Yuhua Luo (Ed.)

LNCS 4101

Cooperative Design, Visualization, and Engineering

Third International Conference, CDVE 2006
Mallorca, Spain, September 2006
Proceedings

Springer

Lecture Notes in Computer Science 4101

Commenced Publication in 1973
Founding and Former Series Editors:
Gerhard Goos, Juris Hartmanis, and Jan van Leeuwen

Yuhua Luo (Ed.)

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Third International Conference, CDVE 2006
Mallorca, Spain, September 17-20, 2006
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Volume Editor

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Library of Congress Control Number: 2006932156

CR Subject Classification (1998): H.5.3, H.5.2, H.5, H.4, C.2.4, D.2.12, D.4, H.2.8

LNCS Sublibrary: SL 3 – Information Systems and Application, incl. Internet/Web and HCI

ISSN 0302-9743
ISBN-10 3-540-44494-7 Springer Berlin Heidelberg New York
ISBN-13 978-3-540-44494-7 Springer Berlin Heidelberg New York

Springer is a part of Springer Science+Business Media

springer.com

Printed in Germany

Typesetting: Camera-ready by author, data conversion by Scientific Publishing Services, Chennai, India
Printed on acid-free paper SPIN: 11863649 06/3142 5 4 3 2 1 0

Preface

This is the third edition of the CDVE conference series. The cooperative design, visualization and engineering community is growing steadily, even if it is still in its infancy. Again, we gathered together on the beautiful Mediterranean island of Mallora to exchange our research and development experience.

This year we received numerous papers on cooperative engineering and many different aspects of cooperative applications. The objective of cooperative design, visualization and engineering is for the successful final production of the products and providing solutions for end user problems. We are happy to see the CDVE conference has more successful results in this end.

I would like to thank all the authors who submitted their papers to the CDVE2006 conference. I would also like to express my thanks to the Program Committee and many volunteer paper reviewers for their valuable contribution to the conference. Their contributions together with the papers published in the CDVE2006 proceedings form part of the history that we will be proud to look back on after years.

September 2006 Yuhua Luo

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Automated Social Network Analysis for Collaborative Work*

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Abstract. Inter-networked computers enable virtual collaborative work. In the course of interacting with one another, individuals send and receive messages and files of various sorts. This may be done within specialized collaborative work environments, or by simply employing a combination of different communication tools and applications. In the course of doing their work, collaborators perform different actions that create and/or otherwise manipulate digital artifacts that are related to different aspects of their collaboration. Social network analysis is used to develop a fuller understanding of interactions between people. We describe a software prototype of a tool that automatically measures and analyzes aspects of collaboration developing visualizations of likely social interactions. In this paper we describe the system, some early results, and several different possible applications of the technology.

1 Introduction

"Computer-supported cooperative work" (CSCW) refers to cooperative work carried out by one or more individuals with computer and network support [1]. CSCW is often used to refer to the situation where people work together in dynamically-formed groups to accomplish particular tasks. Many of the different tasks may be accomplished using various computer applications. The nature of the applications may include file sharing of design documentation, white board applications for brainstorming, messaging systems, video conferencing to facilitate more tangible connection between collaborators and email for asynchronous communication.

These different types of network applications are used at different times depending on which of four modes of CSCW operation [1, 2] participants prefer to use: synchronous, distributed synchronous, asynchronous and distributed asynchronous. Many software applications have been developed specifically for CSCW, while other desktop applications are evolving to include collaboration functions [3].

In this paper we describe the implementation of a system intended to determine, in real time, the development of social networks during collaborative work. This Automated Social Network Analysis Technology (ASNAT) is an implementation and

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* National Research Council Paper Number 48732.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 1 – 8, 2006.

extension of work we have introduced previously [4]. As its key advantage, it is not reliant on the use of any particular design or visualization application. The technology has many different possible uses, some of which we describe in a subsequent section.

In this paper, section 2 describes the problem we are addressing. Section 3 presents our approach, from our abstraction model, to system implementation details. We discuss some results, sketching possible applications of ASNAT in Section 4. Section 5 provides a discussion and conclusions.

2 Problem Statement

Social Network Analysis (SNA) [5] is a very powerful tool used to help form a better understanding of how people work together. SNA has been applied for many different purposes [6, 7, 8, 9]. However it has been found especially useful in understanding how groups of people interact via electronic communication [10, 11] such as usenet news and email. Social network analysts seek to describe, as fully as possible, networks of relationships between people, including relationships maintained by computer or network mediated interactions, or for the allocation of resources needed for work. SNA display relationships as graphs, with nodes representing individuals, and edges representing interactions types. The degree and type of interactions may be represented by the lengths, colors, and widths of nodes and edges. The information used in a social network analysis is almost always gathered manually. Manual collection involves observation and recording of activities, and/or the use of questionnaires, interviews and diaries. The reliability of the SNA results is often questioned because of the complex nature of this process. For instance, incorrect reporting (intentional or not), often occurs when participants record their own activities. Different interactions may not be remembered equally as well. Statistical data processing tools have been used to discover interaction patterns [9]. Analysts have used these patterns to interpret and to uncover what aspects were responsible for successful collaboration (for instance for design purposes) [10]. On a wider scale, SNA has been used to determine how organizations operate.

Our work involves the development of a system for automatically discovering and analyzing social networks inferred from the digital artifacts created when people interact with one another over computers and computer networks.

3 Our Approach

Figure 1 provides a schematic overview of the ASNAT approach. People within organizations communicate and collaborate with one another, while working to achieve their objectives. Computer networks form a common means for communication and interaction. In a computer-mediated environment, people often don’t communicate in real space and time with one another. Instead, they work together using digital means. Networks facilitate remote interaction. In the course of performing various computer and network interactions, digital artifacts are created, shared, modified, moved and destroyed among collaborators. These artifacts may be files, email messages, instant text messages, mouse or keyboard actions, network activities, etc. The artifacts are linked to the collaborative process. Our approach involves discovering artifacts on each computer platform created in the context of collaborations and determining the relationships between artifacts on all computers across a network. In other words, ASNAT performs a reverse engineering process on digital artifacts to detect patterns of human collaboration.

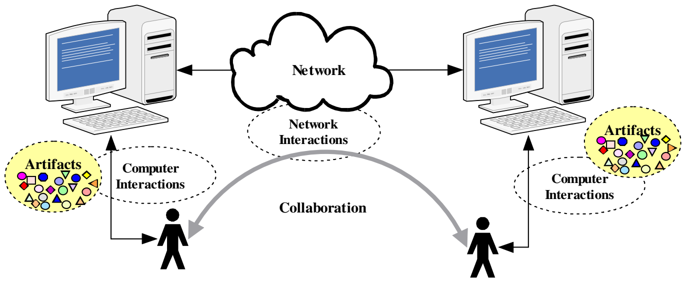

Fig. 1. Human collaborations and computer activities

3.1 Design

In the context of ASNAT, a social network model is a schematic description of a set of social behaviors amongst users based upon digital artifacts developed within an enterprise. Figure 2. shows the ASNAT abstract design model.

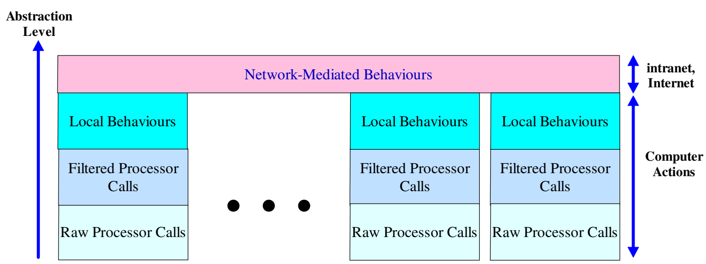

Fig. 2. Abstraction model for ASNAT

ASNAT uses a pair of software agents per computer platform. One agent monitors low level computer system calls, filtering them to produce a set of local artifacts related to local behaviors. The second agent accesses these artifacts, communicates with peers to determine the global relationships based upon a correlation with the artifacts of others. The correlation provides for fuzzy matching of artifacts.

ASNAT uses several components in the course of developing relationship diagrams. These include:

• A data structure to hold the filtered processor calls. There is a very large amount of raw data generated in a short period of time. To reduce the amount of data, unnecessary or duplicate information is filtered out retaining only activities that are collaboration inspired before any further processing.

• A set of rules/logic for creating and updating the relationship model. Based on the filtered data, ASNAT builds models representing local social behaviors. The local model provides views of social networks from an individual point of view.

• A set of methods (interfaces) for manipulating the model and interactions between relationship models. Based on local social behaviors in the third layer, ASNAT can build models representing social behaviors with an enterprise scope for real-time display.

• A graphical representation model for displaying the work flow and SNA models to a user. Currently there are several different software packages available for viewing and manipulating graphical representations of social networks, each with its own image format. We use an internal graphical representation that facilitates rapid display, manipulation, while offering easy conversion into other social network analysis formats (for instance Pajek [12])

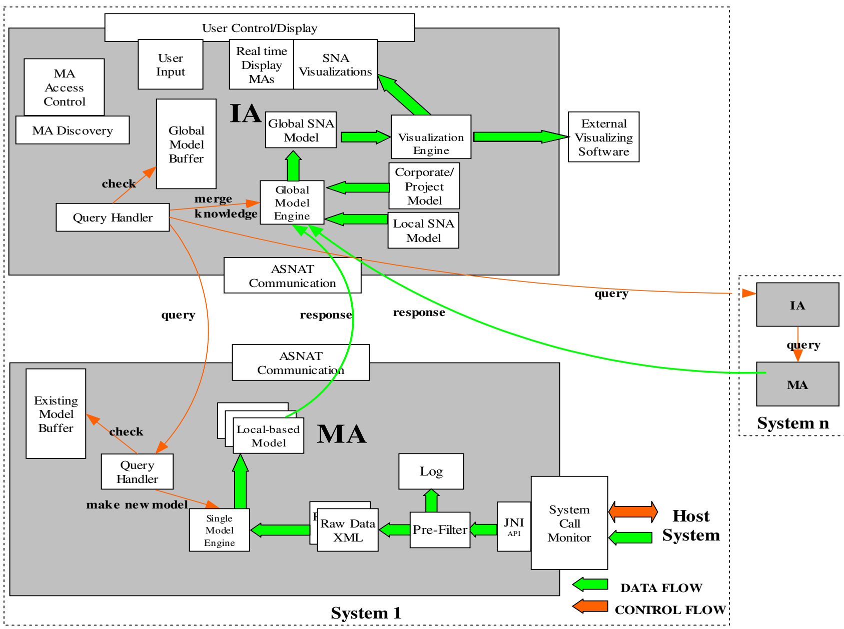

Fig. 3. This diagram details the Monitoring Agent (MA) and the Interface Agent (IA) along with a simplified description of the information flows, shown for only one direction. In reality the IA handles bidirectional queries.

3.2 Implementation

ASNAT is implemented in C++, and Java [13] (on the Java Agent Development Environment (JADE) [14]). It is a decentralized design; using two agents resident on each computer. The Monitor Agent (MA) and the Interface Agent (IA) are illustrated schematically in Figure 3. The agents work together in the collection of artifact activity and for workflow and social network analysis. The Monitor Agent contains the sensing elements. A Java to Native language Interface (JNI) allows our Java application to communicate with lower level system calls (written in C++). The system call monitor can monitor any computer activity (keyboard, mouse, window operations, network accesses, etc.). System call events are filtered to form the digital artifacts relevant for later analysis. The event information is analyzed to build a single user model, organizing artifacts that indicate possible social interactions. There may be many local models based upon the different types of artifacts being monitored.

The Interface Agent (IA) serves several purposes. One purpose is to build global models of networks-of-interest related to the local Monitoring Agent (MA). It does this by using the local models to formulate queries to be sent to other IAs through the IA's Query Handler. Responses from these queries are analyzed for fit within a global social network model based upon models for the local node. The Global Model Engine in turn handles queries from remote IAs to determine the correlation between local and remote artifacts The IA includes a visualization engine for workflow and social network models. A user interface provides many options for presenting and manipulating different social network analyses and visualizations. The IA also facilitates translation of ASNAT social networks into PAJEK format for other analyses.

4 Results and Applications

We have implemented many different sensors and filters for ASNAT. In this section we focus on artifacts related to files alone. Figure 4 is a screen snapshot of the user interface for the ASNAT Interface Agent. We use a multi-paned dialog box to select different views and to control the analysis of artifact relationships. The screen shot shows one graphical view of global file accesses by 4 different users (grey circles). The (red) squares indicate the different files a user has handled. The pink-colored

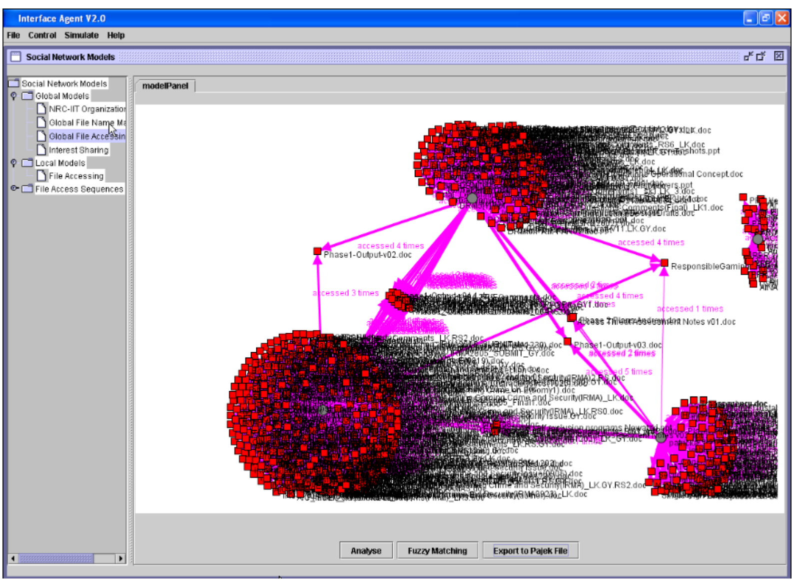

Fig. 4. Screen snapshot of the user interface for the Interface Agent

edges with arrows between users point to red squares indicate files that were apparently shared between the users. In the left panel, an operator can chose different types of views.

Understanding workflow is important within a project or within an organization as a whole. ASNAT provides a visualization of workflow within an organization that can be superimposed upon an organizational structure as shown in Figure 5.

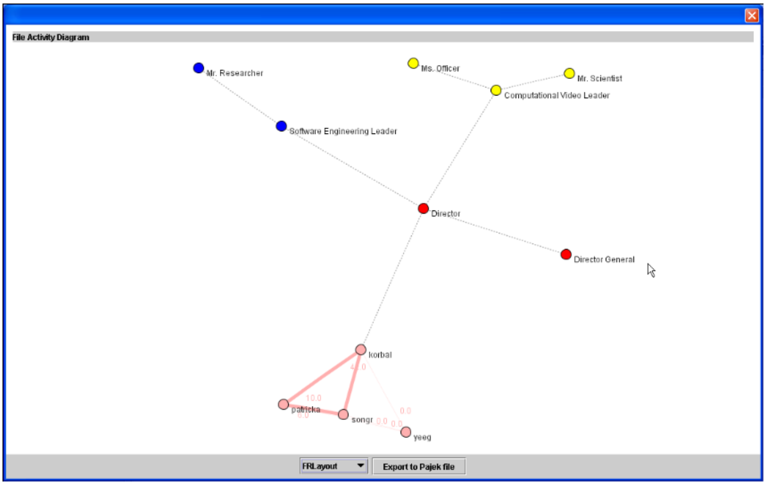

Fig. 5. Screen snapshot from the Interface Agent showing organizational structure superimposed on the interactions between 4 different individuals

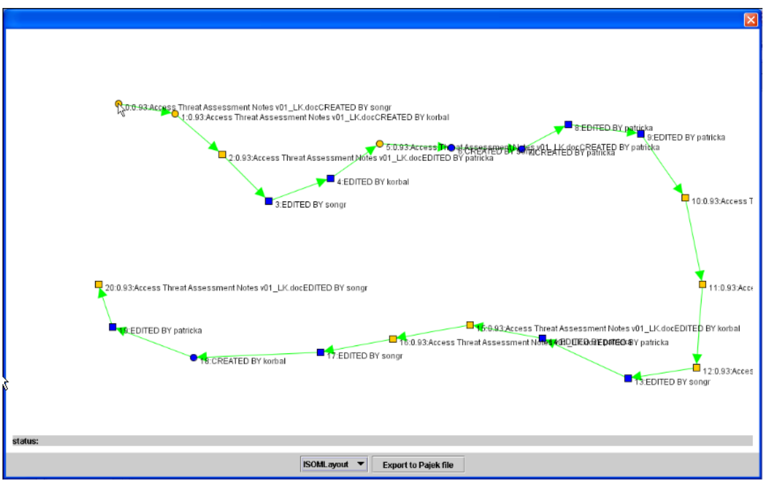

Fig. 6. A screen snapshot for ASNAT showing activity across different users for one file over time. Contributions by different users are described at each node.

Another view implemented in our prototype is a graph of the activity related to one particular file artifact with the passage of time (see Figure 6). As individuals collaborate they generally create, edit, and share files. Sharing files may be accomplished using file transfer programs, network file servers, email, or other means. Clearly, individuals may also change the names of the files they receive and edit. ASNAT keeps track of these changes, logically linking files that may have had a similar origin. This is done both heuristically while users perform different file manipulation operations and by a fuzzy name matching technique in cases where ASNAT is determining relationships forged by examining file activity across different users' computers.

Automated workflow analysis using social networks as implemented in ASNAT has many possible applications. Due to lack of space we only briefly mention them here.

- By tracking interactions with files related to organizational operations (e.g. human resources), the system could map actual work flow amongst employees.
- ASNAT may also be used to assure that employees adhere to project or organizational policies, for instance for security, thus automating compliance.
- At the work-activity level, ASNAT could be linked with project management software to provide team members with a way of determining, at a glance, the status of different parts of the project, irrespective of the collaboration applications. This approach would also be useful for automating the discovery of expertise [15] as well as a tool for understanding the dynamic evolution of social relationships in groups [7]
- When equipped with text summarization or concept extracting software that extracts key contributions from different users in the documents they have produced, ASNAT could automatically produce or update knowledge profiles for organizational staff; an approach that would be helpful in determining expertise [8] or maintaining project/corporate memory.
- As illustrated in Figure 6, ASNAT could produce a type of forensic display associated with building a design-related document. This would be useful to determine what was done, by whom and when - invaluable information for all project members.
- With the addition of software for distributed replication of files produced by team members, ASNAT could become a distributed repository for many different versions of documents associated with a design, allowing users to easily access any version of a design at any time from anywhere on the corporate network.
- ASNAT could be the basis of a system to detect and subvert inappropriate insider behavior. Normal workflow for individuals in different organizational positions may be compared automatically against those for a person under suspicion in a similar position in an organization.

5 Conclusions

In this paper we have described the development of ASNAT, a system that embodies automated social network analysis technology. ASNAT has several possible applications. However, it is clear that in order to be successfully deployed, the functionality of the application must be carefully considered to assure that the system is not used for unbridled monitoring of employee behavior. Currently we are extending the prototype for security and privacy compliance. This work also involves adding security mechanisms to prevent leakage of corporate data through ASNAT operations.

Acknowledgements

The authors acknowledge the Communications Security Establishment for its support in this work. We also acknowledge the assistance of Dr. Yuefei, Yungfeng Li, Tian Yuan, Hui Wang, Myroslav Palenychka, Ravi Chauhan, and Lun Howe Mark.

References

1. B. Bruegge and A. Houghton, Computer-Supported Cooperative Work: Discussion Summary, *Software Engineering: Education and Practice International Conference*, pp. 516-519, 1996.
2. K.L. Mills, Introduction to the Electronic Symposium on Computer-Supported Cooperative Work, A*CM Computing Surveys*, Vol. 31, No. 2, June, pp.105-115, 1999.
3. Ricadela, A., Office 2007 to feature new workflow and collaboration tools, Information Week, Feb. 15, 2006, available at: http://www.informationweek.com/shared/ printableArticle. jhtml?articleID=180202580
4. Temdee, P., Korba, L. Of Networks, Interactions and Agents: An Approach for Social Network Analysis, *Proc. 6th International Conference on CSCW in Design*, London, Ontario, July 12-14, 2001
5. B. Wellman, For a social network analysis of computer networks: a Sociological Perspective on Collaborative Work and Virtual Community, *Proc. of the 1996 conference on ACM SIGCPR/SIGMIS Conference*, pp. 1-11, 1996.
6. Domingos, P., Richardson, M. Mining the Network Value of Customers, *Proc. of the 7th ACM SIGKDD Int. Conf. on Knowledge Discovery and Data Mining,* San Francisco, pp. 57-66, 2001.
7. Gloor, P. A. Capturing Team Dynamics through Temporal Social Surfaces, *Proc. of the 9th Int. Conf. on Information Visualization 2005*, July 6-8. 2005, pp. 939-944.
8. Zhang, J., Ackerman, M. Searching for Expertise in Social Networks: A Simulation of potential Strategies, *Proc. of the 2005 Int. ACM SIGGROUP conf. on Supporting Group Work*, Florida, 2005, pp. 71-80.
9. A. Popescul, L. Ungar. Statistical Relational Learning for Link Prediction, *Workshop on Learning Statistical Models from Relational Data,* IJCAI 2003.
10. Lin, F., Chen, C., Tsai, K. Discovering Group Interaction Patterns in a Teachers Professional Community, *Proc. 36th Ann. Hawaii Int. Conf. on System Science*, Jan. 6-9, 2003.
11. Fischer, D. Using Egocentric Networks to Understand Communication, *IEEE Internet Computing*, Vol 9, Iss. 5, Sept-Oct 2005, pp. 20-28.
12. Pajek: Program for Large Network Analysis Available at: http://vlado.fmf.uni-lj.si/ pub/ networks/pajek/
13. Java programming language. Available at: http://java.sun.com/
14. Jade Platform available at: http://sharon.cselt.it/projects/jade/ March, 2006.
15. Yu, B., Singh, M. Searching Social Networks, *Proc. of the 2nd Int. Joint Conf. on Autonomous Agents and Multiagent Systems*, Melbourne, Australia, 2003, pp. 65-72.

Jabber Based Protocol for Collaborative Mobile Work

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Abstract. In this paper we introduce an application level protocol for sharing of XML based data. This protocol is especially designed for mobile environment. It is able to deal with unreliability of the mobile wireless networks where the client's bandwidth is limited and the connection may frequently fail. We describe the synchronization process of the data from the client side as well as from the server side. The protocol can deal with data synchronization conflicts and can prevent them in most cases by using data locking mechanism. Data buffering mechanism from client and server side is supporting the re-establishing of data consistency after connection failure. The protocol has been verified by means of a scenario from a facility management domain.

1 Introduction

Fast development of miniaturized computers, e.g. handhelds like PDA (Personal Digital Assistant), smart phones and tablet PCs has brought new possibilities into our every day life. When combined with wireless networks like GSM, GPRS, EDGE or UMTS, these technologies promise to open new communication possibilities among people anywhere and anytime. Applications utilizing the possibilities of wireless networks must deal with a set of new issues connected with mobility of the user(s) and reliability of the networks. This is especially true when several users want to share some data and to collaborate on solving an upcoming problem. The currently existing data sharing and collaborative tools as well as the instant messaging tools are designed for stationary networks where the risk of connection failure is not high and therefore it is not solved by the software. Our goal is to solve some of the issues by creating an appropriate protocol for reliable data sharing and synchronization. Such a protocol is able to minimize the risk of data loss and will enable us to perform a smooth work on a shared data.

1.1 Use Case

The functionality of our system is tested and verified on a use case from the domain of facility management. In our primary use case we have a large construction site where the construction site manager is inspecting the work done. During this inspection he/she is equipped with a handheld PDA device with GPRS connectivity. The manager can download construction plans from a central database or can use plan

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 9 – 16, 2006.

stored locally on the PDA device. The plans are in SVG (Scalable Vector Graphics) format [4] and they are therefore suitable for the given task (they can be zoomed without loss of quality). If the manager discovers any problem he/she is not able to solve alone, he/she can contact one or more other experts. They can start a collaborative session. During the session they can share the SVG data or any XML [5] based data and use instant messaging features. The users can browse the data and change them in a form of a shared annotations. The annotations are of multimedia nature, e.g. drawing, text, bitmap images or audio recordings. All users work on their local copies of the data. These copies are transparently synchronized with each other. In case one user losses the network connection, he/she can continue in work on the local copy. All changes will be synchronized as soon as the connection is reestablished. Finally the result of the collaboration is saved on the server and will serve for later post-processing phase.

