segundo, José Eduardo Santarém, 307
Sergio, Inzunza, 169
Sharipbay, Altynbek, 1037
Silva, António, 845
Silva, Carla, 599, 609
Silva, Diogo, 619
Silva, Jorge, 889
Silva, Luis Augusto, 179
Sizo, Amanda, 855
Sjöbergh, Jonas, 123
Smith, Derek H., 223
Smrcka, Lubos, 411
Sneiders, Eriks, 123, 135, 389
Soares, Carlos, 869, 879
Soares, Monique, 609
Soares, Zorandir, 707
Solano, Andrés, 717
Solano, Lida, 797
Solarte, Zeida, 201
Sombrio, Graziela, 1097
Sousa, Maria José, 511, 535
Souza, Ellen, 1015
Souza, Maria Angélica, 835
Spagnuelo, Dayana, 1073
Sussy, Bayona, 523

T
Tapia, Susana Alexandra Arias, 441, 629
Tayrony, Tyago, 787
Teixeira, Gustavo, 213
Teixeira, Marcelo Mendonça, 69
Teles, Ingryd, 1015
Tereso, Anabela, 951, 973
Thieu, Tri Q., 671

U
Ulbricht, Vânia, 1097

V
Valdiviezo-Díaz, Priscila, 993
Valencia, Hernando Buenaño, 441
Valero, Javier Sanz, 659
Van, Thanh The, 233
Verardo, Maurício, 707
Verdún, José Carrillo, 317
Viadanna, Paulo, 835
Viana, Caio, 369
Vicente, Henrique, 157
Vicente, Morales, 523
Viegas, Victor, 369
Vieira, Francielle M.F., 179
Vilar, Guilherme, 69
Vilela, Jéssyka, 609
Vilhena, João, 157
Villanueva, Jhorman, 201
Villarouco, Vilma, 1097
Vinuesa, Luis, 759
Vitório, Douglas, 1015
Vo, Duy H., 671
Vo, Hau H., 671

Y
Yammahi, Aishah Rashid, 187
Yammahi, Maraim Ahmed, 187
Yanaze, Mitsuru Higuchi, 25
Yánez, Raúl Lozada, 467
Yobani, Martinez-Ramirez, 169

Z
Zaher, Hegazy M., 639
Zumbana, Paulina, 1057, 1065
Zunino, Alejandro, 739, 919