2 Problem Definition

Work in the mobile environment brings specific requirements to the user, devices and especially to the software used. In case of a continuous collaborative work, the low reliability of the wireless network is a big problem. Short and long time disconnections may occur, the device may even change IP address or connection type (GPRS to WiFi). The commonly used communication protocols for instant messaging (Jabber, ICQ, Yahoo, MSN) are not designed to deal with problems of mobile networking and data synchronization. We have therefore designed a new application level communication protocol that allows reliable data sharing and smooth user collaboration during unexpected network reconfiguration or disconnection. The data sharing format is implemented as a generic XML based data format and its usage has been demonstrated on sharing of plans in SVG format.

3 Solution

Our solution is based on a client-server architecture see Fig 1. In such architecture the main authority controlling the process of data sharing and synchronization is the dedicated server. This server is usually placed in a static network and the communication bottleneck is therefore not critical. Each mobile client is communicating exclusively with the server and it does not need to store any connection information about other clients. Messages are distributed by the server which limits the traffic on the client side.

Our solution of design and implementation of a protocol for synchronization of data in the mobile environment is derived from an existing instant messaging protocol Jabber. The Jabber protocol uses unique user identifier similar to e-mail address, which makes it resistant to physical address change of the device. It is XML based which makes it easily extensible by introducing new namespaces. The protocol uses “store and forward” technique for data distribution which is a suitable strategy for the unreliable networks.

3.1 Jabber Protocol Extension

The Jabber protocol was extended to support asynchronous sharing of XML data format. In our system each client consists of these basic units (see Fig. 1):

SVG editor is parsing and displaying the SVG data and is the front-end application for the user. The editor is event driven, and it does not distinguish events whose source is the local user or a remote user.

Data synchronization unit is responsible for evaluating of events and acknowledging of events from all sources, storing information data locks and for event buffering if necessary. This unit is the core component for correct data synchronization.

Data transmission unit is implementing the Jabber protocol client with extensions for collaborative work. This unit is responsible for connecting to the server, eventually for reconnecting in case of connection failure. It also implements all well known instant messaging functions like message sending, chatting and others.

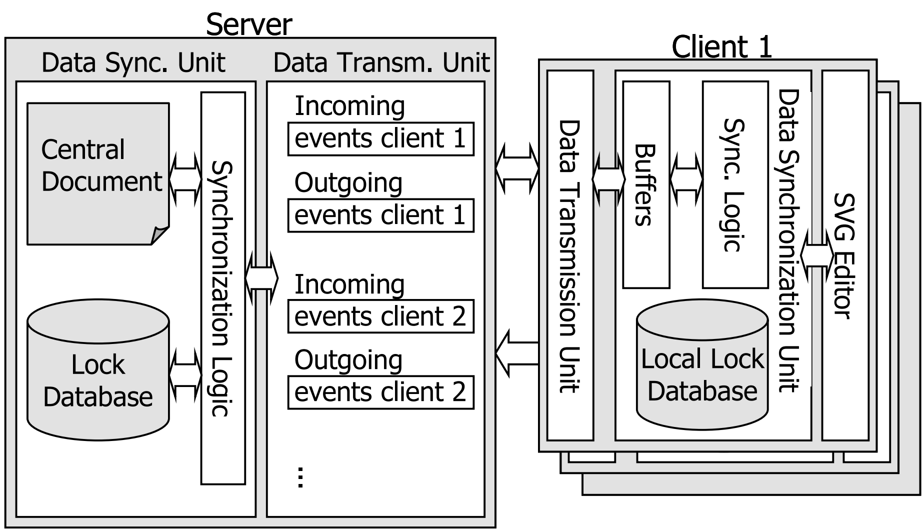

Fig. 1. Client server architecture used in SVG sharing and collaboration system

The data synchronization unit is responsible for updating the document. The updates are in a form of events with XUpdate structure [6]. The source of an event is either the local SVG editor or an editor of another user. The terminology used here is:

- Internal event – A document update, which was made by the local user. This update must be successfully propagated to the central document, which is held by the server. Otherwise, it must be rolled back (undone).
- External event – A document update, which was made by some other user. It is already propagated to the central document, but it is not yet propagated to the document of the local user.

- Update conflict – Two updates are in conflict, if they both update the same document element. Every update affects a number of elements. If these lists of objects of internal and external events are not disjoint, then the updates (events) are in conflict.
- Timestamp – Every update command or event contains a timestamp attribute. The timestamp has meaning of a document version. Document versioning is made on the server side. When a client makes a new internal event, it does not increase a document version. The document version is increased when the internal event is successfully performed by the server.

Figure 2 is illustrating the Internal and External event lifecycle.

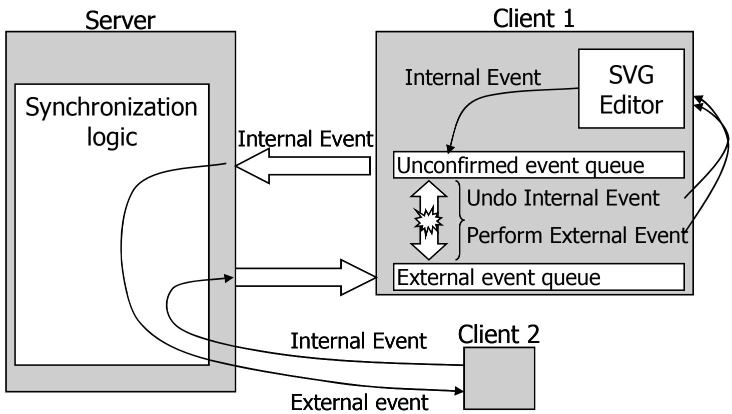

Fig. 2. Internal and External Event lifecycle

3.1.1 Synchronization Model

The synchronization uses the client-server model with one central server. Server holds the actual copy of the document, which is the only valid instance in the system. Every client has its own copy of this document, which may not be the current version at the moment. The purpose of the synchronization model is to synchronize client's local document with the central server and to propagate client updates to the central document. These updates are made in the client's local document. The model should avoid race condition errors caused by concurrent editing of the same object. The risk is furthermore minimized by usage of object locking mechanism. The XML based data (SVG) is divided into elementary parts, in this case XML elements. These parts represent the atomic units the data consist of. Any operation on the data is then affecting one or more elements and it can be described by XML Update. In order to minimize the possible data conflicts, a data locking mechanism is involved. Each client is maintaining a local database of objects locked by the client and objects locked by other clients. No update is allowed on objects locked by other clients until they are unlocked. This is a prevention of synchronization problems by the best knowledge of each client. The elements are locked for the minimum necessary time to perform an operation. For example when the user selects an object in the SVG editor, it is locked. When the object looses focus, it is again unlocked. The server will automatically unlock objects locked by clients who are off-line for a specified time period in order to allow further work to other clients.

When either the server or the client sends any message, it must be acknowledged by a reply from the other side. The reply contains either acknowledgment of the operation or an error code. If the reply is not received, the message is resubmitted after a timeout.

Client Side

Clients use update commands to perform their updates to the central document located on the server. The server replies with the update command result, which can be success or error. Events originating in the client's local SVG editor and not yet acknowledged by the server are called *internal events.* Events originated in SVG editors of other clients or events generated by the server are called *external events*. The synchronization scenario, when a client makes a document update is following, see Fig 3:

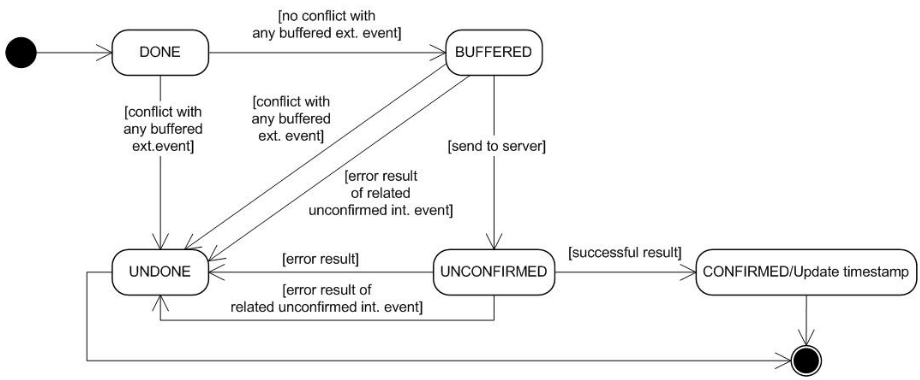

Fig. 3. State chart of the internal event

1. The client sends a document update and performs it conditionally locally in the SVG. The user can smoothly continue at work. Every internal event contains a timestamp. This timestamp is set to the document version on which the update was made. The update is propagated to the client's local document (state DONE).
2. The client checks it's external events buffer. The external event is a successful update, which originated in other client. The external event is always received form the server and is therefore confirmed by it. The external event buffer contains external events, which have been already delivered to the client from the server, but haven't been yet propagated to the local document. If there is a conflict with some buffered external event, then the internal event must be rolled back (UNDONE).
3. If there is no such conflict, then the internal event is queued in the internal events buffer. This buffer contains internal events, which are going to be sent to the server (BUFFERED).

4. When the client receives an external event, it checks the internal events buffer. If there is an update conflict with some buffered internal event, then the internal event is rolled back (UNDONE). The internal event is also roll backed when related internal event finishes with error result.
5. Otherwise, the internal event is sent to the server (UNCONFIRMED).
6. If the server replies with a success, then the update is confirmed (CONFIRMED). The success reply contains a timestamp. The local document version is updated to match the timestamp.
7. If the sever replies with an error, then the internal event is rolled back.

Client – server communication

When another client performs a successful update, it is propagated to other clients in a form of an external event. When a client receives an external event, it will perform the following set of operations:

1. The external event is queued in the external events buffer (BUFFERED ON CLIENT).
2. The client processes the buffered external events one by one according to their timestamps. When performing an external event, the client searches in its internal events buffer and unconfirmed internal events for possible conflicts. If an update conflict is found, then the conflicting internal event is rolled back.
3. If there is no conflict or all conflicting internal events have been already rolled back, then the external event is propagated to the client's document (DONE). The local document version is updated to match the timestamp from the external event.

Fig. 4. State chart of the external event

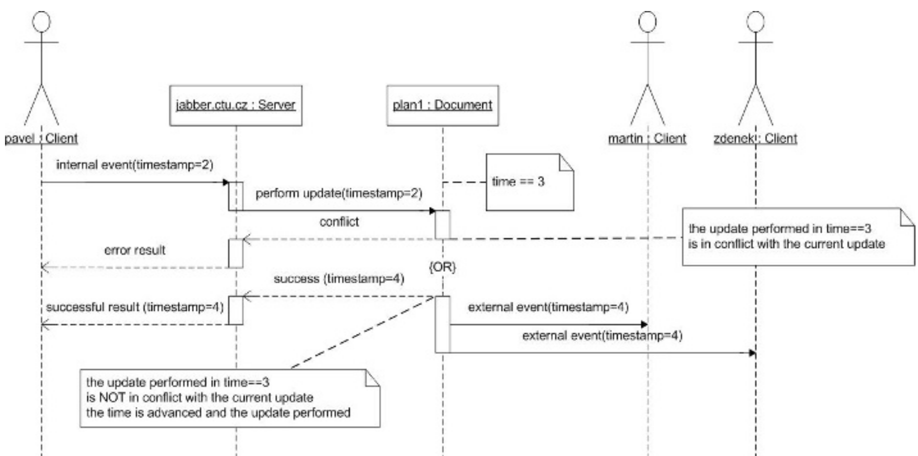

Fig. 5. Synchronization sequence diagram

Server Side

The server is waiting for connections of clients, receives XML updates, resolves data locking, responses to all incoming messages and eventually distributes successful data updates to all registered clients. Messages that are to be sent to the clients are buffered until the client is available or until a long-time off-line timeout passes. In such case the client is pronounced completely disconnected and it's data structures are cleared. Also all objects locked by this client are automatically unlocked and this information is distributed to all other clients.

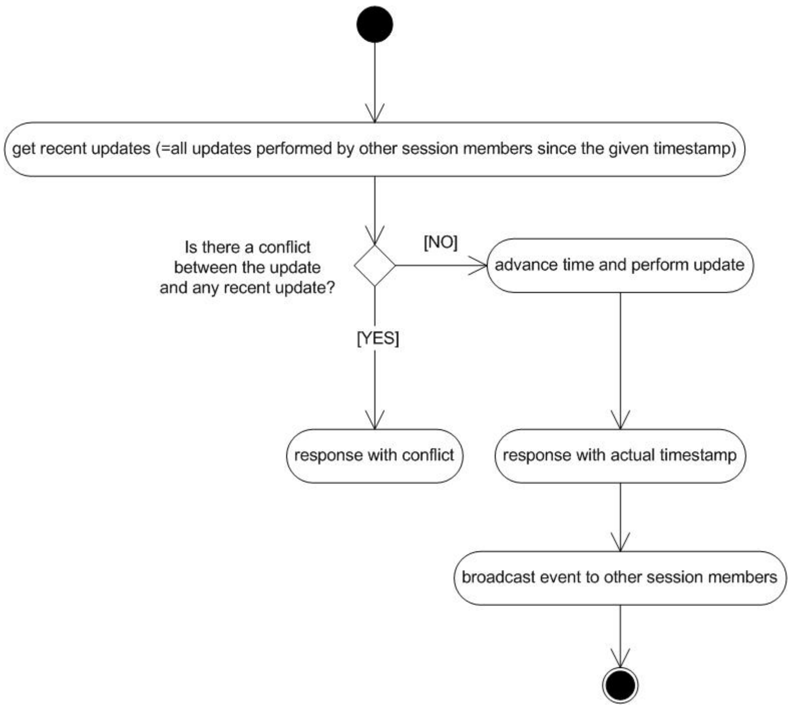

Fig. 6. Processing of update event on the server side

Updates received by the server are the internal events of individual clients. The processing of the update command is following (see Fig 6):

1. Every update command contains a timestamp which corresponds to the document version on which the update was performed on the client side. The server searches all data updates with timestamp equal or higher than the timestamp of the currently performed update for conflicts.
2. If there is an update conflicting with some recent updates, then an error response is set to the client.
3. Otherwise, the server performs an update on the server data instance and increases its version number. The server sends a success response to the client with a new timestamp (new document version). It also broadcasts an event to the other clients sharing this document. This broadcasted event is received by the clients as an external event.

The server is also responsible for maintaining the database of locked objects. Any change in the database is immediately broadcasted to all clients. If a client tries to lock an object, it is either confirmed by the server or it is denied.

4 Conclusion

The described protocol is suitable for mobile collaborative applications that work with XML data. The protocol uses client-server architecture. Client to client communication is always passed through the server. The network traffic needed by the client is thus minimized and it is concentrated by the server. The server is usually placed in a stationary network and is therefore not suffering with limited bandwidth. The protocol enables the users to dynamically change their connection type, connect and disconnect according to the current conditions but still to continue at work. From the user's point of view the synchronization process is performed in the background.

We have successfully implemented the protocol and used it in an SVG sharing tool on Pocket PC platform.

In comparison with the traditional instant messaging protocols, our protocol is especially for the mobile environment and enables a fluent, uninterrupted work.

Acknowledgment

This research has been supported by MSMT under research program No. 6840770014.

This research has been supported by the grant of the Czech Grant Agency No. 01/06/064

References

1. Noble, B.: System Support for Mobile, Adaptive Applications, IEEE Personal Communications Vol. 7, No. 1, February, 2000
2. Klima M., Mikovec Z., Slavik P.: Mobile Data Sharing and Collaboration, Proceedings of the IADIS International Conference WWW/Internet 2003. Lisboa: IADIS Press, 2003, vol. II, pp. 899-902. ISBN 972-98947-1-X
3. Jabber Software Foundation [WWW Document] URL: http://www.jabber.org
4. SVG specification [WWW document] URL: http://www.w3.org/TR/SVG11/
5. W3C Consortium, XML: The Extensible Markup Language, [WWW document] URL: http://www.w3.org/XML/
6. XUpdate specification [WWW document] URL: http://www.xmldb.org/xupdate/xupdate-wd.html
7. Wiegand, D., Balfanz, D., 2004. MUMMY - mobiles Facilty Management with Mobile Computers. In Roland Köhler (Hrsg.): Schweizer Energiefachbuch 200
8. Wiegand, D., 2004. Mobiles Facility Management - Forschungsprojekt MUMMY. In Immobilien Business Vol. 4, S. 53
9. Hoffmann, T., Schwarz, T., 2004. Digitale Datenerfassung im Feld. In ARCADIS Forum 17/04
10. Jacob, H., Hoffmann, T., 2004. Mobiles Wissensmanagement: das Projekt MUMMY. In ARCADIS Forum 17/04

Using Autonomic Computing and Click Stream Analysis for Problem Identification in Continuous Production

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Abstract. Problem identification is an area of research from Autonomic Computing. The problem identification can bring several benefits in a production line, especially in continuous production of the Information Technology Industry. This work presents an approach based on Symptom Ontologies to facilitate problem identification and solution prediction, and use of clickstream analysis for recommendation of material, when the solution is not appropriated.

1 Introduction

One of the main steps in an engineering process is the production, which is responsible for the construction of products that will reach the consumer. If a design is to be manufactured by continuous production, the factory or production line will operate continuously, without interruptions, and the product is passed from machine to machine.

If a machine stops working due to a problem, it can affect directly the productivity. All time used to fix or exchange this machine is spent time, probably incurring in some loss.

A new paradigm from IT can help to effectively detect and prevent problems associated with applications and equipments. It is Autonomic Computing, which provides concepts such as Common Events and Symptoms to facilitate automatic pro-cessing, and consequently, identification, prediction and treatment of problems and incidents. Among those, the detection and description of effective symptoms assumes a prominent role, since any action taken to correct a failure should be based on them.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 17 – 24, 2006.

Some problems are easily inferred by human experience and symptoms can then be easily described, but in other cases the huge complexity of IT solutions makes impracticable for domain experts to know beforehand what kinds of failures, and consequently symptoms, they can expect from their environment. To solve this problem we can employ system verification methodologies and possible solutions' reasoning, based on past cases (like the Case-Based Reasoning paradigm).

This kind of solution, which is based on monitoring and reasoning, needs a common and well-defined knowledge representation of the domain. For it, we use ontologies, which are defined as "a specification of a conceptualization" [1]. That is, an ontology is a formal description of the concepts and relationships that represent a domain. Therefore, for identification, prediction and treatment of problems and incidents in IT elements, one requires a Symptoms Ontology, which consists of elements that describe what symptoms and solutions exists, and what are their relationships.

Sometimes, the reasoning engine can not propose or indicate a solution. In that case a human agent (as a technician) has to solve the problem. If the problem is unusual, the best approach is to recommend some informative material (as pages of forums, web pages with some practices, technical reports and so on) of related issues. In our approach this recommendation is made using click stream analysis of a web server.

Click stream analysis involves to collect and analyze clicks made by users of a site. This analysis can report aggregate data about which pages users visit and in what order. It is the result of the succession of mouse clicks that each user makes (that is, the click stream). Because a large volume of data can be gathered through click stream analysis, many applications use data warehouses to keep and organize these data [2]. Normally, these click streams are stored in Web Server logs. There are a lot of commercial applications that focus on Web log analysis, but most of them are quite limited when the focus is the recommendation or solution analysis.

This work proposes the use of Symptom Ontologies to facilitate problem identification and solution prediction, and use click stream analysis for recommendation of material, when a solution is not satisfactory. For this purpose, some principles will be explained in section 2 and our proposal will be described in section 3. The section 4 outlines the conclusion and future works and the section 5 is dedicated to acknowledgements.

2 Symptoms and Events

An event is an occurrence related to the functioning of a computing node, e.g., a peer in a grid. A symptom, which comes from an event, is the identification that a possible problem occurred. In the Symptom Analysis approach, it may also be identified from state data, metrics or log records. For instance, when a user starts a program (event) and the computer that runs this program stops working (symptom) because of the program, we have examples of an event and a symptom caused by this event.

Events, in our contexts, are defined as actions or occurrences which a system can respond; examples include clicks, key presses and mouse movements. A symptom is a knowledge form that indicates an incident. It could become a possible problem or situation in the managed environment. Basically, symptoms are indications of the existence of something else. They are often associated to an underlying autonomic computing architecture, where they are first order elements of the analysis part of an autonomic control loop. A comprehensive symptom reference model for autonomic computing can be found in Berners-Lee [3].

In autonomic computing, symptoms are recognized in the monitor component of the control loop and used as a basis for an autonomic analysis of a problem or a goal. Symptoms are based on predefined elements (definitions and descriptions) provided by the autonomic manager, along with data that the monitoring infrastructure collects from managed resources, like events, as shown in Figure 1. The symptom definition expresses the conditions used by the monitor component to recognize a symptom existence, and the symptom description specifies the unique characteristics of a particular symptom that is recognized.

In autonomic computing architecture, classes of situations that can be handled in an autonomic way are often called self-*, meaning that different and varied IT functions can be automated and managed by the component itself. The fundamental features, sometimes called self-CHOP [4] are: Self-configuring, Self-healing, Self-optimizing and Self-protecting.

Frequently, symptoms are closely connected to the self-healing discipline of autonomic computing, because their primary intent is to indicate a problem, which is in the realm of the self-healing discipline. Symptoms can also be used, however, as triggers for other kinds of problems, such as those of other disciplines - self-protecting, self-optimizing, and self-configuring. Virtually all kinds of problems or predictions may start due to the occurrence of a symptom.

Figure 2 details an ontology obtained from an identification of symptom classes, properties and individual elements which can best describe the semantics associated to the information present in a symptom and expand these definitions.

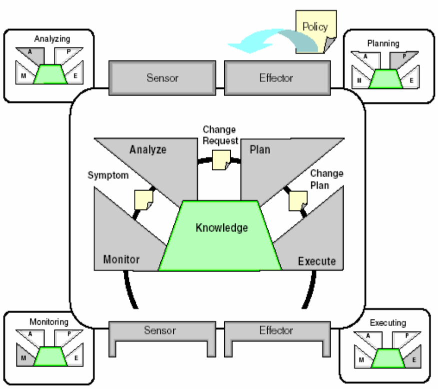

Fig. 1. Functional Details of Autonomic Manager [5]

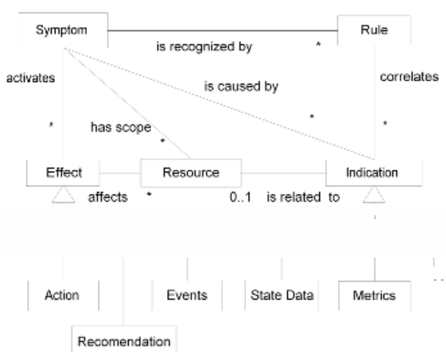

Fig. 2. Base symptoms ontology

It is interesting to notice that some questions about problems that are symptoms could be answered with this ontology:

- **What** is this symptom? Here is the symptom itself, describing the incident.
- **Where** is the troublesome resource? All resources need to be located and identified. This kind of question tries to show where the symptom happens;
- **When** is mapped by the indication that corresponds to an event, the temporal space;
- **Why** is related to the rule that identifies the situation or problem leading to the symptom;
- **Who** identifies anyone who has the competences needed to fix a problem, as a technician;
- **How** describes a set of events which results in the problem, how it is mapped by the effect that a symptom cause and the metrics associated.

3 The Approach

The proposal of this work is to use symptom ontology to detect problems and try to predict some solution. Firstly, this approach treats the monitoring and detection of symptoms, which can be related to a problem in a computer or in a network. When a symptom is detected, the environment accesses the Knowledge Base to find solutions, as all the material (web-informative material) used during the construction of solution. After this, the user can analyze the recommended solution and, if it seems satisfactory, to adopt an action which prevents or solves the problem.

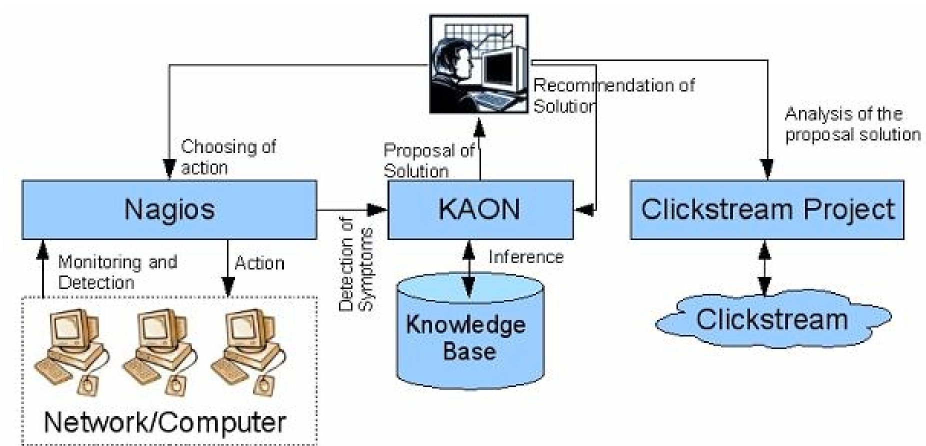

Fig. 3. Problem Detection, Solution Proposal and Material Recommendation for a Continuous Production Context

Nowadays, a lot of users find solutions browsing the Web, through forums, discussion lists, electronic manuals, etc. We propose that, if the recommended solution was not satisfactory, the user can do the click stream analyses and reach the pages and indicators related to the solution. In this context, it is presumed the user who searches by a solution is in a corporative network and all network traffic is stored in a web server or proxy. Thus, he/she can analyze the sources, found by other users, which engender the knowledge represented by solutions. This is important because the adopted solutions, already in the system, possibly do not contain all the information of these web pages.

The click stream analyses is also useful when the user receives several solutions provided by the environment, as it permits the user evaluate some indicators of pages related to the problem, as page-hits numbers, date of last access, average time of visit, and others, and so, to select one of the proposed solutions.

It is important to emphasize that the user can recommend and store solutions to problems based only is her/his experience and learning. Our approach can be better understood by the Figure 3.

3.1 Implementation

The approach implementation uses a set of open-source tools that provides mechanisms to couple plugins. These plugins allow the integration of different tools to perform the desirable action. These tools are detailed as follow:

a) Nagios – the approach uses the Nagios [6] program to monitor and detect problems in computers or networks. Nagios is a system and network monitoring application. It watches hosts and services that a user specifies, alerting him when things go bad and when they get better. The Nagios allows:

- Monitoring of network services (SMTP, POP3, HTTP, NNTP, PING, etc.);
- Monitoring of host resources (processor load, disk usage, etc.);
- Simple plugin design that allows users to easily develop their own service checks;
- Contact notifications when service or host problems occur and get resolved (via email, pager, or user-defined method);
- Ability to define event handlers to be run during service or host events for proactive problem resolution.

We developed a plugin to perform the monitoring and detection of a symptom set related with computers and networks. For instance, this plugin monitors an http server. If this server is not working properly then the Nagios will communicate this symptom to the KAON that will search for possible solutions. The next piece of code defines in the Nagios interface a service that monitors an http server and, after four attempts checking the server, sends a message to a KAON API to communicate the symptom detected.

```
  define service{
          host_name                           somehost
          service_description                 HTTP
          max_check_attempts                  4
          event_handler                       http-problem
          ...other service variables...
          }
  define command{
          command_name    http-problem
          command_line
/usr/local/nagios/libexec/eventhandlers/http-problem
          ... other command lines
          }
```

Once that a solution is chosen by a user, it is possible to define commands that try to fix the problems detected. For example, the next piece of code restarts the http server using Nagios.

```
define command{
        command_name   restart-httpd
        command_line
/usr/local/nagios/libexec/eventhandlers/restart-httpd
        ... other command lines
        }
```

b) KAON – KAON [7] is an open-source ontology management infrastructure. It allows to create and manage ontologies. An important focus of KAON is scalable and efficient reasoning with ontologies. The KAON is used to populate the knowledge base with the symptom ontology (Figure 2). A plugin was created to search and show for a user the specific concepts associated with the symptom detected by the Nagios program. This plugin uses the ONTOPASS [8] [9], which is an adaptation of a KAON´s component, to edit and visualize the ontology in a web browser. The recommendation and action concepts correspond to solutions. Rules correspond to problems recognizing and indication correspond to events that could start a problem. Rules and indication are used by Nagios to monitoring and detection.

c) CLICKSTREAM ANALYSIS – this approach uses the Clickstream Project [10] to provide the clickstream analysis. The new tools of clickstream analysis offer ways to cleaning and transformation of the data present in a log, for this they demand knowledge about the site structure and the application. Consequently, they also demand a human intervention to detect and solve similar problems every time. These applications do not permit to store and share strategies used early. They normally provide trivial analysis like, for example: time of visits, number of visited pages, pages more visited, amount of errors, metrics about performance and traffic, statistics about sessions.

The approach used in this work permits to detect potential problems and provides a way to store, share and recommend strategies used early to solve problems. This approach could use data directly extracted from either Web server logs or applications that pre-processing logs.

3.2 Storing and Recommending Pages

When users starts to navigate through a site we store: i) all tracks (sites and sequences of clicks), ii) time spent in each web page and iii) Hits per page.

All tracks and their associated information are stored and referenced to a symptom (the original symptom which originates all search for material, ideas or practices). This processes finish when the problem is solved. So, all the tracks since the problem identification to the problem solution are stored.

When the same symptom occurs again, all the previous track are presented as a recommendation.

4 Conclusion and Future Work

The base of Symptoms Ontology consists of elements that describe symptoms and their relationships. The purpose of this work is to determine whether the essence of IT problem determination and prediction can be captured through a limited number of generic symptom types. Symptoms with nearly identical structures, such as "application connection error" and "server unreachable error" are classified as generic types, e.g. "network condition X". In this study we analyze a kind of solution deployed by Web server logs.

This is an ongoing work and several hurdles will be overcome in the future. One of them tries to discover what rules recognize specific symptoms. Another issue is to learn how humans solve the problems. In the present scenario, the mechanism for translating the knowledge is executed by a human agent, such as a technician.

In this context we can identify two distinct types of monitored information: raw events and correlated events. A raw event is merely an observation of a certain condition in a monitored resource and is associated with status and reporting conditions. In contrast, correlated events aim at including a certain level of intelligence to the data being reported. A correlated event is something that is, eventually, very similar to a symptom, but it is identified in lower layers that are near to the monitored resource itself.

We also intend to allow the integration of symptom ontologies created in different environments [11]. It will allow the reuse of knowledge with different perspectives.

Currently, this approach needs a human element to validate and decide the appropriate action. We intend to use a direct communication between KAON and Nagios, without user intervention, to allow the execution of some actions. This kind of proposal reduces the time to solve the problems related with computers and networks and therefore it increases the volume on continuous production.

Acknowledgements

This research has the support of CAPES (The Brazilian Coordination for Postgraduate Staff Improvement), CNPq (The Brazilian Council for Scientific and Technological Development) and IBM through its Ph.D. Fellowship Program.

References

1. Gruber, T. R.: A translation approach to portable ontologies. J. on Knowledge Acquisition, Vol. 5(2), (1993) 199-220
2. Sweiger, M., et al.: Clickstream Data Warehousing. New York: J. Wiley & Sons Inc. (2002)
3. Berners-Lee, T., Hendler, J., Lassila, O.: The Semantic Web. Scientific American (2001)
4. Miller, B.: The Autonomic computing edge: Can you CHOP up autonomic computing. http://www-128.ibm.com/developerworks/autonomic/library/ac-edge4 (2005)
5. Perazolo, M.: Symptoms deep dive, Part 1: The autonomic computing symptoms format. http://www-128.ibm.com/developerworks/autonomic/library/ac-symptom1/ (2006)
6. Nagios. http://www.nagios.org/. Acessed in May (2006)

7. KAON, http://kaon.semanticweb.org/, Acessed in May (2006)
8. Pinheiro, W. A., Moura, A. M. C.: An Ontology Based-Approach for Semantic Search in Portals. Database and Expert Systems Applications, 15th International Workshop on (DEXA'04). (2004) 127-131
9. Pinheiro, W. A.: Search in Semantic Portals: an Ontology-Based Approach (in Portuguese), Master Thesis , IME (2004)
10. Clickstream Project. https://clickstream.dev.java.net/. Acessed in May (2006)
11. Oliveira, J.; Souza, J. F.; Paula, M. M. V.; Souza, J. M.: Meaning Negotiation for Consensus Formation in Ontology Integration. In: 10 th International Conference o Computer Supported Cooperative Work in Design, Nanjing. Proceedings of 10 th International Conference o Computer Supported Cooperative Work in Design, v.II. (2006) 787-792

Data Exchange in CAD During Iterative Work with Heterogeneous Systems

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Abstract. This contribution is focused on the data exchange during the iterative work with heterogeneous CAD systems. The important cognition is the fact that without an application infrastructure it is not possible to design a universal data format for data exchange which allows mutual transformation of any data without non returnable distortion. The paper shows the data exchange scenarios that help to solve this problem. The proxy management and differential conversion are introduced. The proxy management is based on storing an additional data in the transformed files. The main pillar of the differential conversion is the log of changes and identifiers' mapping. Both strategies are focused on the problems of the cyclic conversions used during the iterative model/drawing creation and both involve the agents that manage additional data structures, which help to correct the data during backward import.

Keywords: CAD, data exchange, differential conversion, iterative work.

1 Introduction

One of the unsolved problems of the collaborative engineering is the heterogeneity of systems and data sharing between them. This contribution is focused on the data exchange during the iterative work with heterogeneous CAD systems. Frequently more than one CAD system is used during a product design – partly by suitability for certain subtask, partly in according to which systems subcontractors and project's participants work. If the product is designed in a sequence of serial phases, it usually is necessary to transform some CAD data in order to be used in another CAD system.

The cases when the development is iterative are frequent. It means the changes from the exported model are again imported to the original model and there usually is very rigorous demand to keep unedited data without changes and to keep the complex quality of the original model. A particular case study follows. Prague, the capital of the Czech Republic, has one global supplier of electric energy. This company has a unified model of the city that contains a map of energetic networks. This GIS operates on the MicroStation CAD system platform. On the other hand the majority of architects and building designers in the Czech Republic use the AutoCAD CAD systems. A problem arises at the moment when the documentation of a connection to an energetic network is processed. The electricity supplier provides the appropriate snippet of the area in DGN format and demands to return this snippet with changes drawn on.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 25 – 32, 2006.

Because of an automated processing and data quality check-up the strict rules for drawings are defined. The current practice is that there are automated transformations between DGN and DWG formats and also automated additional corrections of them. This scenario leads us to analyse iterative and cyclic data conversions and to generalize of some outcomes. Since in the general more than two CAD systems can be involved in these processes, we have focused also on the idea of generic CAD data format. The paper shows that it is not possible to design any canonical format that ensures loss-less data conversion without a special infrastructure. It introduces an extension of this idea, called proxy management, which shows the way to solve this problem. In the following there is presented so-called differential conversion, that tries to reduce the influence of cyclic conversions between two CAD systems. The basic principles are the identifier mapping [1] and logging of changes.

2 Generic CAD Data Format

There have been several more and mainly less successful attempts to enroot a generic data format. DXF [2], IGES [3], complex STEP and its application protocols [4] and many others can be given as an example. Some of these formats are tightly coupled with particular technologies (e.g. DXF with AutoCAD), which predetermines them for the data exchange between one product and the rest of the world. The others (e.g. STEP) try to establish a canonical data format, that is neutral, focused both on the data exchange between heterogeneous systems, and also on data storing in longer term than is expected lifetime of a CAD system in which the data was created. It is obvious that the goal of generic format is the possibility of loss-less transformation from/to *any* CAD data format. The situations when only one-way transformation is needed exist (e.g. electronic publishing into PDF), but those are specific cases, that cannot be used as the basis of general data exchange mechanisms. In addition to demands for both-way and loss-less transformation is reasonable to establish the demand of unambiguousness. For instance, in a data format of one CAD system a rectangle can be represented either by RECTANGLE entity type or by four entities of LINE type. However the different representation can hide different semantic meaning, defined for example by 3rd party application, by enterprise standard and so on.

Let's define the data transformation as

$$f : X \to Y, \tag{1}$$

where the X is a set that represented the domain of a source format and the Y is a set that represented the domain of a destination format. Then by aforementioned reasons is demanded that

$$\forall X' \subseteq X \text{ is } f^{-1} \circ f(X') = X' \tag{2}$$

and

$$\forall Y' \subseteq Y \text{ is } f \circ f^{-1}(Y') = Y'. \tag{3}$$

That is bijection.

If it is possible to find two CAD systems A, B with inner data representations X, Y, for which the generic format G is intended, such that the transformation *f* defined above does not exist, it is not possible to find the following transformation:

$$g = f_1 \circ f_2^{-1}\text{, where } f_1 : X \to G \text{ and } f_2 : Y \to G, \quad (4)$$

in spite of the partial transformations $f_{1,2}$ exist. The cause is following:

$$\exists x, z : x \in X \wedge z = f_1(x) \wedge z \notin range(Y) \Rightarrow \neg\exists y : y = f_2^{-1}(z), \quad (5)$$

$$\text{i.e. } range(Y) \subset (range(X) \cup range(Y)). \quad (6)$$

So, universal canonical format cannot be designed, because it is not possible to find both transformations to unambiguously transform the domain of source data format to the range of destination format.

It is not difficult to find two systems appropriate to this condition. On the one hand for example the MicroStation systems represent a circle as a special case of an ellipse (ELLIPSE entity type). On the other hand for instance the AutoCAD based systems distinguish between circles (CIRCLE entity type) and ellipses (ELLIPSE entity type). The common direct transformation utilities between AutoCAD and MicroStation transform the AutoCAD's circles to the Microstation's ellipses, and in backward conversion the ellipses with the same length of the major and minor axles are transformed to the circles and the others to the ellipses. When the neutral format is involved, the behaviour of the system is similar and it can cause the aforementioned lost of semantics information.

3 Cyclic Conversions

As it was commented in the Introduction, the problems arise mainly during the cyclic conversions, i.e. during the backward conversion of the modified model into the original format. The problems can be divided into three basic categories:

- The distortions and conversion faults,
- Ambiguous or incomplete conversion,
- Identifiers lost.

The distortion and conversion faults can be eliminated by suitable design of converting tools and canonical format if it is used. Ambiguousness of a conversion can be definitively solved neither by the converting tools nor by the design of canonical format. Beside the cases described above it is necessary to involve into the ambiguous conversion as well an incomplete data conversion of particular objects (it can be e.g. precision lost, relationships lost, etc.)

The identifier lost is a special issue that need not cause any real problem in all cases. Each object in CAD drawing/model has an own unambiguous identifier and the systems of identifiers are in particular CAD systems usually different. Thus, during the data conversion a new identifier is assigned to each object and the information about original identifier gets lost. During the backward conversion to the original data format the new identifiers are again assigned to the objects, which are not in any defined relationship to the original ones. Since these identifiers are in fact the internal issue of the CAD systems, it usually does not cause any problem. However if the CAD system is extended by an additional application, that for example establishes relationships between graphical objects and records in an external database, it usually is done through the aforementioned identifiers, but during cyclic conversion the relationships are totally damaged.

4 Proxy Management Solution

To state that it is not possible to design generic format is too strong and it is not the result that the world would like to hear. Thus it is necessary to find appropriate solutions that help to minimize the problem of systems' heterogeneity. The first of our proposals is so-called proxy management.

4.1 Proxy Objects

The basic idea of proxy management lies on establishment of so-called proxy objects or a proxy data of existing objects. These are some objects that contain extended information about transformed objects so that during backward transformation the data, that during classic transformation gets lost, are available.

The idea of the proxy objects is not completely new – the AutoCAD's proxy objects have inspired us. However these are used for another purpose and their behaviour is different as well. Thanks to the ObjectARX/DBX technologies the AutoCAD systems allow the extension of a system by own entity types. Users' entity types can be programmatically created with the support of C++ interface thanks to the objects' inheritance. A user application defines all behaviour, including drawing, saving into DWG files, geometrical operations and so on. Autodesk had to solve the situation when a drawing encompasses the objects of the new entity types, but a service application is not present. In this case the objects behave like proxy objects that have information for static drawing and basic behaviour, which is generated when the entity is saved into drawing yet (i.e. when the service application was present).

A similar strategy can be used in the case of manipulation with the data of another format. When the data is imported from a canonical format, the drawing is enriched by proxy objects without graphical representation which encompass additional information and meta-information. These can be either standalone database objects (e.g. in the case of AutoCAD for instance the custom named dictionaries) or data extensions of imported entities (in the case of AutoCAD for example the extension dictionaries or entity extended data). Then for the backward conversion, i.e. during data export, it is possible to operate with this data. Similar data extensions are supported practically by each CAD system, so this strategy can be used in the wide scale of systems. When the data extension is not possible, the data can be stored into the external files or other persistent storages. In this case the presence of all connected files must be controlled.

4.2 Proxy Management Agents

The problem of proxy objects is an editing. When the object in a drawing/model is changed, modified or added, the quality of the data stored in proxy object or relationships between them can be damaged, the relationships can even get lost. The basic approach is to design export/import such that during the import the data will be able to recover and to receive the maximum of valid information from the proxy objects. The advanced way is to use so-called proxy management agents, which are special application – the plug-in modules for the CAD systems. They monitor user activities and/or model/drawing database changes. Within each change or adding new object they can perform some standard scenario. However they also can activate a module with a user interface and ask user for additional information. This way allows keeping data in one CAD system in appropriate quality for processing it in another (original) CAD system. Similarly to the data extending even the application extending of CAD systems is common practice, for which there are appropriate tools. When the application extending is not possible, the alternative methods, like operating system events' monitoring, can be used. However these solutions usually are very labour intensive, problematic and often it is not possible to cover all demand functionality.

5 Differential Conversion

The second proposed way how to reduce the influence of the cyclic conversions is so-called differential conversion. During the data manipulation between cyclic conversions, often only a small percentage of the objects is modified. If only these modified objects will be transferred between models/drawings, the other objects would keep undamaged. This approach demands an application support at both (or all) participating systems. The scenario of differential conversion is following:

- When the data is exported, all objects with all information are exported, identically to the common full conversion. Simultaneously the current data are backed up (in the original format).
- When the data is imported, all objects are loaded, again identically to the common full conversion. Thus it is indifferent if the transformation is done during the export, import or both these operations.
- During the work with model/drawing in the non-native system the differential conversion agent monitors the changes. When any change of the CAD model occurs, the record is written into log of changes. More accurately, the agent monitors the changes and when the model is saved, the log of changes is actualized. In order to right functionality the model/drawing saving and actualization of the log of changes must be an atomic operation.
- When the modifications are finished, the data export is invoked. In the basic scenario the data conversions are linked with the import operation of a native CAD system, which the data will read in following step. However if a canonical format is used, the full conversion is done even here, so it is necessary to be aware of the possible identifier loss.
- When the data is backwardly imported, the data that was backed up in first step are used as initial state. From the new data the selection is performed and according to the log of changes only the new and changed objects are imported and the objects that were erased are erased too. The other objects are kept from the backup.

5.1 Identifiers' Mapping

In order to be able to perform the scenario of a differential conversion, it is necessary to know the identifiers' mapping. And it is not only the 1:1 relationship – it has illustrated the example of a rectangle which was represented by four lines. Thus the map of identifiers contains as well the information about assembling/disassembling of transformed objects. The identifiers' map along with the log of changes is the next external data file of the differential conversion. The draft of XMLSchema for XML based map of identifiers is downloadable here: **http://dc.ota.cz/**.

5.2 Log of Changes

The aforementioned log of changes is nothing more than chronological list of changes. Each change is a record with the object identifier and change type description as the only required fields. Change type description is "add", "modify" or "erase". The new (transformed) object identifier is used, because newly added objects do not have original identifier. The additional reason is easily monitoring of changes for disassembled objects (the 1:N relations in identifiers' mapping). The CAD system, where the data is imported, is responsible to translate object identifiers back. The log of changes XMLSchema draft is also downloadable at **http://dc.ota.cz/**.

5.3 Differential Conversion in Enterprise Integration

The described data transformation is not put into any context of any enterprise integration. However it would be a mistake to suppose that it is another stand-alone integration strategy. The transformations can be automated and utilized in existing integration strategies. The conversion applications can be designed as connectors for integration buses or hubs and can be used by general integration. On CDVE 2004 our simple small-scale integration strategy called Unified Communication Model was introduced [5], and also in this strategy it is possible to utilize this scenario.

5.4 Differential Conversion in Collaborative Engineering

The differential conversion can be extended more by some principles of collaborative engineering: using of locks, comparison of the logs of changes, and data merging. The identifiers' map can be extended by information about the locks of groups of objects in a model/drawing. Then the agent of differential conversion can block the editing of locked objects. It is one of mechanisms how to enable parallel work of more than one engineer with the same data. If the unlocked/same data are edited, it is easy to compare the particular logs of changes and find for instance the same objects' editing. The import operation can be extended by ability to import data from more files simultaneously, with possible interaction in the cases of the logs' of changes collisions.

5.5 Proxy Management and Differential Conversion

The combination of the proxy management and differential conversion is possible and in the case of advanced proxy management it can be additional improvement of data exchange. The behaviour of the differential conversion – i.e. backward import only of affected objects – is kept and proxy management can additionally manage more accurate information about changes or extra information about new objects. The log of changes encompasses only the information that some object was edited. A proxy object, or a proxy data of an existing object, can by actualized by the agent according to a particular change and according to this backward data import can be affected (improved).

5.6 Generic CAD Data Format and Differential Conversion

In the basic draft the differential conversion is recommended to use in peer-to-peer mode, i.e. without any canonical format as a mediator. The increasing number of data transformations means the increasing number of possible data distortions. However no all cases correspond with the case study presented in the Introduction. More then two CAD systems are involved quite frequently, even the final number of collaborating systems is unknown. Then the using of generic format is strictly recommended and even here is possible to use the differential conversion. However it is necessary to control the identifiers' map and the log of changes, according to keep the information about changes still valid to be able to perform differential data import. There is as well the possibility to use more than one identifiers' map, however then the component that is responsible to backward import must be able to perform multiple translation of identifiers according to multiple maps.

6 Relation to Unified Communication Model

The aforementioned Unified Communication Model can be used with both presented strategies. The simple UCM requests can mediate query/answer if the differential conversion is supported. The wrapping UCM requests then transfer the data of model/drawing including the special data of differential conversion – the identifiers' map and log of changes. It is possible to use both compressed form (e.g. all files in a ZIP archive) or to transfer one file per a UCM request/reply. The processing of the data depends on an import/export component of a CAD system, which communicates by particular specific interface with UCM. There is not defined any special interface for communication between these components.

The utilisation of proxy management is totally independent to UCM – the proxy objects with additional information are stored directly into the CAD systems' files and its representation depends only on the components that perform the import/export of the data format.

7 Conclusion

The important outcome is the fact that without application infrastructure it is not possible to design a universal data format for CAD data exchange which allows mutual transformation of any CAD data without non returnable distortion. The paper has showed the modes of CAD data exchange that help to solve this problem – the proxy management and differential conversion.

The experimental phase is in progress at the moment. Only the basic prototypes – i.e. the differential conversion draft, its integration into UCM, and proxy management of very limited scope of entity types – have been tested on MicroStation and AutoCAD systems. The future work is focused on testing the whole described functionality using more CAD systems. The project development will be documented at the aforementioned web site **http://dc.ota.cz/**.

Acknowledgements

The research has been supported by the grant of the Czech Grant Agency No. 201/06/0648 and by MSMT under research program No. 6840770014.

References

1. Amor, R. W. – Hosking, J. G.: Mappings: the glue in an integrated system, 1st European Conference on product and process modelling in the building industry, Rotterdam,The Netherlands), A.A. Balkema Publishers, Rotterdam, The Netherlands, 1995, pp. 117-123. ISBN 90-5410-584-8.
2. Autodesk: DXF Reference. Autodesk, Inc. USA, 2006.
3. Softimage 3D: IGES Reference Guide. Avid Technology, Inc. 1999: http://www.uni-duesseldorf.de/URZ/hardware/parallel/local/softimage/Soft3D_html/pdf_base/iges.pdf in March 2006.
4. ISO 10303, Publicly available parts. http://www.nist.gov/sc4/step/parts/ in January 2004.
5. Ota, M. – Jelínek, I.: The Method of Unified Internet-Based Communication for Manufacturing Companies, In Cooperative Design, Visualization, and Engineering, Springer, Berlin, 2004. ISBN 3-540-23149-8.

A Collaborative Design Platform for Assembly Process Planning

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Abstract. This paper presents a web-based virtual environment which supports designers geographically distributed to engage in the same assembly scenario and complete the assembly task synchronously. Firstly, a client-server based architecture for collaborative assembly is discussed. The discussion highlights how to decompose the collaborative assembly environment into several functional modules, and how to deploy the right module on the right side. Secondly, some key technologies including task classification and subdivision, and multimodal interaction, are discussed in detail. At last, we give our implementations and discuss limitations in our current research effort.

Keywords: Virtual Reality, Collaborative Design, Assembly Design.

1 Introduction

Product design is a complex activity which involves collaboration between designers geographically distributed. Starting from the end of last century, more and more research and development work has been done to renovate traditional CAD systems to be distributed and collaborative[1].

Assembly design is part of the product design and is typically a highly iterative activity from the conceptual design phase to the detail design phase. Till now, there has not been a single tool which can help designers to complete the whole assembly design process, including assembly planning, evaluation and verification.

And what's more, virtual reality(VR) technology has become another research hotspot to integrate different CAD tools into an assembly design environment. VR is a technology which is often regarded as an extension to 3D computer graphics with advanced input and output devices. By virtue of VR, designers can plan, evaluate, and verify the assembly of mechanical systems more intuitively.

This paper introduces our web-based collaborative virtual environment for real time assembly design. The architecture of the system and some key technologies are discussed in details.

2 Related Research

The collaborative virtual assembly environment crosses multiple domains and involves multiple technologies, including the architecture, the model representation,

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 33 – 40, 2006.

the communication and conflict, and the multi-modal interaction. There have been many researches about VR based assembly design and collaborative assembly design up to now.

Gao[2] gave a summary about the research and development status of collaborative computer-aided design. Typically, according to on which side the assembly functions performed, the architecture of the real time assembly system can be classified into three types: the "thin server + strong client" type, the "strong server + thin client" type, and the "peer to peer" type. Shyamsundar and Gadh[3] presented a three-tier client server architecture in their cPAD(collaborative product assembly design) system, including the intelligent server, the application server and the client. The architecture can be considered the extension of the "strong server + thin client" type, and the intelligent server, as the middle tier, mediates all requests between the client and the servers.

The product attribute and behavior information in virtual assembly including information for product, feature, geometry & topology and display are organized differently. Shyamsundar and Gadh[4] also presented a compact Internet centric product assembly representation called AREP. The AREP represents a collection of assembly features to constrain the design assemblies assigned to individual designer, further to form a whole collaboratively developed assembly. Liu[5] presented a multi-level representation of product information for virtual assembly. Different levels are linked together, and the model can meet the requirements of real-time VR assembly system. Methodologies to detect and manage conflicts arising from a collaborative activity are also investigated[6].

Jayaram[7] has developed a virtual assembly design environment(VADE) granted by NIST to investigate the use of virtual reality for assembly design. VADE combines advanced CAD/CAM software with the virtual reality technology to produce an environment that allows engineers to virtually assemble a series of components. Based on the assumption that "if you can disassemble a component, you can assemble it, and vice versa.", Wan[8] also developed a virtual disassembly environment on their CAVE platform. It provides designers with a fully immersive 3D environment for assembly design and analysis. Rajarathinam[9] described the framework of a collaborative virtual environment (V2V), which allows the same site and the remote site multi-modal collaboration between multiple designers primarily focusing on collaborative engineering, but didn't talk about how to avoid conflicts on the collaborative condition.

3 Architecture of the Environment

As mentioned above, according to on which side the assembly functions performed, the architecture of the real time assembly system can be classified into some types. Pure "thin server+ strong client" and "strong server+ thin client" type both have their advantages and disadvantages. Data streaming technology based on commands instead of 3D models is propitious to light-weight the bandwidth of Internet; clients can manage the assembly calculations locally which are easy such as interactive manipulation, orders execution, display, etc; it's easy to deploy a collaborative system through equipping standalone CAD systems with a communication facility. Engineering involves making difficult tradeoffs.

The key is that considering the functional and performance requirement, we should deploy the right functional module on the right side.

Figure 1 shows the architecture of the collaborative virtual assembly environment. The system can be divided into three modules: the I/O unit, the task process unit, and the model management unit. Further, we divide the task process unit into two sub-units: the client side task process unit and the server side task process unit. And similarly, the model management unit is divided into the client side sub-unit and the server side sub-unit.

The input unit receives various kinds of inputs from designers, and integrates the information into assembly tasks, which can stand for designers' design intent and can be interpreted by the system. 3D assembly scene will be displayed by the output unit, and designers can get visual and aural feedback in different kinds of platforms, including CAVE, Work-Bench, or PC.

The assembly tasks are pre-processed by the Local Task Process Unit. Some of them, e.g. changing the viewpoint, can be executed in client site locally, and some of them, e.g., changing the place of one assembly part, must be submitted to the server side task process unit. The server site task process unit has a task queue to buffer and schedule tasks from different clients, which can ensure that each client execute the same tasks with the same sequence.

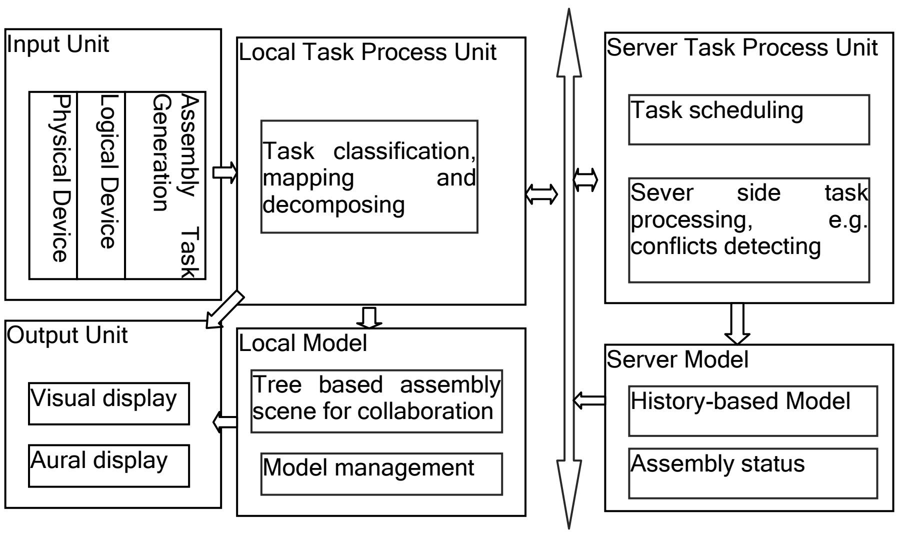

Fig. 1. Architecture of the collaborative virtual assembly environment

Different levels of product information for virtual assembly are also classified and organized into two models. Local model mainly includes information for display, and the server model includes information for server side task process unit, e.g. assembly status information for conflicts detecting, and history-based model for synchronizing the assembly process.

The usage scenario of our collaborative assembly environment is as follows:

Model Preprocessing: 1) A designer complete the product assembly model in a commercial CAD system, such as Pro/E, Solid Works. 2) Solid Model can be translated into a neutral file format, which can be processed by our system. Most of this information will be used to organize the local model. 3) Some other information including the assembly constraints, and the final places and orientations of each assembly part, and the assemble sequence can be obtained by utilizing programming interfaces of CAD systems. Most of this information will be used to help designers to operate properly and easily.
Session Starting: 1) When the first designer creates a new session, he loads a collaborative assembly scene. Solid model will be used to build the local model, and a copy of the Solid Mode will be submitted to the server side as the starting point of the history model. Information such as the assembly sequence will also transmit up to the server side. 2) When another client joins the session, the collaborative system constructs the same local model as the first designer's by downloading and executing the server side history based model.
Collaborative Virtual Assembly: 1) One designer start evaluating the assembly planning in the virtual environment with various interactive manners such as the mouse、keyboard、microphone、Flock of Birds、CyberGlove etc. A multi-modal integration algorithm will be used to obtain the real assembly tasks from the designer. 2) The assembly task will be pre-processed by the local task process unit to decide whether the task will be executed locally or be submitted to the server. 3) The server maintains an assembly tasks queue and takes out one task from the queue and decide whether or not it will result in a conflict according to current assembly status maintained on the server side. 4) The server side task process unit handles the passed tasks, updates the server model, and broadcasts its results to the local task process unit of all clients for further processing.

The following parts of this paper discuss in detail some core technologies based on the architecture introduced above.

4 Multi-modal Interaction

In the web-based collaborative virtual environment, designers from different places might use different platforms. With a five-layer multi-modal scheme(Figure 2), designers can select the right manner for themselves to interact with the environment, and the assembly task process unit can process tasks in a uniform manner and neglect differences between different input devices.

Figure 2 shows the scheme. The bottom layer is the physical layer which describes all the equipments that can be used in this system. The signal layer describes the most original data that can be obtained from the corresponding physical devices. These two layers can be used not only in the virtual assembly applications, but also many other VR applications. The lexical layer describes two kinds of words that can be interpreted by the assembly system: command words and parameter words. The syntax layer describes all assembly tasks which can be executed in the virtual assembly application. Most of the assembly tasks are composed of one command word and several parameter words. The virtual assembly application will try to interpret inputs from different devices and synthesize them into the final assembly tasks through the mapping and abstraction methods of several layers. It's not very convenient for a designer to completely and precisely input every assembly task, and the semantic layer can help the assembly system comprehend the designer's intent according to his operation contexts.

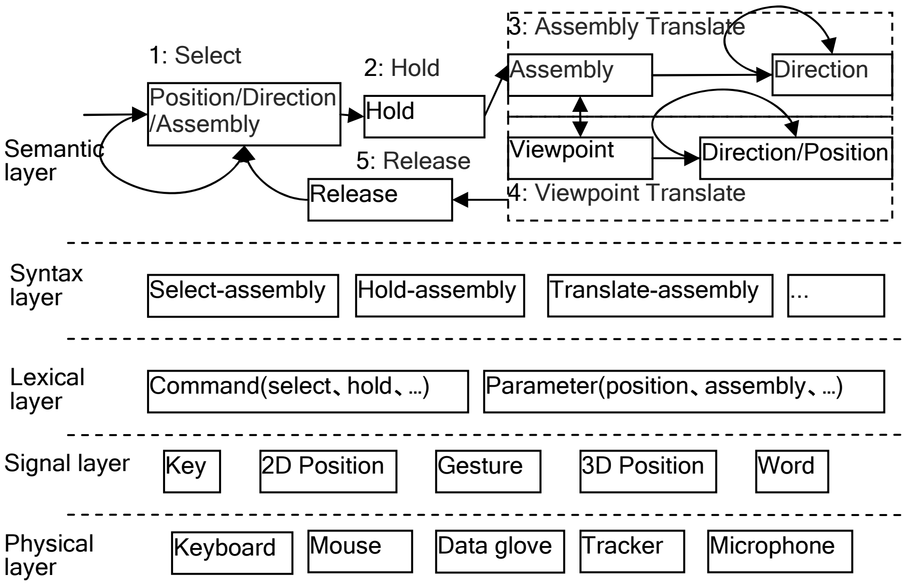

Fig. 2. Five-layer multi-modal scheme virtual assembly

In figure 2, an instance is given to illustrate how the semantic layer works to help the system better understand a designer's intent. Part of the assembly process can be divided into five states: the select state, the hold state, the assembly translate state, the viewpoint translate state, and the release state. Every state corresponds to one assembly task in the syntax layer. Because some information is implicit in relationships between statuses, the system can enable designers to omit some inputs through the following steps: 1) define some initial ready statuses, which are ready to accept some words from the lexical layer. For example, we can define the select state as the initial ready state, which can accept words such as position, direction, and assembly. 2) Execute the corresponding assembly task and then make the successive status ready once one of the current ready states receives a valid word. For example, if the designer wants to select an assembly, he can point to the assembly, or move his virtual hand on the assembly, or speak out the name of the assembly, and then the system executes the "select-assembly" task and makes the successive state(the select state & the hold state) ready, which means, the designer can select another assembly or hold the current selected assembly.

The semantic layer is also helpful to diminish confusion. For example, when a designer says “left”, the system can tell whether he wants to translate the assembly left or to transform the viewpoint left according to his interaction context.

5 Task Processing

In the web-based collaborative assembly system, we divide the assembly tasks into three types according to their process manners: the viewpoint transformation type, the scene modification type, and the communication type.

Table 1. The classification of tasks in the collaborative assembly system

Task type	Task name	Task handling approaches
Viewpoint transformation	Zooming / Viewpoint transformation	Execute on the client site locally and do not submit to the server
Scene modification	Model loading	First designer uploads the solid model to the server; The server saves the model into the history-based model as the initial state.
	Scene synchronization	A client sends a request to the server, downloads the history-based model, and constructs its local model by executing sequence of the assembly tasks.
	Assembly selection, holding, translating, and releasing	A client submits tasks that have passed the local collision detection to the server; The server detects whether a submitted task can result in conflicts, e.g. selecting an assembly that has already been selected by the other client, saves tasks that have passed conflict detection into the history-based model, and then transmits them to the other clients.
Communication	Text style Speech style	Send messages to the server and transmit them to other clients directly

Table 1 lists some assembly tasks and their corresponding types and handling approaches. Since different clients can manipulate assemblies with different viewpoints, it is not necessary to send the local viewpoint transformation assembly tasks to the other clients. Tasks of the communication type, such as text and audio messages, should be sent to server. Then, they can be broadcasted to other clients directly and don't need to be processed further on the server side.

Tasks of the scene modification type need more interaction between clients and the server. As for the model loading task and the scene synchronization task, the interaction only involves one client and the server. Tasks such as the assembly selection, holding, and translating, need to be collaboratively processed. It's necessary to avoid conflicts.

Tasks of scene modification must be submitted to the server before it can be executed locally and the server detects potential conflicts, e.g. selecting an assembly that has already been selected by the other client. In addition, all the clients receive the same tasks set in the same order. In our system, we only keep the assembly status in the server, so some conflicts, such as collisions between assemblies, can't be detected. If collision occurs, it's reasonable to execute an additional reverse operation. Because different clients might give different results when two assemblies are very close, we let the client that submits the task make a pre-collision detection locally. Only the passed tasks can be submitted to the server.

6 Implementations

Hoops 3D is a high-level 3D sub-routine library which provides developers with advanced components for graphics, streaming and collaboration. Hoops 3D application framework module provides ability to view and manipulate the 3D model on different platforms, including PC based virtual environment, SGI WorkBench and CAVE virtual display environment. Hoops 3D stream module provides ability to upload and download the initial solid model efficiently. Hoops 3D net module provides web-based collaboration ability, except that it only allows modifying the scene through the one by one manner.

Fig. 3. Scene of collaborative assembly environment

Utilizing Hoops 3D, we have developed a collaborative virtual environment for real time assembly design, and different designers can engage in the same assembly tasks synchronously on different hardware platforms. Figure 3 shows some usage scenarios. The first picture shows a simplified solid model of a mechanic press, which is built with Solid Edge and contains about 30 sub-assemblies. The middle picture shows that two designers assemble the mechanic press collaboratively on the PC platform with various input devices. From the last picture which is obtained from our WorkBench display environment, we notice that two baffles are assembled at the same time.

7 Conclusions

Based on the current research and developing tools, a prototype system to aid the assembly process of the mechanic press is developed. The collaborative virtual assembly environment crosses many fields involving virtual reality, collaborative design, and assembly simulation, and we still have a long way to go:

To enrich the environment, more assembly simulation tools and algorithms need to be integrated on the server side.

We need standards and methods to help us evaluate the advantages and disadvantages when we try to integrate the VR technology into the collaborative assembly system.

Different platforms have different displaying and calculating performance, which is very important to the collaborative virtual environment for real time assembly design. And it is a problem that needs to be further studied.

References

1. Li, W.D., Lu, W.F., Fuh, J.Y.H., and Wong, Y.S.: Collaborative computer-aided design – research and development status, Computer-Aided Design (2005) 931-940
2. Gao, S.M., He, F.Z.: Survey of Distributed and Collaborative Design. Journal of Computer-Aided Design & Computer Graphics (2004) 149-157
3. Shyamsundar, N., Gadh, R: Collaborative virtual prototyping of product assemblies over the Internet. Computer-Aided Design (2002) 755-768
4. Shyamsundar, N., Gadh, R: Internet-based collaborative product design with assembly features and virtual design spaces. Computer-Aided Design (2001) 637-651
5. Liu, Z.Y., Tan J.R., Zhang, S.Y.: The Multi-level representation of product information for virtual assembly, Journal of Computer-Aided Design & Computer Graphics (2001) 223-228
6. Case MP, Lu SCY: Discourse model for collaborative design. Computer Aided Design (1996) 333-345
7. Jayaram, S., Jararam, U., Wang, Y., Tirumal, H: VADE: A Virtual Assembly Design Environment. IEEE Computer Graphics and Application (1999) 44-50
8. Wan, H.G., Gao, S.H., Peng, Q.S.: VDVAS: An Integrated Virtual Design and Virtual Assembly Environment. Journal of Image and Graphics A (2002) 27-35
9. Arangarasan, R., Gadh, R: Geometric Modeling and Collaborative Design In a Multi-Modal Multi-Sensory Virtual Environment. In Proceedings of DETC (2000), ASME, Baltimore, MD, as file CIE14592.pdf on CD-ROM

Mosaics of Visualization: An Approach to Embedded Interaction Through Identification Process

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Abstract. New forms of interaction are arising closer to the users and embedded in the intelligent environments. In this work we present a context-aware application through Radiofrequency Identification (RFID) offering services to the users in an implicit way. The only required interaction with the system is to wear a little device called tag (smart label). Some of these services such as location, presence, access or inventory are implicit in this technology. Another, more important for us, is the visualization service, we call "Mosaic of Visualization". Our main goal is to link the easy interaction by means of the identification process, through RFID technology, with the presentation of information.

1 Introduction

Ambient Intelligence (AmI) has the vision that technology should adapt to the user's needs, solving daily activities without any extra interaction [1]. New challenges of computing arise. The traditional computer is distributed to a whole set of devices placed around us providing users with an intelligent background. AmI is based on three key technologies: Ubiquitous Computing integrating microprocessors into everyday objects. Ubiquitous Communication allows these objects to communicate with each other and with users. Finally, natural interfaces interacting with the environment in an easier and more personalized way.

However, for this vision to become a reality it is necessary to handle the context-aware information. Brooks considers some aspects that we shall now mention as being important: [2]: "who" (identity awareness) managing the user's profiles and the way that context differentiates them in order to attain appropriate behavior; "where" (location awareness) as the knowledge of the location of people and the objects that will carry out the tasks; "when" (time awareness) referring to the acquisition and maintenance of information about time and date, static schedules and the dynamism of the user's calendar; "what" (task awareness), focusing on what the user is doing, the task he is carrying out and all that he or she wants to achieve. Others propose new forms of interaction which are more natural and closer to the user. Albrecht Schmidt

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 41 – 48, 2006.

[3,4] proposes a definition of Implicit Human Interaction (iHCI): "*iHCI is the interaction of a human with the environment and with artefacts, which is aimed to accomplish a goal. Within this process the system acquires implicit input from the user and may present implicit output to the user*". Schmidt also defines implicit input as user perceptions interacting with the physical environment. At this moment, the system can anticipate the user, offering services with explicit output. In addition this author defines embedded interaction in two terms. The first one embeds technologies into artefacts, devices and environments. The second one, on a conceptual level, is the embedding of interactions in user activities (tasks or actions) Schmidt et al [5].

In this work we propose the identification process as an implicit input. The system perceives the user identity, his profile and other kinds of dynamic data. This information complemented by the context in which the user is found, as well as the schedule and time, make it possible to anticipate the user's actions. We try to solve the lack between implicit input by identification and the output through visualization of information

Under the next heading the "who model" by RFID is presented. In the section three a proposal for context-awareness by identification is studied. The next point presents our proposal of Context-Awareness Visualization-Based Services, called "Mosaics". Then, two proposals putting into practice the visualization services is shown. Finally, conclusions are set out.

2 The "who" Model

People identification is a very good implicit input to the computer. The easy action of walking near an antenna allows the system to read and write information such as Id. Number, profile and other such items which are very useful, depending on the context where the users are. We have focused the context aspects mentioned before on the identification process [6, 7, 8]. We are therefore placing these concepts strategically in order to obtain visualization services for the users as seen in Figure 1.

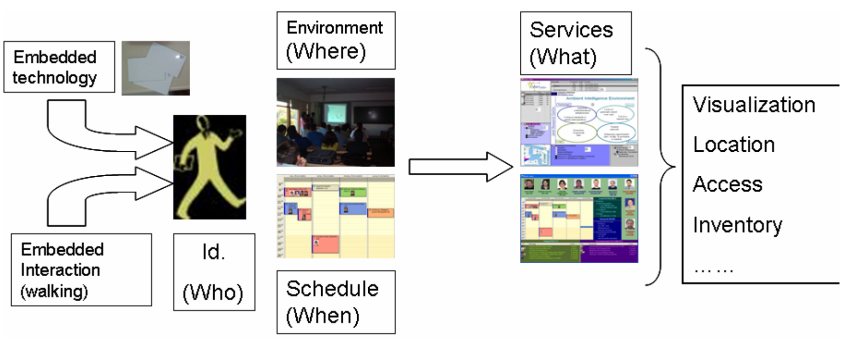

Fig. 1. Context concepts through Identification

The user can also obtain typical identification services such as location, access, presence, inventory, phone call routing, etc. All of these are obtained with a combination of "who", "where" and "when" concepts of context. We have called it the "who model". Through this, it is possible to handle non-intrusive services without any extra-cost of interaction. With this model we try to solve the lack between these kinds of inputs and outputs. Both of them, in a non-intrusive way, allow the user to concentrate on the task, not on the tool.

2.1 RFID Technology

We have adapted RFID technology with the purpose of identifying people. In this technology three kinds of objects are clearly differentiated: the reader (reader or transceiver) connected to the computer, the antenna and the label (tag or transponder). The last one is a small device containing a transponder circuit that takes, in the case of the passive tags, the wave energy that the reader continually emits and reads and writes the information that these may include. Figure 2 shows two RFID sets. The one on the right presents a reader and an antenna with a read-and-write capability reach of over 75 cm. This has been specially designed for its location on room doors, or near boards. The one on the top left is a contact reader including an antenna with a reach of only 10 cm. A model of the tag is also shown. This identification system is ideal for individual use.

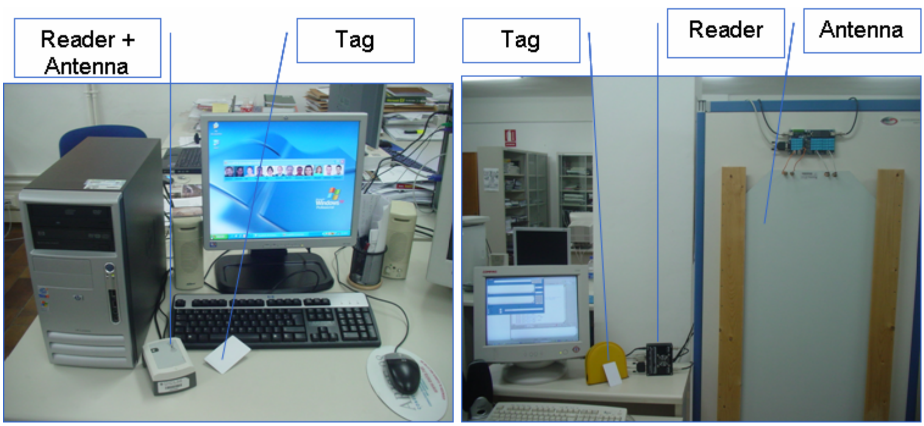

Fig. 2. RFID devices

We have built different applications to obtain typical services which this technology offers. The location service is solved placing an antenna near a door. Also, we can place two of them to know who enters or leaves a room. Complementing this service, the access control is observable. For instance, people scheduled for a meeting are allowed to enter the meeting room. A similar service is the presence control. It consists of checking the presence of a group of workers. Also, inventory and routing phone calls are possible to control with this technology and the corresponding application.

3 Visualization-Based Services

In order to obtain optimized information services for users it is necessary to pay attention to the ‘w’ concepts mentioned before. The “who”, displaying the “what” in “where” (location) are all essential. Other aspects picked up in an ontology that we have developed such as size, priority (profile) and schedule are kept in mind to establish the Visualization Mosaics.

3.1 Visualization Mosaics

The presentation of information is important without needing the user's request. This presentation and the independence of the display device are important factors to be considered. We are trying to consider every visualization component as a puzzle piece. For that, the visualization service is regarded as a mosaic of information. For the representation of each mosaic, we have applied a XML-based language. In it, the pieces of the mosaic, the size and the kind of each element are considered. In Figure 3 the XML representation of a mosaic is shown.

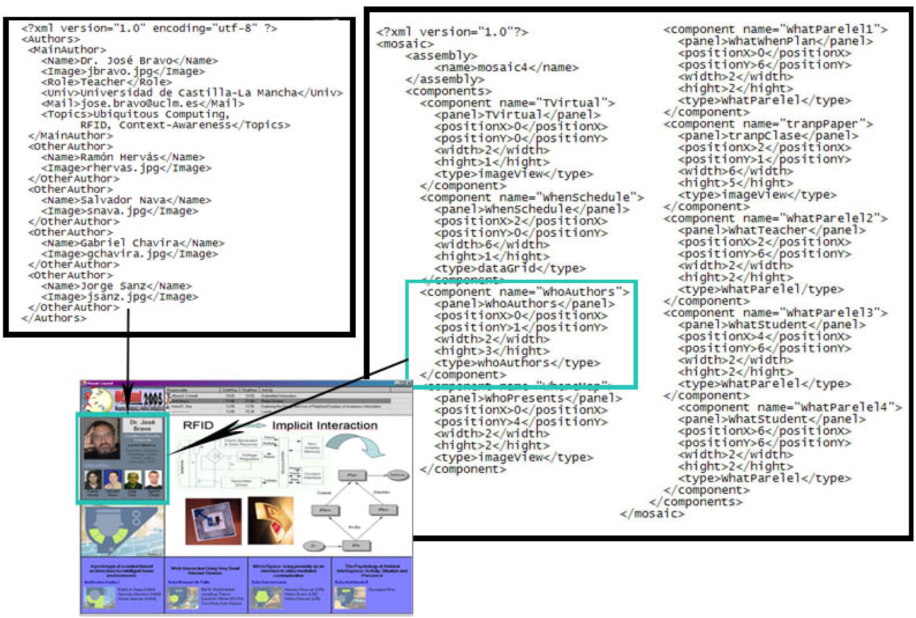

Fig. 3. XML-Based Mosaic

The visualization service involves three modules which are clearly differentiated: The Analysis Context Module, responsible for the changes of the context and the managing of a Data Base. The Mosaic Generation Module which obtains data that will be presented in the selected mosaic. Finally, the Mosaic-Composer Module that executes the mosaic and generates the user interface automatically.

The activation of the mosaics depends on the implicit input obtained when the system identifies people wearing rfid tags. Accordingly the identification, profile, environment, schedule and time are shown by every mosaic with information adapted to the users. Also, the kind of mosaic depends on the assigned role according to the context. This role can be of presentation (classroom, conference context, meeting, etc.), virtual board showing news and notices, information concerning the research lab members, etc. All of them in a university context but we think it is possible to extrapolate to other contexts such as health care, business, etc.

4 Visualization Services at Campus

Our first experience has been in a campus context with two different scenarios: the classroom environment and the meeting of groups of students. In the first one, the contents of visualization service depend on the "who model" mentioned before, that is, according to the schedule, place and time. In the second one, the contents to visualize appear according to the formatted information before the meeting.

4.1 The Classroom Environment

The classroom is equipped with a computer, reader and antennas. We have placed an antenna on the door and another near the board. This architecture enables the lecturer and students wearing tags to manage information for the class contents. When teachers and students enter the classroom, location (attendance) and access control services are activated automatically.

In Figure 4, a mosaic of information is shown. The part of the mosaic labelled (1) shows the classroom attendance. In (2), a lecturer's plan is presented. This controls all the activities for this session. In (3) a building plant informs the students about activities that will take place. Next one (4) shows the lecturer's contents for this class. The others, (6) and (7) the documents, links and proposed exercises are shown.

This mosaic appears when the lecturer enters the classroom or approaches the board (proximity). If the student is the one approaching the board, the answer he has given to the problem proposed previously can be displayed. Another possibility is for some presentation, or indeed any other kind of information to be shown. We solve the conflicts of many people near the board by means of control of audience. In some cases, the functionality of the sensors allows the teacher to authorize o deny the student proximity service.

The mosaic is different for each attendance profile. In the time between classes the information is about news and announcements for students. Only when the lecturer leaves the class is another mosaic activated. This process arises when the door antenna detects that he/she leaves the classroom.

Another important aspect consists of storing the information of the lesson in tags. To do so, a Data Base including this documentation must exist. This will be indexed by codes which are put onto the tags. Teachers and students carry this information when they go through the door on leaving the classroom.

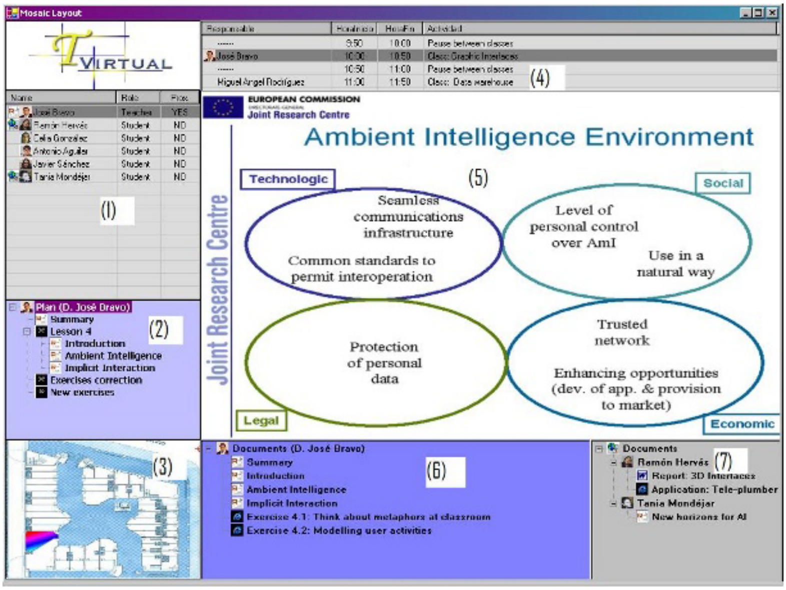

Fig. 4. The Classroom's Mosaic

Finally, all the activities in the classroom are completed by work at home, supported by a contact reader, which reads the information included in tags and/or rewrites more for the next class. This process allows the students to give their presentation (problem solved, doubts, etc.) in time for class. Also, the contact reader allows the lecturer to manage the information in the tag.

4.2 An Experience Supporting Students' Cooperative Work

We have carried out an evaluated experience with some groups of students. It consists of a cooperative work where each student contributes a part. Every part has to be transmitted to the others. In order to help the students and facilitate the discussion we have built a simple tool to format the information adequately. See Figure 5 (left). The format of information consists of writing the main and secondary text, like a typical presentation slide, linking figures and graphics. This is stored in the student's tag and, later, in the group meeting upon, approaching the board, the mosaic appears automatically. See Figure 5 (right). This mosaic shows different parts detailed as follows: In the top left the title of the complete work for the group. Below this, a list of the students and their jobs can be seen; also, the affiliation of a student who is currently presenting and his index is offered. In the large area on the right, a concentrated slide with text, images and graphics attached is shown. Then, at the bottom of the mosaic, the attached elements are presented. Our system chooses the best kind of mosaic for each slide automatically. This is responsible for distributing the space for text, images and graphics.

It is obvious that in these implicit inputs and outputs some kind of additional interaction is expected. For that we have placed a number of sensors below the display with different functionalities. By only passing a hand near each sensor the user can obtain answers from the system. The interaction required for each hand movement is a combination of identification and sensors. So, control of different information for each student and the functionality of each sensor are adapted to them according to their needs in every mosaic.

In order to make this experience more real, the students, at the beginning, only know the tool to format the information. Later, in the meeting room, everyone understands the effect of the mosaic and the functionality of sensors below the board. We think this impact is important and this gave us a clearer idea about the acceptance of the new computational situation. The evaluation had two different kinds of students. The groups of the class doing their presentations using the tool and the mosaic and the other groups, that didn't use it. The results are very interesting. While the implicated students were asked about their interest in the experience, the first 71% said good, in the second group 66% said good but the rest of this group classified the experience as excellent. The second question is about the interaction by proximity. In the first group 85 % said excellent compared to 66% in the second one. The third aspect of interaction with sensors, 43% of the first group said average and the other 28% good and 28% fair, while 44% of the second group thought good and 44% average. Regarding the appropriateness of the mosaic to present information, 28% of the first group said excellent and 56% good. In the second 33% said excellent and 55% good. Lastly, when asked about the global evaluation of the experience, 44% of the first group said excellent and 44% good. In the second one, 44% said excellent and 44 % good. Seeing this data we conclude that the students accepted this new form of interaction satisfactorily in terms of proximity and transforming the students' information.

Fig. 5. Students' tool and cooperative work mosaic

5 Conclusions

In this paper we have presented a proposal of visualization of information. This is possible without any extra interaction from the user. For that we have applied a specialized sensorial capability that RFID facilitates. This way of showing non-intrusive context-awareness information tries to be a step in the modelling scenarios where users can concentrate on the task and not on the tool.

After this experience it is necessary to think about building an Identification-Based Framework. With this tool, it will be possible to study different contexts with similar features and services that can be offered. Therefore we could better understand the knowledge of context.

Acknowledgments

This work has been financed by a 2005-2006 SERVIDOR project (PBI-05-034) from Junta de Comunidades de Castilla-La Mancha and the Ministerio de Ciencia y Tecnología in Mosaic Learning project 2005-2007 (TSI2005-08225-C07-07).

References

1. ISTAG, Scenarios for Ambient Intelligence in 2010. Feb. 2001. http://www.cordis.lu/ist/istag.htm.
2. Brooks, K. (2003). "The Context Quintet: narrative elements applied to Context Awareness". In Human Computer Interaction International Proceedings. Crete (Greece) by Erlbaum Associates, Inc.
3. Schmidt, A. (2000). "Implicit Human Computer Interaction Through Context". Personal Technologies Volume 4(2&3) 191-199
4. Schmidt, A. (2005). "Interactive Context-Aware Systems. Intering with Ambient Intelligence". In Ambient Intelligence. G. Riva, F. Vatalaro, F. Davide & M. Alcañiz (Eds.).16 José Bravo, Ramón Hervás, Inocente Sánchez, Agustin Crespo. "Servicios por identificación en el aula ubicua". In Avances en Informática Educativa. Juan Manuel Sánchez et al. (Eds.). Servicio de Publicaciones – Universidad de Extremadura. ISBN84-7723-654-2.
5. Schmidt, A., M. Kranz, and P. Holleis. Interacting with the Ubiquitous Computing – Towards Embedding Interaction. in Smart Objects & Ambient Intelligence (sOc-EuSAI 2005). 2005. Grenoble, Francia.
6. Bravo, J., Hervás R., Nava, S & Chavira, G. "Ubiquitous Computing at classroom: An Approach through identification process". Special Issue on Computer and Educations. Journal of Universal Computer Science. Vol. 11-9. September 2005.
7. Bravo, J., Hervás, R., Chavira, G., Nava, S. & Sanz, J. (2005). "Display-based services through identification: An approach in a conference context". Ubiquitous Computing & Ambient Intelligence (UCAmI'05). Thomson. ISBN:84-9732-442-0. pp.3-10.
8. Bravo, J., Hervás, R., Chavira, G. & Nava, S. "Modeling Contexts by RFID-Sensor Fusion". Workshop on Context Modeling and Reasoning (CoMoRea 2006), PerCom 2006. Pisa (Italy)

The Use of Cooperative Visualization in the Enhancement of Corporate Planning in Small and Medium-Sized Enterprises

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Abstract. Small and medium-sized enterprises (SMEs) significantly contribute to the majority of national economies. Often they are confronted with difficulties. This paper reports on a project that was carried out in order to help managers of small and medium-sized enterprises to improve managerial processes. This work proposes a visual model for diagnosing corporate planning in SMEs. Developed computer programs contain tests that allow collaborative examination of the state of planning in SMEs and visually analyzing the results. By using this model, managers of small and medium-sized enterprises in collaboration with experts can improve corporate planning. The proposed visual model was tested in small and medium-sized enterprises and proved to be valuable for enhancing corporate planning.

Keywords: cooperative visualization, small and medium-sized enterprises, planning.

1 Introduction

Cooperative visualization is used widely in science, especially in medicine, fluid mechanics, meteorology, and some others areas. The application of visualization in business processes seems to be a rather promising direction that is presently in the initial stages of development [4]. Small and medium-sized business development is a subject of support from the governments of many countries. The application of visualization in this sector has great potential.

Small and medium-sized enterprises (SMEs) play an important role in the economy. In the EU, for example, they provide jobs for 75 million people and count for 99% of all registered enterprises [5]. However, doing business is not always an easy task for SMEs. Small and medium-sized firms face financial, resource (including human resource), managerial, and other problems more often than their larger counterparts. Access to new, expensive technologies is limited for SMEs.

The necessity of a visual model for diagnosing planning in SMEs emerged during a survey of management processes in small and medium-sized enterprises and through in-depth interviews with SMEs managers in Ukraine [6]. The survey results showed that planning is the weakest element in SMEs' management: 76% of examined executives do not use planning at all in their every-day practice.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 49 – 56, 2006.

In-depth interviews demonstrated that entrepreneurs often a) do not realize the importance and necessity of planning for their business, and b) simply are not familiar with planning methods and techniques.

Under these circumstances, I have decided to create a tool that will assist entrepreneurs to better plan their business. I pursued several goals. First, this instrument should serve research aims: to aid in investigating the current state of planning in SMEs. Second, it should show a manager responsible for planning in an SME whether his/her planning efforts are effective and sufficient. Third, it should be a means for productive cooperation between SME managers and scientists (or consultants from business support organizations). The latter give recommendations regarding changes that ought to be undertaken to enhance planning effectiveness.

Such an instrument should meet the following criteria: be simple, low-cost, non-time consuming, user-friendly, and presentable. As the result, I have developed a visual diagnostic model for planning in SMEs that lets managers to determine existing problems and establish a framework for using planning instruments in management.

The paper is organized as follows. The next section presents the visual model for diagnostic of planning in SMEs. Then I illustrate the results of testing the visual model in a small enterprise. The paper terminates with conclusions and proposals for future research.

2 The Visual Model for Diagnosing Corporate Planning in SMEs

The visual model for diagnosing corporate planning in SMEs is a mechanism used in the general process of forming or upgrading an existing planning system. Schematically this process is depicted in Fig.1.

The method of diagnostics is based, on the one hand, on the principle of 'best practice benchmarking' [2]. On the other hand, it is grounded on the procedure of logical analysis that consists of the two following stages.

1. Set down the main aspects of the subject of research – the planning system in SMEs – through the interpretation of the concept that expresses its essence. That is to say, the corporate planning system (CPS) is the extent of conscious utilization of specific methods to forecast the future of the small and medium-sized enterprises depending on objective and subjective factors.
2. Determine the operational concepts that the main concept – the state of the corporate planning system - can be broken into. Such constituents, in my opinion, are:
   - The degree of business dependence on business risks,
   - The level of planning independence as a function of management,
   - The extent of goals' diversity,
   - The comprehension of the role of planning by enterprise executives (and/or owner-manager),
   - The planning horizons,

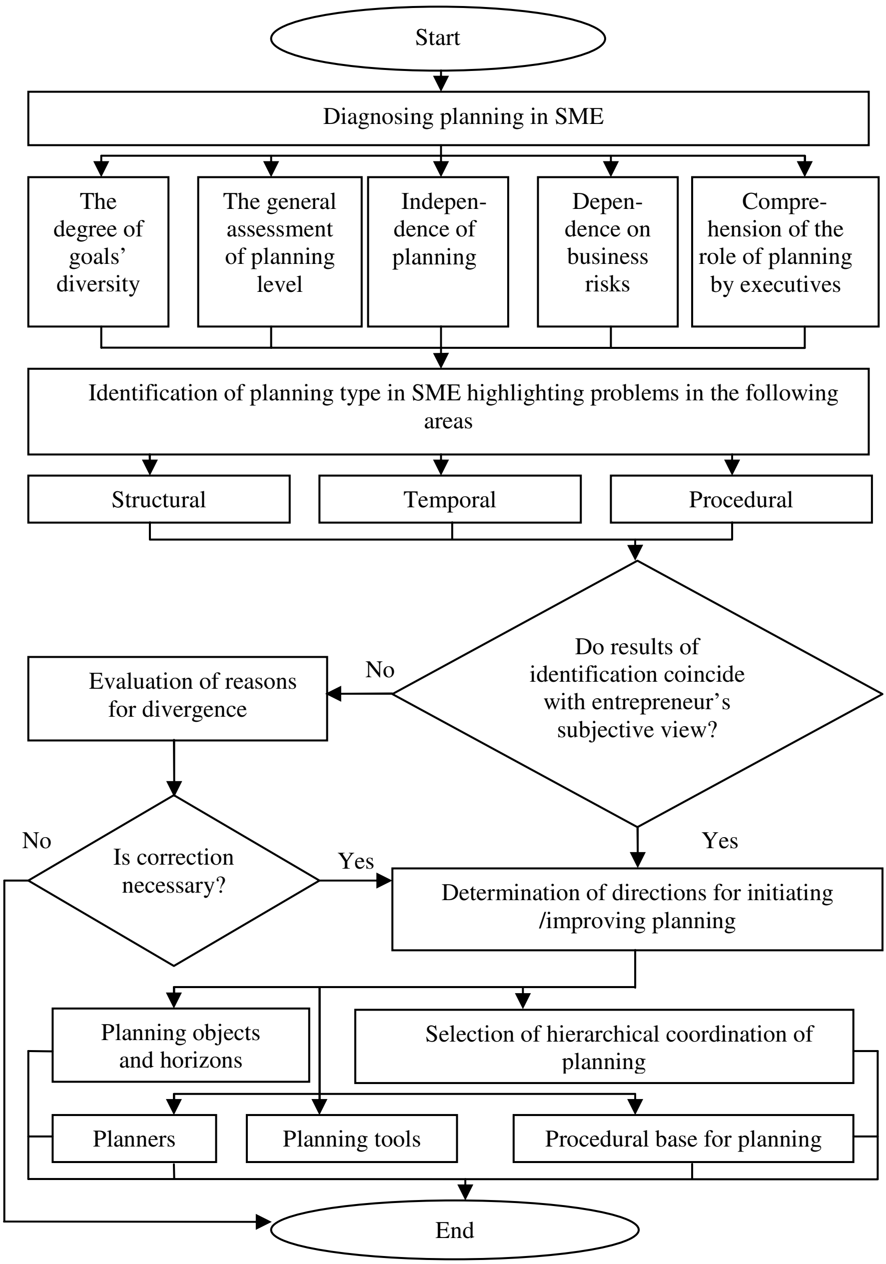


Fig. 1. Procedure for improving the planning system in small and medium-sized enterprises

- The degree of detailed elaboration and formalization of planning, and
- The level of planning methods and technologies.

2.1 Cooperative Web-Based Visualization

According to [1], there are three possible approaches to client-based systems in cooperative visualization:

a) Visualization design and core software are both present on the client,
b) Visualization design is downloaded from server, while core software is present on the client, or
c) Visualization design and core software are downloaded from the server.

For the purposes of our project, the second alternative is the most appropriate as it complies with the initial requirements of the model. The tool for small businesses should be not expensive; therefore, it employs core software that is widely available. We used Microsoft Windows as the core software. Developed computer programs containing tests and visualization designs can be downloaded from a server.

2.2 Data Collection and Analysis

I have developed special tests to estimate each constituent of the corporate planning system. Each test consists of ten dichotomic questions that characterize these elements. Presence or absence of the characteristics in an SME and the skills of the entrepreneur/manager are recorded on a binary scale, using 'yes-no' answers.

I have chosen a ten-point scale with unequal intervals to test the elements' effect on the CPS. This is stipulated by a number of requirements to scale, in particular scale sensitivity that characterizes the ability to determine the attitude of respondents to the phenomena under investigation with one or more degrees of differentiation. The option to choose the number of subjective indicator positions belongs to the researchers. In my judgment, a smaller number of questions, for example five, will not provide the opportunity to entirely characterize the variables, and a greater number (15-20) will complicate the analysis and will take longer time for both the 'passenger' (user) and the 'pilot' (expert). Assessment proceeds on three levels: high (8-10 points), average (5-7 points), and low (0-4 points).

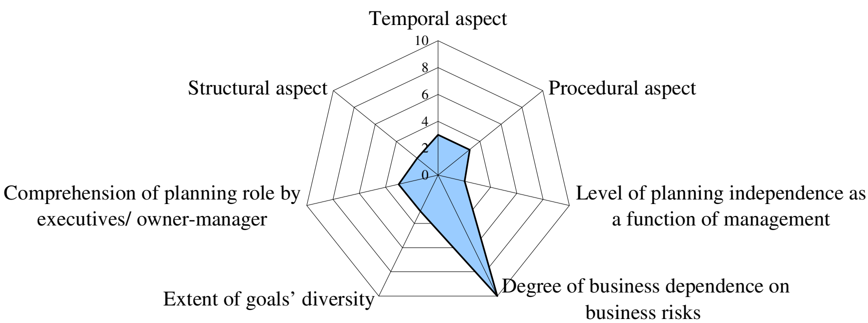
The questions from these tests are built into the computer program. Answering the queries, the manager gains insight into the state of the corporate planning system in his/her enterprise in seven basic elements that can be represented visually in a 2-D model in the form of polygonal figure. This is the first figure in the visual model. I used a red-colored polygon to visually show the state of planning in the manager's enterprise. But what does it actually mean? How good or how bad is planning in the SME?

For detecting problems, test findings should be compared with a given standard (best practice model) that characterizes the optimal state of the corporate planning system. It is obvious that this can not be universal for all small and medium-sized enterprises, because firms vary at least in size, the field of business, and the sum of annual turnover.

It is appropriate to mention here that there is no common accepted definition of small and medium-sized enterprises in the world. For example, in the USA, all enterprises that employ fewer than 500 people are considered as small, and those having not more than 20 employees are ‘very small’. In the European Union, the definition of SMEs was recently reconsidered [5]. All SMEs are classified now into three categories according to quantitative features (headcount, annual turnover, and balance sheet) and qualitative features (independence from other businesses): micro, small, and medium-sized enterprises.

From this point of view, I divided small and medium-sized business entities into three sub-groups and developed a best practice model of corporate planning for each sub-group. In the visual model, I have oriented on the EU classification of SMEs. This has several explanations. First, such a categorization, in my opinion, is the most rational of currently existing definitions. Second, the EU definition is already accepted in twenty five European countries and five more candidate states should adopt it after joining the EU.

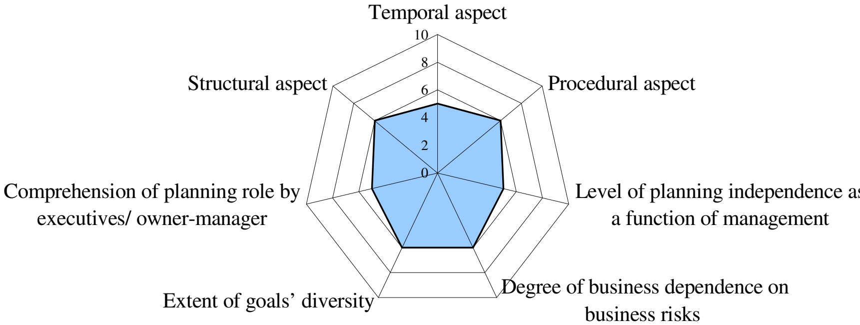
Microenterprises (a staff of 1-9 persons; an annual turnover up to €2 million, and/or an annual balance sheet up to €2 million). The scale of business is not large, which is why it is rather accessible for review. There is probably no need to draw formalized plans, though the leader (often this is owner-manager) has to make certain forecasts for the near-term outlook, mainly financial. The best practice model is shown in Fig. 2.



Quanitative parameters:
1. Number of employees: 1-9
2. Turnover: up to €2 million per annum
3. or Annual balance sheet: up to € 2 million

Fig. 2. Best practice model for planning in microenterprises

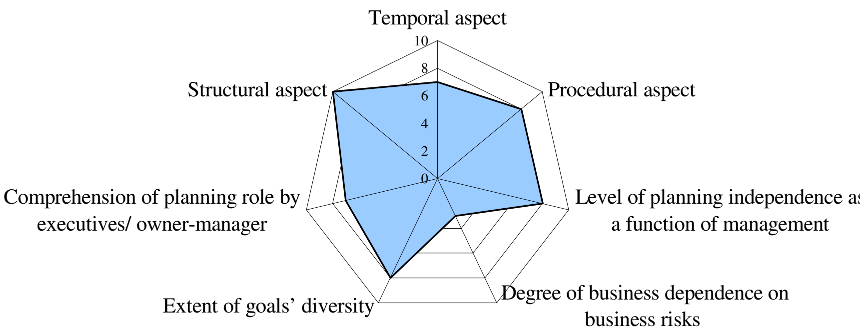
Small enterprises (a staff of 10-49 persons, an annual turnover up to €10 million, and/or an annual balance sheet up to €10 million). The scope of activity is greater than for the previous group. It is quite possible that the enterprise is active in a number of business fields and has several levels of management. That is why the role of planning is growing, and the firm must have well-defined goals, operational planning, and plan key functional areas. It is advisable to have a manager with planning skills. The model for this category is shown in Fig. 3.



Quanitative parameters:
1. Number of employees: 10-49
2. Turnover: up to €10 million per annum
3. or Annual balance sheet: up to € 10 million

Fig. 3. Best practice model for planning in small enterprises

Medium-sized enterprises (a staff of 50-250 persons, an annual turnover up to € 50 million, and/or an annual balance sheet up to €43 million). The role of planning is rising compared to micro and small enterprises. The increase in the firm's size stipulates an expansion in forecasting and its time horizon. Therefore, the best choice here is the high level of all parameters: operational, long-range, and strategic planning with the coverage of all directions of the company's business activities (Fig. 4).



Quanitative parameters:
1. Number of employees: 50-250;
2. Turnover: up to €50 million per annum
3. or Annual balance sheet: up to € 43 million

Fig. 4. Best practice model for planning in medium-sized enterprises

Finally, the results of the examination (the red polygon) are overlaid on the best practice model of planning corresponding to the type of SME (Fig. 2, 3, or 4) where the manager is employed. At the end of testing, the executive immediately receives a visual image of the ‘state of play’ for planning in his firm in comparison with the benchmark (the blue-colored polygonal figure). The variable(s) that need correction, change in management actions, will be easily visible from the images. If the polygon corresponding to the state of planning in the SME is equal to or surpasses the ‘best practice’s’ polygon, it means that planning efforts in the given firm are sufficient and do not need alteration.

Otherwise, the planning system should be upgraded. The results of the visualization go from the client (SME manager) to the server, where an expert collects and analyses them. In this case asynchronous collaboration takes place. The expert processes the results of the testing when he/she has time and responds to the user giving recommendations concerning ways to improve the system. In this case the consultant and the manager may not have personal contact. They can be thousands of miles away from each other and operate in different time zones. After implementation of the suggestions for improving planning in the SME, diagnosing can be repeated to control the usefulness of the changes.

3 Testing the Elaborated Model

The given procedure for improving corporate planning was implemented in the company *Euroservice,* which belongs to the category of ‘small enterprises’ based on the previously determined criteria. The results of the testing are presented in Fig. 5.

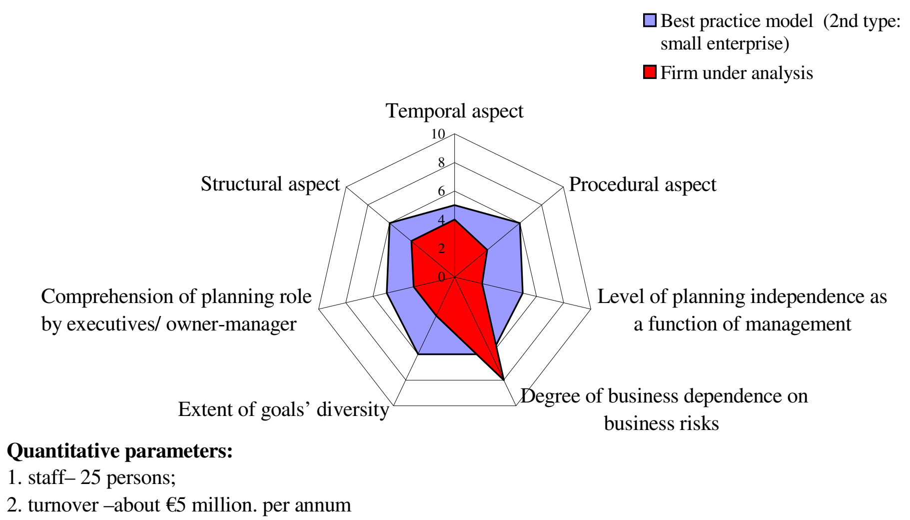


Fig. 5. The results of diagnosing the planning system for the company ‘Euroservice’

As can be seen from Fig. 5, some elements of planning do exist in *Euroservice* (in the form of budgets for each department), but the level of planning is significantly lower than is the optimal standard for these types of SMEs. Consultants prepared a program of planning modification for *Euroservice* and the top-managers in the company accepted it and decided to carry out a stepwise refinement of corporate planning. In the first stage, budgeting was improved. Here there had been a number of drawbacks, in particular that marketing budgets were lacking in all the company's divisions. In the second stage, formalized operational and short-run planning was implemented. More detailed information on how *Euroservice* organized improving of planning is contained in [3].

Application of the visual model for diagnosing planning in thirty-two other SMEs has allowed managers to appraise the status of company planning. The results have shown that in seven enterprises the level of planning was high, in twelve enterprises planning was carried out but not sufficiently, and in 13 firms the planning was absent. Experts provided support for those enterprises which needed reform of planning.

4 Conclusions

It has been argued that the visual diagnostic model for planning in small and medium-sized enterprises makes it possible to visually analyze large amounts of data received as the result of an examination of corporate planning.

The results highlight the potential of using the visual model for scientific purposes, allowing scholars to get data on the state of planning in SMEs. The usefulness of this model includes a practical benefit for entrepreneurs who can measure the sophistication of their planning work. Finally, the visual diagnostic system makes it possible to get feedback from an expert in the area of corporate planning who receives resulting images from a collaborative server.

Further research can expand the visualization model to examine other key functions of management in SMEs (organization, motivation, and control) and a firm's other functional spheres (marketing, finance, etc.).

References

1. Brodlie, K.W., Duce, D.A., Gallop, J.R., Wood J.D.: Distributed Cooperative Visualization. EUROGRAPHICS '98. Workshop (1998) 223-251.
2. Clarke, A., Garside, J.: The Development of a Best Practice Model for Change Management. European Management Journal 15(5) (1997) 537-545.
3. Parsyak, V., Zhuravlyova (Solesvik), M.: Planning in Small and Medium-Sized Enterprises. Institute of Agrarian Economics Publishing, Kiev (2001).
4. Sochats, K., Morse, E.: Visualization. http://ltl13.exp.sis.pitt.edu/Website/Webresume/VisualizationPaper/Visual.htm
5. The New SME Definition: User Guide and Model Declaration. http://europa.eu.int/
6. Zhuravlyova (Solesvik), M.: Determination of Problems in SME's Planning. Bulletin of the Ukrainian State Maritime Technical University, Vol.6. USMTU, Nikolaev (2000) 157-168.

Collaborative Web-Based 3D Masterplanning

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Abstract. This paper describes an approach to empowering heterogeneous groups of people to share the tasks of digitising and updating buildings that may convey a credible sense of presence. We argue that more effective tools are required to clearly display alternative and ad-hoc local planning proposals in web based interactive 3D, free at the point of access. Initial workshops have shown that such tools are only likely to be used if those so doing can influence the outcome. Consensus needs to be obtained among a broad group to exert strong influence. Tools are therefore needed to share concerns, examine alternatives, and propose solutions through collaborative citizen based proposals, examination and discussion. Consequently the VEPs Interreg project has been examining how to optimise shared web based collaborative digital 3D modelling and discussion, focused on urban and rural environments, where the increasing availability of LiDAR laser scanning offers appropriately accurate remote sensed data.

1 Introduction

This paper discusses recent work in the VEPs Interreg project [1] that has been examining how to optimise operator based digital 3D modelling of urban and rural environments, where the increasing availability of highly accurate Light Detection and Ranging (LiDAR) laser based scanning offers appropriate remote sensed data, and opportunities to automate parts if not all the process. The automation process was described in Richman et al 2005 'Remote Sensing, LIDAR, automated data capture and the VEPS project' [2]. The extent of this automation depends on the precision of the intervals at which the data is captured. We would argue that Master Planning is an inherently collaborative process, and that enhanced public participation in the process requires consensus. Web tools have been prototyped to examine how citizens can upload their own modelling into this context for exploration of 'what-if' alternatives without requiring explicit CAD skills, and to share their modelling with others, or to download and modify modelling by others, to generate interactive discussion. These will where possible be based upon existing digital city or countryside modelling in the VRML or emerging X3D international standards.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 57 – 64, 2006.

2 The VEPs ePlanner

VEPs, the ‘Virtual Environmental Planning System’, is an Interreg IIIB funded European project focused on the North West Europe region [1]. The project and its goals were described in our paper in last year’s CDVE conference [3]. Initial workshops that were held in the UK, France and Germany, focused on Planners, Architects, Citizens and Politicians, invited open discussion about needs and issues. These identified (among other requirements) that collaborative use of such a system should facilitate:

- free access to tools and data to ensure that it is available for all;
- the visual representation of comments /objections;
- search functions and queries;
- users enabled to set their own visualisation preferences;
- public participation with optional playback of the complete argumentation chain or just with results;
- interaction with other users and particularly with decision makers;
- tools for leaving comments; rating / ranking comments; peer group moderation of commenting; replying to comments;
- the freedom to choose and explore different options.

It was particularly stressed that while use of the system may possibly be facilitated by decision makers, it must be seen as independent / unbiased.

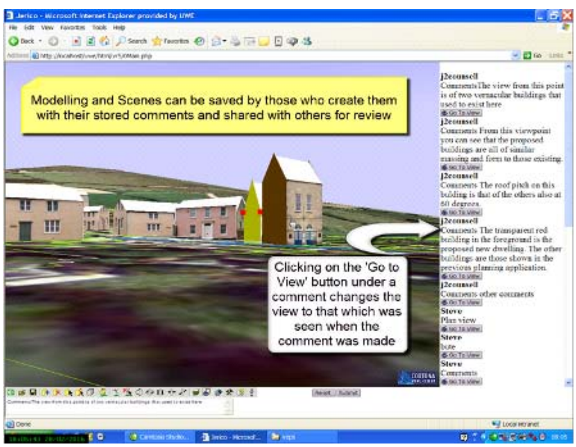

Fig. 1. In the VEPs ePlanner toolset, invoking the comment tool captures the viewport (camera) coordinates, and stores them for retrieval with the comment. The comments of others can be retrieved with their modelling, clicking on the comment buttons on the right invokes each view in turn, forming the basis of a narrative explanation of the originators ‘point of view’.

2.1 Block Extrusion Models vs Credible Presence Models and LiDAR

The most widespread current use of LiDAR, in England and Wales, is undertaken by the Environment Agency, primarily for flood analysis. In practice it has been found that such analysis is effective currently based on a grid at 2m centres, so although the technology can deliver greater accuracy, the majority of the coverage is captured and stored at the 2m level of detail. Data is available for limited areas, such as London, at significantly higher resolutions[1]. However the Intermap Nextmap commercial complete coverage of the UK based on SAR (Radar) technology is currently in a 5m grid. Using the 5m SAR data or the 2m LiDAR data it is difficult to identify and extract an accurate outline of a building, although the 2m data provides accurate height information for the extrusion of simple building block models (where the building outline may be determined from other sources, such as mapping). It is equally uncertain that 3 coplanar points will fall within the pitch of a roof, so that if an outline of the roof plane were available the roof pitch could be automatically established. It is almost certain that chimneys, dormers and other fine detail that is so significant in creating credible urban skylines will only be captured intermittently. Therefore most available data is not high enough resolution to effectively identify and extract immediately recognizable building form that conveys a credible sense of presence at street level, including the roof profile(s) as silhouetted against the sky.

This poses the question as to what can be done in the meantime to make effective use of the bare earth DTMs and simple building block models that are increasingly available. A project goal is to simplify the process and reduce the costs of creating and updating large area urban and rural modelling that conveys a credible sense of presence and is acceptably up to date. A credible sense of presence in this context may be measured by whether such a scene at street level would be readily recognized by the majority of users, since this is the viewpoint from which many planning based visual impact judgements are to be made. While the background buildings may still usefully be automatically extruded up as blocks, it is held that the foreground buildings will require more detail than much of the available remote sensed data can currently provide for automation. Foreground buildings that lack relief (such as windows, doors, porches, gutters, downpipes and other detail) are not usually found to convey credible presence, although this can be achieved by applied bitmaps rather than necessarily through modelling or scanning.

At the 0.25cm level of detail the full morphology of buildings could be captured, and updated to detect and to show change as often as the scanning takes place. However it will take a long time or a significant shift in the allocation of resources for data at this level of detail to become a comprehensive coverage for the UK.. Thus where updating of high presence models does happen this paper puts forward the view that due to cost it is often likely to be piecemeal, and to take place over a long period, during which software, bandwidth, standards and available detail may change significantly. Operator engagement in the process at present appears unavoidable. Commercial companies such as Bluesky in the UK offer to create ‘"real world" models of entire cities’ [4], using expert operators accustomed to photo-grammetry practice. This paper examines a possible approach to reducing that expertise and hence the cost.

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[1] With the instruments and aircraft positioning already available the data can in principle be captured at a level of detail of 25cm in the X and Y axes and 15cm in Z.

2.2 Web Tools for New Modelling Within VEPs

The VEPs project is focused on easing the task of creating and comparing 3D modelling of what does not exist, within an existing context. Tools are needed that allow modelling to be created in the context of the varying height of the DTM. While it is useful to be able to trace round existing aerial imagery and even to elevate modelling with bitmaps, this is not enough to meet the need. It is suggested that it is important to be able to freely if simply model in context using as referents the shape of the terrain and the form of adjacent buildings structure and landscape to be retained. These modelling tools should ideally be open source and deploy VRML, X3D and similar emerging open standards. These standards require plug-ins or extensions to current web browsers to operate at present. In examining the available plug-ins those for VRML have been available the longest and are the most developed.

Digitisation of new modelling in context requires a particular scripting behaviour of VRML, the touch sensor. This is now described in X3D as the "PointingDeviceSensor" component, of which the touch sensor is a particular 'node'. "Pointing-device sensors detect user pointing events such as the user clicking on a piece of geometry (i.e., TouchSensor)…. As the user moves the bearing over the TouchSensor node's geometry, the point of intersection (if any) between the bearing and the geometry is determined…. hitPoint_changed events contain the 3D point on the surface of the underlying geometry, given in the TouchSensor node's coordinate system"[5]. Although a number of current and emerging browser plug-ins provide either the VRML or X3D functionality, all of those tested with the exception of the Cortona VRML plug-in, lacked sufficient precision to calculate the accurate location of the cursor in relation to the existing contextual geometry. Thus currently only the Cortona plug-in has been found to adequately enable accurate digitisation for interactive modelling (at VRML 97 single-bit precision.[2]) The functionality for the 'what-if' collaborative modelling toolset is currently written therefore using the Cortona Software Development Kit.

Exploratory modelling is created through digitisation on the DTM. It deploys (one of a possible number of) pre-defined parametric building or other 3D objects via the ExternProto primitive. On 'save' the modified parameters (ExternProto object reference and instance, perimeter, position, height with face definitions including bitmap, colour, transparency) are written to a PHP database locally. On 'share' this data is written to the server. Others can then read the data from the server, either to view it, or to save it locally prior to modification or extension, and then share it via the server again. That is appropriate for asynchronous collaboration. For synchronous collaboration and discussion it is intended to explore the use of real-time many to many video conferencing in conjunction with desktop sharing using the web based Marratech conferencing system [6]. Users, whether the originator or other collaborators/'members of the public' with whom the originator has shared the modelling, can interactively modify the elevational height of a selected building and adjust the slope or form of its roof, but not yet move the building once created or

[2] "Precision - VRML97 provides only single-precision floating point values. This is insufficient to represent data on a planetary scale down to around 10 m resolution or beyond. GeoVRML provides solutions to extend this precision and enable sub-millimeter positional accuracies." http://www.geovrml.org/download/1.0/geovrml1_0.pdf.

adjust its plan form[3] (this is in development). A library of CAD derived VRML components (including complete buildings with bitmap surfaces and groups of buildings as zip files) is in development that can be positioned in the scene, and these can currently be scaled, moved in any axis, and rotated. Consequently proposed buildings derived from CAD and provided by design consultancies or developers can also be uploaded and viewed in the same context. This current 3D e-Planner prototype toolset is undergoing user evaluation. At present it consists of a DTM with draped aerial imagery and vector mapping. It has the capacity to provide two zones, an inner neighbourhood where users can interact and model, and an outer contextual zone that is interactively navigable but 'locked'. Within the interactive modelling zone (which can be an entire neighbourhood or scene) users can both digitise by tracing the aerial imagery or digitise new buildings in context, in either plan or 3D view.

Users can adjust the colour or transparency of a selected building, change them to wireline, or add rectified images (perhaps taken by digital camera or camera-phone) to a single selected elevation or all elevations. Some exploration has also taken place of how best to show point cloud data in the context of the model for use in more accurately visually checking or digitising heights, but this feature has yet to be implemented. There is perhaps a presumption that photos of existing and perhaps nearby buildings will provide the template elevations for the proposed. However this does not preclude the use of scanned or photographed sketch drawings for elevations, which may in fact prove more effective at conveying the 'uncertainty' of the proposal and thus encouraging the exploration of alternatives and a free debate.

Within the limitations of the web browser and plug-in (cast shadows are not readily achievable in VRML for example[4]) it is possible to create scenes that offer a high sense of presence as defined earlier. The currently developed tools for web based digitisation are not nearly as flexible as those in CAD, so some building forms are not easy to achieve. (The predecessor non-web based software for digitisation of this form written by S. Smith called Pavan offered a wide enough scope to readily digitise the whole Tower of London complete with crenellations, turrets, and cupolas, so complex form is possible [7].) There is assumed to be a need for a balance between simplicity and ease of use and the provision of more powerful but more complex features, which will be investigated. There are further unresolved issues of verisimilitude in such modelling. For example whether it is important that VR optimised for the web tends to offer a less photo-realistic appearance than 'high-end' VR; when and how to express uncertainty as part of a narrative; and to what extent detail should be depicted.

2.3 Issues of Verisimilitude Versus Photo-Realism

Those using these tools should be able to engage in dialogue and draw attention to or focus on issues by 'marking up' points of concern or consensus, and relate their comments and mark-up to their 3D visualisation or that of others. One approach under development is to enable comments and mark-up to be appended as if overlaid on the

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[3] Currently buildings can be deleted, and therefore modified by re-digitising.

[4] In the development of X3D "we are nearing the Grail of absolutely realistic 3D simulation, although we are not yet able to have things such as a shadow following a character" Richard Trigaux of http://www.shedrupling.org in web3d.org message board discussion June 8th 2004. http://www.web3d.org/message_boards/viewtopic.php?t=24&.

viewport. There is an implicit assumption in much VR that movement is linear and corresponds with movement in the real world. In the film world non linear conventions have developed to tell effective stories and to draw attention. An example is that of the montage non-sequential juxtaposition of shots [8]. A montage approach may form an acceptable alternative in those situations where a single wide angle view cannot serve. Similarly it has been suggested that “in place of time-delays arising from the accidents of place, we could use time-delays as an analogue of other qualities, for example the remoteness of one idea (as embodied by an object, building, etc.) from another” [9].

These suggest approaches to navigating from one issue of concern to another, as part of a narrative explanation of a point of view, during a web based collaborative discussion. Within this discussion it is suggested that the form of representation in itself constitutes an important element of the dialogue. In the VEPs project attempts to create and explore tools to generate an asynchronous narrative description of one person’s appraisal of a scheme, or of a series of alternate proposals, for later review by other collaborators, are at an early stage, and significantly more refinement is envisaged following user feedback. The full project results are not expected until 2008. The first iteration of tools and tests with collaborative discussion and comment on line by user groups has begun. These results, available in mid summer 2006, will then be used to guide the refinement and further development of the system.

We are concerned with the consistency of the individual’s planning appraisal judgement from the time they experience the VR representation to the moment of their confrontation with the built outcome. “The relevance to VR is that, like most computer representations, Virtual Environments and Virtual Objects have a precision and a finality which may be difficult to resist - the ‘real presence' which is one of their strengths could, used inappropriately, be their weakness”[9]. If the ‘unskilled’ user is shocked, when they finally sees the built result of the planned proposal that they evaluated, then the earlier VR representation clearly lacked verisimilitude. By which time it is often too late to redress the situation.

This implies the possibility of expressing the degree of contrast between alternative proposals intended for debate by increasingly non-photo-realistic and thus ‘uncertain’ representations. It is suggested that photo-realistic representation is on a spectrum that can itself be used to express the views of someone engaged in collaborative discussion. To convey their view that one option is ‘better’ than another, the user could rank the options through the representation they assign. Users should thus be able to contrast photo-real representation at will with a range of other representation techniques, more graphic or more cartoon like. “As long as the guiding image is still developing it remains tentative, generic, vague…This vagueness however is by no means a negative quality. The sketch stands for a whole range of possibilities without being tangibly committed to any one of them”[9].

It is also suggested that a scene will often contain a fixed and unchallengeable context that should therefore remain represented in a photo-realistic manner. Therefore we suggest that it would be useful to distort part only of a photo realistic VR scene to draw attention to specific less certain and more challengeable proposals [10]. Boyd Davis et al go on to state that “Distortion is a loaded word. It implies falsehood. We think we know the difference between a visually distorted and an undistorted image. However, distortion can be a more subtle affair, which assists rather than impedes the user's experience…A crude example from this century would be the use of selective focussing to take in and out of attention different parts of a movie scene, perhaps pulling focus from one character's face to another's"[9]. It is perhaps not surprising that this juxtaposition of perhaps uncertain 'model' superimposed on 'real' context has long been effectively used in planning appraisal in the form of photo-montage.

It is also an issue as to whether over much detail acts as a distraction to focused decision making at early proposal stages when it is more important to assess a range of potential interpretations, such as the alternative 3D 'massing' of building proposals. However there is the opposing issue that an absence of detail that is implicit in the real end result presents a misleading interpretation of the relationship between the potential building and its context. Detail can be shown to underpin judgements about relative size. Hence in the original Exmoor National Park Design Guide of 1979 [11] it was suggested that in order to reduce the apparent visual impact of large agricultural sheds in the landscape, details such as doors, windows, guttering and downpipes should all be of exaggerated dimensions. They would it was suggested then look like much smaller (and thus less intrusive) buildings closer to the viewer. Consequently it may be thought that judgements formed on the basis of for example generalised building blocks that lack detail may thus lack verisimilitude and hence be flawed. Little research has yet been found that addresses these issues, or that establishes how citizens can make reliable informed decisions at an early stage in the planning process, to establish acceptable 'fuzzy' templates that positively establish the bounds of acceptability, rather than merely reacting to detailed proposals.

3 Conclusion

Effective tools are held to be required for collaborative citizen based examination and development of alternative proposals. This paper has described one approach to reducing the cost of large area urban modelling by empowering heterogeneous groups of people to share the tasks of digitising and updating buildings that convey a credible sense of presence. It recognises the increasing availability of detailed 3D bare earth terrain models, aerial photography and the increasing availability of simple building block data sets. It seeks to find remedies through a public participative process in creating and updating local detailed building data sets, since these often do not exist where they are needed for public participative debate on planning proposals. Normally the generation of 3D urban models containing such detailed building street scenes currently involves high production costs, which limit their use and availability for change updates. The VEPs project aims to provide tools that allow citizens to become more involved in the modelling and the planning process. It is suggested that one way of achieving this increased participation is by empowering citizens to take responsibility for the editing and updating of their own neighbourhoods in 3D form and proposing their own "what if" scenarios for their future development.

Within the planning process it is suggested that user choice from a variety of forms of representation are needed both for narrative description, for expressing certainty or uncertainty, and for drawing attention to or focusing on issues of concern. Just as it is clear that unskilled users are more comfortable with 'realistic' images than with drawings, so it is suggested that they are likely to be most comfortable with the language of film, deployed in a familiar way in the 'new' medium of web VR.

Acknowledgements

The project work presented in this paper is co-financed through the INTERREG IIIB North West Europe programme.

References

1. www.veps3d.org Virtual Environmental Planning system ,funded Dec 2004 to 2007, by INTERREG IIIB NWE-ENO (a Community Initiative Programme funded by the European Regional Development Fund www.nweurope.org)
2. Richman, A. Hamilton, A. Arayici, Y. Counsell, J. Tkhelidze, B. (2005) 'Remote Sensing, LIDAR, automated data capture and the VEPS project' in proceedings of IV05 9th Intl Conference on Information Visualisation London, edited by Banissi et al, published by the IEEE Computer Soc. Los Alamitos California.
3. Duhr,S, Bates-Brkljac, N. Counsell, J. 2005. 'Public Digital Collaboration in Planning' in ' Cooperative Design, Visualisation and Engineering' Ed. Professor Y Luo, 'Lecture Notes in Computer Science 3675' published by Springer-Verlag, Heidelburg, pp 186-193.
4. http://www.bluesky-world.com/buildingmodels.html
5. The PointingDeviceSensor is defined in the emerging standard for X3D at http://www.web3d.org/x3d/specifications/ISO-IEC-19775-X3DAbstractSpecification_+_ Amendment 1_to_Part1/Part01/components/pointingsensor.html
6. www.marratech.com
7. Counsell, J. Bates-Brkljac, N. Smith, S. 2004. 'GIS based Urban Information Systems as a basis for the generation of complex 3D VRML models', in Studies in Regional and Urban Planning Issue 10 August 2004. pp 129-139.
8. Eisenstein, S. (1946) 'The Film Sense' Harcourt Brace & co.
9. Boyd Davis, S. et al. (1996) 'The Design of Virtual Environments with particular reference to VRML' published by the JISC Advisory Group on Computer Graphics in the UK. http://www.agocg.ac.uk/reports/virtual/vrmldes/vrmldes.pdf
10. Appleton, K. and Lovett, A. (2003) GIS-based visualisation of rural landscapes: defining 'sufficient' realism for environmental decision-making, Landscape and Urban Planning, v.65, issue 3, pp117-131
11. ENP Design Guide (1979) published by the National Park Authority. www.exmoor-nationalpark.gov.uk/index/learning_about/learning_publications.htm

Use of Patterns for Knowledge Management in the Ceramic Tile Design Chain

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Abstract. Knowledge Management (KM) is a complex objective, especially in the instance of extended enterprises consisting of SMEs, and critical in new product design and development (NPD). The use of patterns is essential to get KM in collaborative NPD processes. This paper presents the use of patterns adopted in the CE-TILE project to standardize information and knowledge in collaborative work. The different types of patterns and models established for the knowledge capture, formalization and configuration are also described.

Keywords: Collaborative Knowledge Management, Reference Model, Patterns, Design Process, Project Methodology, Collaborative Cluster, Product Lifecycle Management.

1 Introduction

In recent years, tools for integrated information management are aimed at increasing performance in collaborative environments. Specifically, tools like PDM (*Product Data Management*), cPDm (*collaborative Product Definition management*) and PLM (*Product Lifecycle Management*), which allow simplifying and unifying the flows of product information, operating with data from all departments of the company [1]. The fact that the most modern of those tools are Web-compatible also facilitates the inter-enterprise communication, allowing the consideration of the extended enterprise concept. Nevertheless, the implementation of design environments based on these tools is not a trivial question: it requires the introduction of cultural and organizational changes in the enterprise. In this paper we want to emphasize the changes that affect knowledge management (KM), which is defined by Ergazakis et al. [2] as the process of creating value from the intangible assets of an enterprise; it can be related to the internal knowledge of the enterprise, and also to customers and stakeholders. In general, capture, classification, storage and continued update of the knowledge are fundamental actions in every continuous renovation process. In particular, the need to acquire knowledge is critical in new product development [3].

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 65 – 74, 2006.

Knowledge management is a particularly important bottleneck for SMEs. When SMEs work in an isolated way, they do not have sufficient economic or technological capacity to promote procedures based on the management of processes addressed to collaborative environments. On the contrary, they do fulfil enough capacity when they work in an Extended Enterprise environment, but in this case, they lack the organizational structure as much as the leadership for driving the process, it is to say, for managing the necessary changes. Besides, it is particularly significant that SME's lack the mutual confidence necessary to share knowledge, and they lack too the experience to implement mechanisms of knowledge management to share knowledge within the Extended Enterprise without running the risk of bringing out all his know-how into the open.

Within this context, the authors are participating in a project (CE-TILE) aimed at establishing a network of knowledge to allow collaborating and sharing information among ceramic tile sector companies (SMEs, most of them), with the aim of solving the knowledge management problems related in general to the product lifecycle processes, and in particular, to the design process. The commercial applications Collaboration Projects and Collaboration cFolders [4] were selected for their utilization within the project. They allow all the extended enterprise partners to join the design process and to share knowledge. But the implementation of these tools is complex: patterns of behaviour that can support the commercial applications, that respond to the roles and tasks of the different members from the extended company, and that guarantee the privacy of the internal knowledge management for each enterprise must be defined. In this sense, this paper tries to show the relevance of the use of patterns to get knowledge management. Next, in section 2, the need to establish patterns that standardize information and knowledge in collaborative work is justified. Section 3 points out the specific aspects in the CE-TILE project development where models or patterns have been used, whereas section 4 presents the use of different types of patterns: the forms for capturing knowledge and the representation techniques to formalize it (4.1.), and the patterns created in the chosen software application for the management of the processes (4.2.). Section 5 presents the results. A section for the conclusions closes this paper.

2 About the Need of Reference Models and Patterns for Knowledge Management

The ceramic tile design process involves different types of companies that work and collaborate together with a common objective: the new product development (NPD). Nevertheless, collaboration is frequently inefficient, as guidelines for a suitable management of relations and processes have not been settled down. It has been argued that initiatives for KM will result in an improvement in the processes execution [5]. Hence, the use of reference models and patterns for the processes and activities is essential, since these processes suppose a critical connection between the KM and the results obtained. Thus, the establishment of reference patterns allows the access and conservation of the possessed knowledge. Instances of certain tasks or processes take place by means of the execution of these patterns, and like this, it is allowed the use of the knowledge [6]. Patterns and models can feed themselves with the experience to improve later execution. In other words, there is a need to establish models and patterns of collaborative knowledge to improve the work and relations among the enterprises implied in the design process. Enterprise modelling, and specifically processes modelling, is an effective tool for the management of organizational changes [7]. Patterns transform implicit knowledge into explicit one, which is the unique one that can be used by all the members of an organization. It is collective knowledge, that is to say, the knowledge found at processes of a work group or organizational unit [8]. Pattern libraries make it easier the work, as they allow both to select the suitable one in each particular case and to update and add new patterns throughout new experiences development. In sum, "creating a knowledge repository, for being understood, used and shared by the partners" is basic [9].

Models and patterns are neither static nor universal; on the contrary, they must be discussed, reviewed, modified, enriched, etc., in a dynamic and collaborative process, until they fit the needs and specific requirements. These patterns and models, combined with new technologies for the communication and the collaboration, which are more and more integrated in the different aspects of the daily work, suppose a powerful strength in the enterprise knowledge architecture, that offers interesting opportunities for the competitive improvement, basically when relations take place at inter-enterprise level [6].

3 Knowledge Management at CE-TILE Project

Different models and patterns have been developed in the CE-TILE project: a) a methodology for the project development and certain forms for capturing knowledge, which are based on the MOKA methodology [10] and the KBE lifecycle, and b) activity models for formalising knowledge, and specific patterns for a software application.

The CE-TILE project pursued the development of a specific model for the management of collaborative projects. First, the specific model was obtained from a wider scope reference model. Then, it served as a basis to design a pilot technological infrastructure and a collaborative experience. Thus, several cycles were generated in the CE-TILE project:

1. Definition of a Conceptual Frame (which establishes a common vocabulary and delimits the system reach) and a Generic Activity Model. It constitutes a "should-be" model that represents the ideal activities for a generic design system, pertaining to products marked by tendencies and fashions.
2. Definition of a Specific Reference Model for ceramic product design projects (it is formed by activity, information, organizational, role, and other partial models), and establishment of a technological infrastructure and a software platform for developing a pilot experience (next cycle). Several applications pertaining to MySAP PLM (which was the tool chosen for the accomplishment of the pilot experience) were analysed, and finally, the solution cProjects Suite was applied for the process/project management and for favouring the cooperation. cProjects Suite is formed by the applications *Collaboration Projects* (cProjects), that gives support to the project management, and *Collaboration Folders* (cFolders), that consists of a platform for communication and for sharing knowledge among the

project participants. The configuration of these applications to adapt them to the ceramic sector characteristics also belongs to this second cycle of the project.

In this cycle, some forms were used for capturing knowledge, and generic patterns were developed for standardizing the types of projects in the software applications.

3. Development of a Pilot Experience that allows valuing the advantages reached by collaborative design environments. Establishment of a Specific Activity Model for the pilot experience ("to-be" model).

The results were a few models of the design process with different coverage and concretion level. The know-how we gained in the platform design and development, and in the own pilot experience, became the key for the gradual refinement of the specific model. Thus, these three cycles are not sequential, as some information flows exist among them, so that its mutual re-feeding causes the continuous improvement of the process.

For an efficient development of these cycles and their re-feedings, it is necessary to define a methodology that establishes the actions to undertake, and that makes possible its improvement and reusability. A methodology fundamentally consists [11] of a set of instructions and guidelines on how a complex process must be carried out. According to Lovett et al. [11], some of the main benefits of the use of a methodology are: to take advantage of the experts knowledge, to avoid the omission of essential tasks, and to easier the project management, since stages and activities can be identified and, if necessary, members of the development equipment can be staffed.

As far as our aim was defining a process to manage the knowledge in the project, we looked for a set of activities which allow the transition between categories of knowledge. Bernus and Kalpic [12] show various knowledge management frameworks and activities. However, the methodology finally chosen for the development of the above defined cycles was based on the generic lifecycle for the development and maintenance of applications KBE, *Knowledge Based Engineering*. This model of KBE System lifecycle is adopted by the MOKA methodology, aimed at structuring and representing engineering knowledge, giving support to KBE applications [13]. This methodology for analyzing and modelling products, design processes and the related knowledge, requires the previous establishment of the phases of the KBE system lifecycle. These stages fit the actions that configure each cycle of the CE-TILE project: a) *Identify*, where we established the action plan, the objectives and the scope of the project cycles; b) *Justify*, to obtain the project establishment and the agreement of the implied parts, c) *Capture*, in order to acquire, structure, represent (in an informal way) and add knowledge; d) *Formalise* the knowledge previously captured in the frame of a suitable technique; e) *Build*; configuring the software tools chosen for the pilot experience, and establishing the operative infrastructure (it corresponds with the *Package* stage in the model of KBE System Lifecycle), and f) *Execute*, where the MOKA original actions *Distribute*, *Introduce* and *Use* were summarized in only one, focused on the execution and the performance.

We apply this KBE lifecycle customized to the three stages of development of the CE-TILE project, which go from a generic point of view up to more specific aspects. A singularity is than in the first cycle, the two last actions (*Build* and *Execute*) are not considered, because construction and execution make no sense in the generic activity model. The construction of the software system for the improvement in the knowledge interchange begins in the second of the cycles, and the execution corresponds to the third cycle. Although these lifecycles are convergent and go throughout their development towards a more specific level of concretion, they in fact constitute an iterative process of re-feeding, to take advantage of the opportunities to complete and to improve the acquired knowledge. Therefore, sometimes it is worth to return towards levels of a global point of view once we have reached actions pertaining to the most specific cycles. This can happen because it is simpler to define generic aspects once certain specific information has been obtained, or because the opportunity to complete and to improve the knowledge already acquired throughout the project development has been identified. It is indeed what has happened with the generic development, previous to the ceramic specific modelling. Therefore, these cycles allow the continuous improvement of the project, by means of the different directions and senses in which information and knowledge flow between actions.

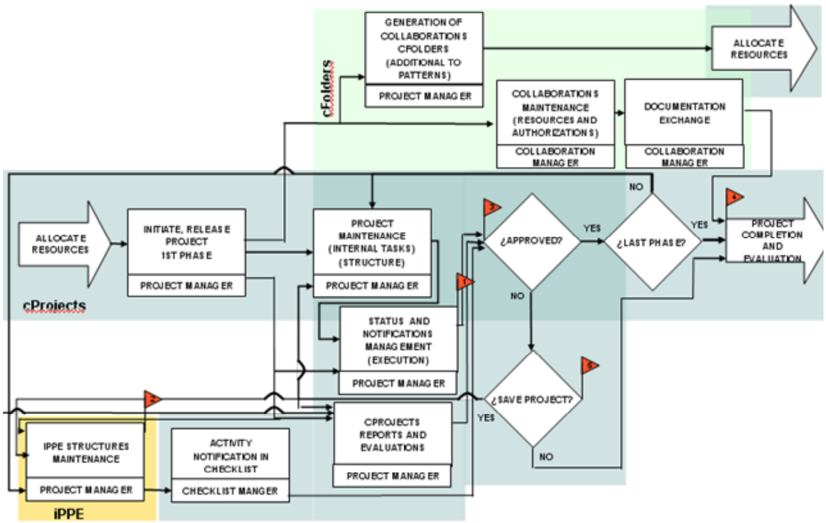
4 Use of Patterns at Collaborative Knowledge Management

As our objective is centred in the analysis of the process-knowledge-management in the ceramic design, we are going to focus our attention on the second of the project cycles, that is to say, the specific one for the ceramic sector development. In this cycle, the actions with a greater prominence in knowledge management agree with those that the MOKA methodology considers to be the main phases [13]: *Capture* and *Formalize*. We shall also consider the requirements of the *Build* stage.

Once the informal representation of the process knowledge has been obtained (*Capture*), the following step is formal modelling, or formalization (*Formalize*). The design activities, reflected in an IDEF0 model, are used to define end-to-end processes. Next, the building or implementation of the adapted functionalities (cProjects and cFolders) can begin, and specific patterns for defining and structuring processes to be executed must be created (*Build*). In the following sections the option for capturing knowledge in the second cycle of the project is explained, as well as the creation of standardized patterns for the application chosen in the pilot experience for managing the project.

4.1 Knowledge Capture, Storage and Formalization

In order to obtain the structured management of the acquired knowledge, another adaptation with respect to the MOKA methodology has been used. We use the forms offered by this methodology to capture and informally store knowledge. These forms are denominated ICARE forms, from the different elements or categories in which the knowledge is classified*: Illustrations, Constraints, Activities, Rules and Entities* [10]. In our case, we have used forms only for two kinds of elements: *Activitie*s (for the processes description) and *Entities* (to detail documents related to the product). The use of these forms has been beneficial, since it has facilitated the work of collecting and retaining information from interviews in a structured way, while it also established the reach of the required knowledge. This second aspect is advantageous as it guides the explanations of the interviewed person. From the information stored in these forms, the formalization in IDEF0 of the activity model has been directly tackled. Some partial IDEF0 diagrams are shown in [14] and [15]. Later, these activities have been represented in "end-to-end" processes (fig.1), which allowed us to obtain a graphical representation of a complete process and detailed knowledge of the activities flows and its sequence. Besides, all the responsibilities involved in the process are identified, with the support of role-activity matrices, including the necessary relations among areas or partners. This technique also facilitates the identification of problems and opportunities of improvement, and has into account the software applications that give support in the project.



Task \ Role	PROGRAM MANAGER	PROJECT MANAGER	PHASE MANAGER	TASK RESPONSIBLE	ITEM LIST RESPONSIBLE	CHECK LIST RESPONSIBLE	APPROVAL	COMMITTEE/ DECISION MAKER	COLLABORATION RESPONSIBLE
PROJECT INITIATION	C	R/E	I	I	I	I			I
PROJECT MAINTENANCE		R/E	E	I	I	I	I		I
STATUS NOTIFICATION / PHASE		R/E	E	I	I	I			
STATUS NOTIFICATION / TASK			R/E	E					
STATUS NOTIFICATION / ITEM LIST			I	I	R/E	I			
STATUS NOTIFICATION / CHECK LIST			I		I	R/E			
cPROJECTS EVALUATIONS	R/E	E					I		
APPROVALS		I/E	E/I				R		
cFOLDERS GENERATION		R/E	E						I
cFOLDERS MAINTENANCE									R/E

R: Responsible;
E: Executant;
C: Consulted;
I: Informed

Fig. 1. Formalization of the captured knowledge: “End-to-end” processes, with a matrix of responsibilities

4.2 Build: Elaboration of Generic Patterns for the Adopted Solution

Current needs in projects of development require software solutions that offer new functionalities, able to allow a wide reach, including all the processes throughout the product lifecycle. PLM give support to product and process information, through departments and companies in the supply chain. Since our interest is centred in the *collaborative* knowledge management of the process, we have chosen the solution cProjects Suite of mySAP PLM to support the management of the pilot experience. There are other tools for project management with a larger reach (like *Project System*, which also belongs to mySAP PLM), but the former applications fit better our interests as they specially emphasize collaboration and communication among enterprises, and consider some aspects of the quality in the process. These are key features for reaching the objectives of the project.

Specifically, cProjects allows the creation of different types of patterns or models, among which project models will be emphasized. This application structures the project in a set of elements, such as phases, tasks, checklists, etc. In this way, a project can be created, and defined like a project model. Thus, a pattern which can be used to facilitate the creation of new projects with similar characteristics and structure is obtained. This way, prior to a new product development process, the project model can be chosen and, if necessary, adapted for its use.

Different types of projects (projects with different structures, intervening roles, terms, objectives, etc.) can exist, due, for instance, to the desired type of product, to the proposal origin, etc. Different options have been analyzed by the CE-TILE research team, to generate project models that constitute a knowledge repository, and that can be used by the ceramic enterprises at new project creation, depending on its type. It is not an automatic selection process; the person in charge of the project will use his/her experience and knowledge to decide, from the models available, the option that better adapts to the particularities of the specific project. One possibility consists of generating a single "comprehensive" model, with a structure that includes all the known project variants, and which will be simplified whenever it is needed to create a new project, eliminating the unnecessary elements. In the pilot experience, the research group established a preliminary generic pattern. The participating enterprises simplified this first pattern for its application. Several phases (like *Detailed design*), tasks (like *Obtain a plaster model of the relief of the model*) and items of checklists (like *Special enamels test*) were eliminated, and other were modified (fig.2). Nevertheless, this option is too complex to be settled like a general norm. For this reason, at the CE-TILE project, the research group should identify a standard set of models for different types of projects (based on the information captured at interviews and on the knowledge from literature), so that the model is chosen by the person in charge of each new project, depending on the particular needs (for example, to define a model to develop tile coverings, another one for pavings, etc.) and it is adapted, if required, by creating or eliminating elements. Our pilot experience adds evidences in the sense that having a “standard” set of models, previously elaborated either by a university research group or by an external consultant enterprise, is beneficial for the companies during the process of selection of the appropriate model. In any case, in the enterprises, the people in charge of the project are the responsible in choosing the model that adapts to the characteristics of each particular project. An interesting question that remains open for the future is the search of guided selection methods of the appropriate model for each situation. This set of models can be enlarged gradually with new “tailored” patterns, based on the experience obtained by the ceramic companies in the development of new projects. cFolders also allows the constitution of models to structure folders, documents, forums, and other elements in the collaborations that are created in the project.

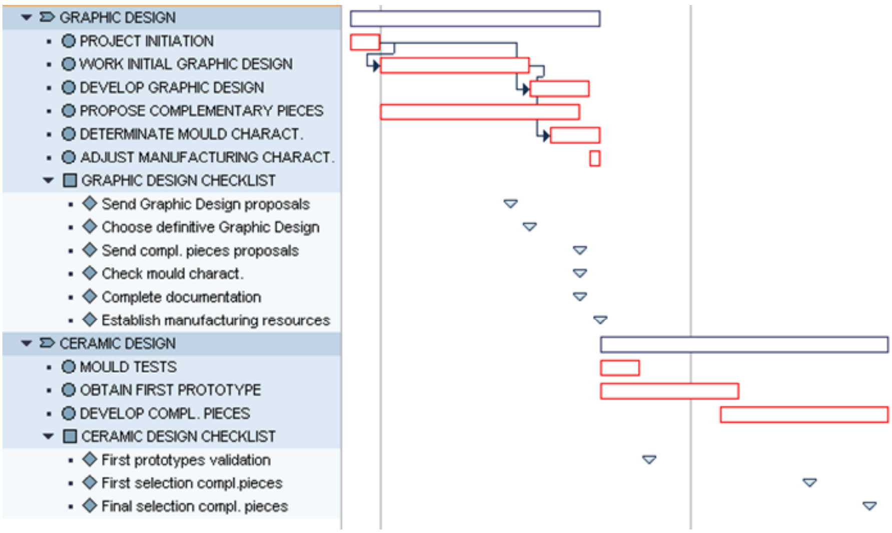


Fig. 2. Structure of project phases, activities and checklists

5 Results

Currently we are in the closing phase of the CE-TILE pilot experience, in which the end users of the PLM applications must evaluate the results obtained. The methodology for the project development was initially adopted to have a general guideline. As the project advanced, we saw those cycles to be dynamic, and to have characteristics that facilitate re-feedings, which initially had not been considered. These information flows have allowed us to obtain richer results. With respect to the forms for the knowledge achievement, they have prevented the omission of relevant information. In addition, the professionals interviewed to capture their informal knowledge, did better understood what they were asked, and the resulting formal knowledge was stored in a more structured way. The guided interviews allowed a faster knowledge capture.

The models defined in the application cProjects allow to create projects from patterns previously established. These models were developed by the CE-TILE research group, based on the information provided by the ceramic companies and the knowledge captured from the bibliography. A repository is obtained therefore, of which the people in charge of the NPD project will have to choose the suitable model in each particular case. In the pilot experience, the research group established a generic model, which was later simplified by the ceramic companies, for developing the pilot experience.

This fact aids to standardize the project structure as well as the existing types of projects. In addition, the omission of important aspects is avoided; both internal aspects (like procedures, instructions, rules, etc.) and external ones (norms, legislation, etc.). Anyway, it is important for the projects to adapt to the necessary particular conditions in each case, that is to say, that patterns always suppose an aid and a support for the work, without restricting freedom or creativity. Although the pattern initially developed was quite general, it focused on a certain type of project. It is expected to enrich it with the pilot experience results and to establish new patterns that respond to the needs of new product development projects.

6 Conclusions

The creation, storage, adaptation and use of patterns for planning, defining and controlling the execution of processes and activities, constitute a very effective tool in knowledge management. Patterns allow to establish, specify, standardize and apply knowledge, and also to enrich the existing one and to create new knowledge. They establish the steps to follow, serving as a guide for the accomplishment of the actions, and at the same time they constitute a method to verify that execution fits planning. They compile knowledge, and feed themselves with new experiences. Like this, they are framed in an iterative process of continuous improvement. Therefore, they are not rigid structures, but they must have a high flexibility.

The article has presented the use of patterns and models in the development of a collaborative project. The development of the pilot experience allowed to identify opportunities for the use of patterns in knowledge management. We understand that an exhaustive analysis of software tools for the management of new product development projects exceeds the reach of the article. We limited the extent of the work to describe the election of collaborative applications in a particular experience, limited by the needs of the participant companies. One of these limitations is that the chosen tool had to belong to SAP, or to a fully compatible solution, since this was the already implemented ERP in one of the leader companies taking part in the pilot experience. Among the tools available in mySAP PLM, the research team analyzed several options for the project management, opting finally for cProjects Suite, since it is characterized by its collaborative nature. This choice responds to the collaboration needs of development projects, in greater extend than other applications of mySAP PLM, as it can be the case of Project System.

It is expected in an immediate future to extend the number of patterns for structuring and characterizing different types of new product development projects, as well as the patterns related to types of collaborations, with the support of the PLM applications. Another interesting aspect for the modelling and the infrastructure improvement, in which the research group is interested, consists of the incorporation of new visions and generic utilities, like a greater consideration of the voice of the customer in the design process, or the aggregation of new quality methodologies. These visions and utilities must validate their suitability and be concreted by means of its incorporation in new and more complete design experiences. The results obtained should extend and improve the existing models.

References

1. Dickerson C. PDM Product Data Management: An Overview. Society of Manufacturing Engineers Blue Books. CASA.SME. (1997).
2. Ergazakis K., Karnezis K., Metaxiotis K. and Psarras, I. (2002). Knowledge Management in Enterprises: A Research Agenda. PAKM 2002, LNAI 2569, pp.37-48.
3. Peregrim J.T. Knowledge Acquisition in New Product Development. Product Development & Management Association. http://www.pdma.org/visions/oct96/pe.html
4. SAP AG, "MySAP Product Lifecycle Management. Statement of Direction", 2005. http://www.sap.com/solutions/business-suite/plm/brochures/index.epx
5. Nickols F. 2000 "Knowlegde Management (KM) and Process Performance. Implications for Action". http://home.att.net/~nickols/KM_and_Processes.htm
6. Manheim M.L. (1998). Beyond Groupware and Workflow (The theory of cognitive informatics and its implication for a people-based enterprise information architecture). Web site http://www.e-workflow.org
7. Chung P.W.H., Cheung L. Stader J., Jarvis P., Moore J. and Macintosh A. (2002). Knowledge-based process management – an approach to handling adaptative workflow. Knowledge-Based systems. 16. pp. 149-160.
8. Mittelmann A. (2002). Practical Aspects of Knowledge Management in Industry. Proceedings 4th International Conference on Practical Aspects of Knowledge Management, Vienna 3 Dec 2002
9. Mo J.P.T. and Zhou M. (2003). Tools and methods for managing intangible assets of virtual enterprise. Computers in industry, 51. pp. 197-210.
10. Stokes M. for MOKA Consortium. (2001). Managing Engineering Knowledge - MOKA Methodology for Knowledge Based Engineering Applications. Professional Engineering Publishing. ISBN: 1860582958.
11. Lovett P.J., Ingram A. and Bancroft, C.N. (2000) "Knowledge-based engineering for SMEs – a methodology". Journal of Materials Processing Technology. 107 pp. 384-389.
12. Bernus P. and Kalpic B. (2004). "The Nature of Knowledge and its Sharing through Models". Knowledge Sharing in the Integrated Enterprise. International Federation for Information Processing. ICEIMT 04 ISBN 0-387-26608-9.
13. Oldham K., Kneebone S., Callot M., Murton A. and Brimble R. (1998) "MOKA – a methodology and tools Oriented to Knowledge-based engineering Applications". Proceedings of the Conference on Integration in Manufacturing. Göteborg, Sweden. pp. 198-207.
14. Vila C., Romero F., Galmés V. and Agost M.J. (2005) "Collaborative Solution for Cooperation, Coordination and Knowledge Management in the Ceramic Tile Design Chain". Proceedings of Second International Conference, Cooperative Design, Visualization, and Engineering. Palma de Mallorca, Spain. LNCS 3675, pp.86-93.
15. Romero F., Company P., Vila C. and Agost M.J. "Enterprise Activity Modelling in a Collaborative Ceramic Tile Design Chain". Research in Engineering Design. Under revision.

Towards an Agent and Knowledge Enacted Dynamic Workflow Management System for Intelligent Manufacturing Grid

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Abstract. To cope with the dynamism of the intelligent manufacturing grid environment, an agent and knowledge enacted dynamic workflow management system is proposed to support the manufacturing process modeling, control and management, smoothing the integration of the flow of the work during collaborative manufacturing process. Autonomous software agents are used to implement the functional components and to encapsulate the end user and participating resource in the system. The domain knowledge is constructed to support the agent conversation and abstract workflow modeling; Knowledge based rule mechanisms is applied to support process scheduling and enactment in the multi-agent environment. The design and prototype implementation of the system is discussed and demonstrated with a case study.

1 Introduction

Manufacturing grid[1] ,as an analog to computing grid, was proposed to enable the sharing, selection, aggregation and integration of manufacturing resources and services distributed geographically and owned by different organization , and supply them to users with the appearance of a single virtual manufacturing resource over the internet seamlessly, transparently and dynamically when needed. With the complexity of the collaborative manufacturing job and diversity and heterogeneity of resources in the grid, there is a growing requirement for intelligent manufacturing grid to accomplish the manufacturing job submitted by the user by gathering all the resources required by each tasks in the job and map and dispatch the tasks onto corresponding resources for execution in an intelligent way.

The manufacturing job and process in intelligent manufacturing grid should be modeled, scheduled and managed with the support of workflow systems to achieve operational efficiencies. The manufacturing grid is a highly dynamic environment since the participants are subject to frequent changes. The grid node representing participating enterprise can join and leave the system at will, and grid service may added, evolve, removed or updated, and actor for workflow activity can't be specified in the workflow model in advance. Also, a detailed manufacturing process may not be

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 75 – 82, 2006.

obtained at the outset. The initial model may includes high-level sub processes which will be refined gradually or even modified during the execution. Finally, the manufacturing job is a cross-organizational process and the workflow manager requires flexibility to select partners dynamically. Duo to the unreliable nature of manufacturing resources in the manufacturing grid, dynamic and flexible workflow is required to support integration of business process scattered across enterprises.

2 The Related Works

The use of agent has been proved a good means of intelligent tasks distribution and adapting to changing circumstances in the manufacturing grid. Agent technology is naturally suitable to support dynamic workflow and process management by providing flexible, scalable, distributed and intelligent solutions for negotiation, scheduling and resource allocation at run time [2]. Agent based workflow can be considered as a workflow process that is planned, performed, communicated and coordinated in a multi–agent environment, in which agent are either invocated by a central workflow engine to implement certain tasks contributing the process or used to represent the process logic and take full responsibilities to analyze, automate and inspect workflows [2]. Dynamic assignment of tasks to actors during the process execution rather than established at build time increase the workflow flexibility. [3]proposes an e-service mediating inter-enterprise workflow management architecture in which activities are dynamically bond to the implementation at run time through service mediation and selection mechanism to achieve enactment flexibility. Web service model has been embraced in current workflow initiatives to support automatic process execution. The future trends will be integrating agent and web service for flexible workflow enactment and management [4-5].

Workflow management for computing gird, or grid workflow, has been extensive investigated to enable users to compose and execute complex grid applications on distributed heterogeneous and unreliable computing resources without taking case of lower level details [6]. In this paper, agent based architecture, dynamic task assignment through resource and service mediation, knowledge based rule for process description and execution are combined to provide a dynamic workflow management system to meet the requirement of intelligent manufacturing grid.

3 Agent and Knowledge Enacted Dynamic Workflow System

3.1 System Architecture

Agent and knowledge enacted dynamic workflow management system is designed to support the operation of intelligent manufacturing grid by offering the definition of manufacturing process at a high level of abstraction and their automatic execution on the basis of the available resource agents in the grid. The system architecture is shown in figure1 with 4 layers.

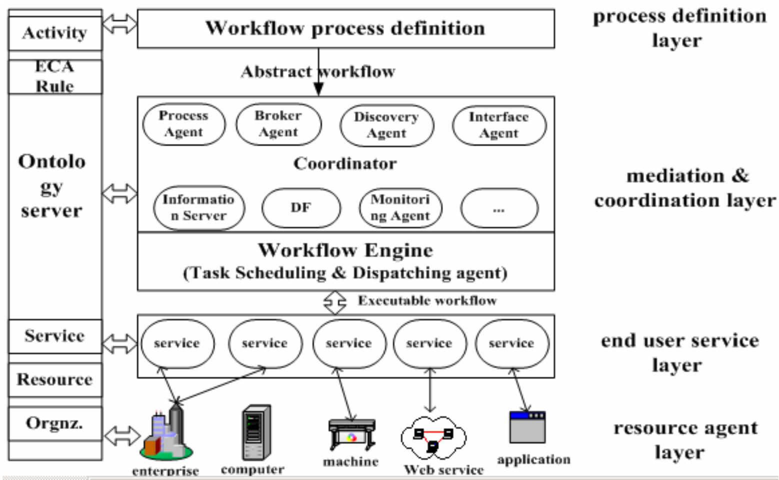

Fig. 1. The system architecture

The process definition layer mainly contains workflow definition tools used at build time to construct abstract workflow process, including the definition of tasks and precedence relations between tasks. An abstract manufacturing workflow process is described by abstract resource (service) which is the description of resources (service) abstracted to express a class of resources (service) providing the same function [7]. The task implementation is not considered in the abstract process on this layer, making the system more flexible and scalable as it is easy to redeploy workflow activities by invoking new resources discovered dynamically from the grid.

The abstract workflow should be translated into executable workflow to be put into execution. This step mainly involves resource selection and bonding realized on mediation and coordination layer by replacing the abstract resource and service with resource agent instances. The mediation and coordination layer mainly consists of a set of agents providing a variety of system-wide core services like matchmaking service, process scheduling service, directory service, information service etc, to support transparent and coordinated process planning ,scheduling and execution.

The end user services layer consists of a variety of manufacturing service offered by service provider nodes encapsulated as resource agents. The resource agents can be machines, tools, software applications, web services, legacy systems, or organizations unit like enterprises which possess necessary knowledge and capability to perform the actual manufacturing activity in the workflow, and they are invocated dynamically by the system agents. The manufacturing services and resource are also described in the ontology to support service discovery and selection.

The system implementation is illustrated in figure 2.The service provider and service consumer(end user) can download the workflow client and connect to the server side where the system agents runs. The client is an interface agent to encapsulate grid resources as resource agents (RA) and provide work-list management for RAs. The client also acts as an interface to support the end users to construct, submit, control and manage the execution of workflow process. The agents in the system include user interface agent(UIA), agent management service(AMS), directory service agent(DF), information service agent(ISA), process agent(PA), process planning agent(PPA), resource discovery agent(RDA), resource brokering agent(RBA), task scheduling agent(TSA), task dispatching agent(TDA), task monitoring agent(TMA) and a set of resource agents(RA). DF maintains a list of services advertised by RAs, allowing agent to register with the system and offer services to other agents. RDA provides matchmaking service to support agent discovery by searching for agents with matching capabilities. The RBA assists users to locate suitable RAs and use their service during the execution of workflow process. An executable workflow is generated by the PPA with optimized task assignment plan. AMS maintains live information about agent availability and their profiles. For each process, a PA will be initialized to represent the occurrence of the process. TSA is responsible for scheduling tasks in workflow instances to be executed according to the process logic.

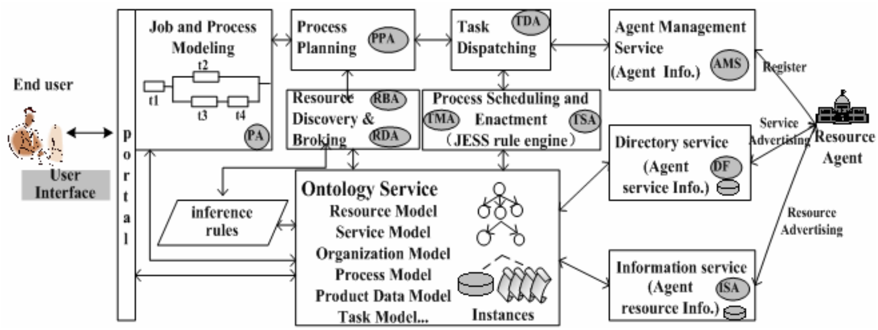

Fig. 2. The system implementation

3.2 Knowledge Based Agent Conversation and the Ontology

Besides the common agent communication language (FIPA ACL) and interaction protocols, agent needs the same understanding about the domain for the conversation at knowledge level. The domain classes, attributes, relations, axioms and instances are defined in the ontology, serving as standards for agent communication by providing shared vocabulary and semantics of the language expressing the content of messages. Existing upper ontology such as enterprise ontology [8], workflow ontology [9], manufacturing ontology [10] are combined and extended to support agent conversations. Main domain concepts include *Product*, *Job*, *Process*, *Task*, *Resource*, *Service*, *Rule*, *Role*, *Agent*, *Time Point*, *Organizational Unit* etc. The profile of OWL-S[11] is adopted as the service description framework.

3.3 Knowledge Based Abstract Workflow Modeling

Various kinds of workflow process description languages and standard are developed e.g. UML, PSL, PNML, XPDL, BEPL4WS, OWL-S etc. The activity based techniques focus on modeling the work involved in a process and their dependences, with routing rules to specify the data flow and workflow structure. The routing rules can be specified in ECA rules to provide a more powerful way to support ad-hoc, adaptive, flexible and dynamic business process modifiable in run time. Also, knowledge based workflow modeling technique, using ontology to describe the business process, has advantages of expressiveness, model verification and change management [10].

```
<Milling
rdf:ID="DistributedManufacturing_Instance_1">
    <name
rdf:datatype="http://www.w3.org/2001/XMLSche
ma#string"
         >CuXiWaiXing</name>
    <requireService>
       <Class rdf:ID="Milling_Service"/>
    </requireService>
    <requireResource>
          <Class
rdf:ID="5_AXIS_NCMillingMachine"/>
    </requireResource>…</ Milling >
```

```
<Rule
rdf:ID="DistributedManufacturing_Instance_15">
      <event><Event
rdf:ID="DistributedManufacturing_Instance_16">
         <onEnd><Milling
rdf:ID="DistributedManufacturing_Instance_1"/>
         </onEnd>    </Event> </event>
      <Do><Milling
rdf:ID="DistributedManufacturing_Instance_12"/
>
      </Do>
    </Rule>
```

Fig. 3. The manufacturing workflow process representation

In the system, the abstract workflow process is described by a set of task instances representing manufacturing activities and ECA rule instances representing the control flow using workflow terminology in the ontology. The task instances are used as service and resource requirements to find corresponding resource agents that can implement the activities. The control logic like *sequence*, *join*, *fork*, *choice*, *merge* are all expressed in ECA rule instances. Figure 3 shows a segment of the manufacturing process description in OWL. Changes in the process will only cause changes in ECA rule instances and task instances. The agents, organizations, service, resource and other information in the workflow are all modeled as instances in the ontology.

3.4 Knowledge Supported Executable Workflow Generation

Different parts of the workflow process are executed by different resource agents in the manufacturing grid in a distributed manner. For each workflow instance, a task allocation plan will be generated to establish an executable workflow. There are two alternative approaches for establishing the association between a task and its implementation. The compiling approach is to generate the executable workflow according to real time states of the grid environment, which is further sent to the workflow engine to be executed. The explanation approach is to execute the abstract workflow step by step and the task implementation is selected dynamically during the run-time.

The service and resource matchmaking is implemented by RDA to maps the given tasks onto a set of resource agents. For each task, RDA will search the DF and ISA, match the resource and service implement requirement specification against the available resources and services descriptions advertised by the RAs, and return a set of potential agents that can satisfy the task requirement, from which an appropriate service providers will be selected to execute the task according to some criterion considering agent availability, status, quality of service etc. The resource and service matching process is based on the domain ontology model to ensure flexible semantic matching at knowledge level [12]. For example, if resource C_j has a sub-class C_i, then any task which can be fulfilled by C_j can also be fulfilled by C_i as far as the capability is concerned. Based on the relationship among concepts, a match matching algorisms is implemented which make use of inference rules extracted from the ontology to ensure the semantic equivalence. The market based FIPA contract net protocol is implemented for agent selection as the resource agents are autonomous and distributed which includes three stages: bid invitation, bid responding from the resource agent, and task awarding. After the resource agent is selected for task implementation, a contract is made between the end user and the resource agents to specify all relevant aspects of service provision, such as the price, quality and deadline of the service.

If the resource matching fail because the task requires more resources than that any of the resource agents can provide, the system will help the manager to decompose the task into several sub-tasks, each of which will be re-matched and re-assigned to a resource agent. The discipline of task decomposition is to keep the sub-tasks as isolated as possible with a minimal amount of interactions. The task that can be assigned to one single resource agent will not be decomposed.

3.5 Knowledge Based Workflow Enactment and Coordination

The workflow process is enacted by TSA on the basis of the ECA rules instances through knowledge based rule mechanisms. Task in the workflow instance are initiated, managed, maintained, and executed as the sequences indicated in the ECA rules. Knowledge based process enactment is implemented as an expert system.

1. Translate the ontology model into the equivalent concept, facts and rules in Jess [13]with the following methods ,as illustrated in table 1:
   - The concepts in the ontology will be translated into templates.
   - The instances of rule in the ontology will be translated into scheduling rules.
   - Instances of concept other than rule in the ontology will be translated into fact.
   - All task instances are set to be in "INACTIVE" state by default.
   - When the job starts, the first task in the process was initiated and the sate is set to be "INITIATED".
2. For each task initiated, the task dispatching agent will dispatch it to the suitable resource agent as previously planned (compiling approach) or newly chosen (explanation approach), and send an inform massage to the corresponding agent, which will refresh its work-list on receiving the inform message by redisplaying the GUI with new tasks allocated, and then work on it.
3. When a task is completed, the responsible RA will change the task state to "COMPLETED" through the user interface, and then informs the TSA to schedule the next task.
4. TSA watches the actual state of each task and related conditions. When there is an event indicating the completion of a task, the TSA will run the scheduling rules using jess rule engine to match the LHS of each scheduling rule against the facts in the knowledge base, and update the task state according to the RHS of the rule, e.g. trigger the consequent task in the process by changing the state to "INITIATED".
5. Continue step 2 to step 4 till the whole job is completed.

The job is executed in a dynamic and uncertain process which requires coordination. If any exception occurs during the process like machine fail, quality fail or tardiness, the responsible resource agent (often people in real case) will send a message to the end user to inform the manager for appropriate actions to be taken, e.g. to allocate the task to another resource agent. Also, the event notification for process coordination like completions of a task, cancellation of a task, reallocation of a task delegation or deadline alert, is also based on message exchange.

Table 1. Translate knowledge model into jess

Element in ontology	Syntax	Element in jess	Example
Concept/Class	owl:Class >	deftemplate	(deftemplate Task (slot ID (Type String)) (slot name (Type String)) (slot state (Type String))(multislot requireResource)…)
Instances of Rule	Rule rdf:ID="…">	defrule	(defrule DistriManInst _15 (Task(ID DistriManInst_1) (state COMPLETED))=>(Do Task(ID DistriManInst _12)))
Other instances of Class	Task rdf:ID=″…">	deffacts or asserts	(deffacts tasks (Task (ID DistriManInst_1) (name CuXiWaiXing) (state INACTIVE) (requireResource 5_AXIS_NCMillingMachine)…))

4 System Implementation

A multi-agent and knowledge based dynamic workflow system prototype is constructed on the basis of JADE Framework [14]. The system agents are programmed in java class extending agent class. The workflow participants (either resource or end user) will run the executable workflow client, connect and get registered as an agent in general container to the jade main container server to form a multi agent distributed environment. The end user can assemble and configure the manufacturing workflow through the process modeling interface. And the service agent can advertise manufacturing resources and services to the system. For each task in the job, the resource discovery agent can provide the potential resource agents for end user to choose from. Tasks in the workflow instance are scheduled by TSA, and the state of each task during execution is displayed in the TMA.

5 Conclusion

This paper presents an agent based knowledge enacted dynamic workflow system to support process modeling and management for intelligent manufacturing grid, and a prototype system is implemented on the basis of JADE and Jess rule engine. The system shows several advantages:

– The concept and relationship are precisely defined in shared ontology, ensuring correct interaction among agents. The ontology can support common sense inference and model reuse as well.
– Knowledge model provide a more powerful and flexible way to express, validate and dynamically change the workflow process to support adaptive process management.
– The agent is characterized with autonomous behavior. Expert system and rule mechanism are integrated in knowledge based model and agent action can be implemented using ECA rules.

Acknowledgement

This work is supported by Chinese Aeronautic Science Program (Grant No. 04H53063).

References

1. Yu Tao,Yi-Ping Yuan,Jun Li etal. A multi agent based approach for manufacturing grid workflow .Proceedings of 2005 International Conference on Machine Learning and Cybernetics, Vol. 1(2005)199 – 204.
2. Yuhong Yan, Zakaria Maamar, Weiming shen. Integration of workflow and agent technology for business process management. The Sixth International Conference on CSCW in Design.(2001)420 – 426.
3. Jinmin Hu and Paul Grefen .Conceptual framework and architecture for service mediating workflow management.Information and Software Technology,2003,45(13):929-939.
4. Paul A.Buhler, Jose M.Vidal. Towards adaptive workflow enactment using multi agent systems. Information technology and management 2005(6):61-87.
5. Shuying Wang, Weiming Shen and Qi Hao. An agent-based Web service workflow model for inter-enterprise collaboration . Expert Systems with Applications, January 2006.
6. Han Yu, Xin Bai, Dan C. Marinescu. Workflow management and resource discovery for an intelligent grid.Parallel computing 2005, 31(7):797-811.
7. Wenjun Wang, Xinpeng Liu et al. Mapping Business Workflows onto Network Services Environments, Lecture Notes in Computer Science, Vol.3251,2004: 97 – 104.
8. Gruninger,M.,and Fox,M.S.Enterprise modeling. AI Magazine, 1998(19):109-121.
9. Lee,Ha Bin; Kim,Jong Woo and Park,Sung Joo .KWM: knowledge-based workflow model for agile organization. Journal of Intelligent Information Systems, 1999,13(3): 261-278.
10. Timm I J and Woelk P O. Ontology based capability management for distributed problem solving in the manufacturing domain. In M.Schillo et al.(Eds.): MATES 2003,LNAI 2831,2003:168-179.
11. http://www.daml.org/services/owl-s/1.1/overview/
12. Paolucci M, Kawamura T, Payne T R,et al .Semantic Matching of Web Services Capabilities.In the First International Semantic Web Conference (ISWC), Sardinia, June, 2002.
13. http://herzberg.ca.sandia.gov/jess/
14. http://jade.cselt.it/

A Cooperative Engineering Environment Using Virtual Reality with Sensory User Interfaces for Steel Bridge Erection

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Abstract. In this research, a product model for representing steel girder bridges was developed, based on IFC of IAI. In order to control 3D objects in the CAD world effectively, first, a virtual reality (VR) CAD system was developed for engineering of steel girder bridges by using the developed product model, Java 3D, liquid crystal shutter glasses, infrared emitter unit, etc. Then, to improve the user interface, an electro-magnetic sensor system was added for controlling 3D objects in the virtual world. This system can be used for interference checking between moving girders and surrounding structures during erection. In order to enable multiple users to view the 3D bridge model from different locations and angles, a cooperative engineering environment was proposed. In this environment, each user wears a head mounted display (HMD) instead of liquid crystal shutter glasses. A prototype system is being developed for verification of the proposed methodology.

1 Introduction

Product models represent the geometry and attribute information of products and facilities based on the object oriented paradigm. 3D CAD systems are usually used to view, control and modify the product model as a major user interface. However, it is hard for most engineers to acquire the ability to use 3D CAD systems, and they feel difficulty in controlling 3D objects when many objects are laid out in a complex manner. Although a perspective view image on a flat display monitor, generated from a 3D model, can be viewed as a stereoscopic image, most viewers cannot feel immersed in the virtual world because the image lacks true cubic effect. Thus, the virtual reality (VR) technique with a stereoscopic vision should be used to enhance the user interface of 3D CAD systems.

Virtual reality is a realistic simulation by a computer system using interactive software and hardware. The requirements for virtual reality usually include virtual world, immersion, sensory feedback, and interactivity. The virtual world can be realized as a three-dimensional space by using computer graphics. The user can feel immersed in

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 83 – 90, 2006.

the virtual world by using a special display system. Feedback and interaction can be realized by using a sensor system connected with the virtual world and the user.

In this research, a product model has been developed for representing steel plate girder bridges by expanding Industry Foundation Classes (IFC) of International Alliance for Interoperability [1]. A VR-CAD system was developed to view, control, and modify this product model effectively. In this system, graphics are generated by using Java3D. To generate stereoscopic views, liquid crystal shutter glasses and an infrared emitter unit were used.

Although the developed VR-CAD system demonstrated its feasibility and effectiveness, the mouse operation of the system had a problem and needed improvement as a user interface with the 3D virtual world. Therefore, sensor systems including an electro-magnetic wave transmitter and receivers were used to realize sensory feedback and interactivity. The sensor system allows the user to grab, move, and control each member of a steel plate girder bridge by moving a magnetic sensor in a 3D manner. We applied this VR-CAD system with the sensor system to check the interference between the member which the user is moving and the surrounding objects such as other members of the bridge, buildings, trees, construction machines, etc., for erection planning. This application showed the effective use of the VR-CAD system.

The next step was to develop a framework that allows multiple users to view the virtual world from different directions and to move the steel girder for erection planning. The system based on this framework allows engineers and construction workers to plan the erection work cooperatively.

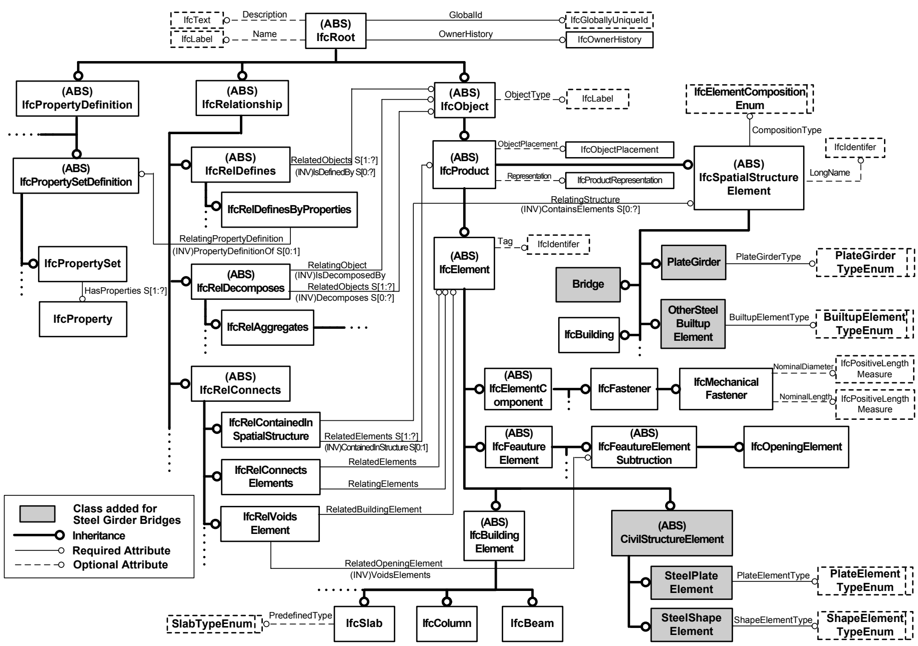

Fig. 1. A Part of the developed product model for steel girder bridges

2 A Product Model for Steel Girder Bridges

A product model for steel girder bridges has been developed by adding three classes, Bridge, PlateGirder, and OtherSteelBuiltupElement, as subclasses of IfcSpatialStructureElement to IFC2x2 of IAI, as shown in Fig. 1 [2], [3]. The Bridge class represents the whole bridge superstructure. Thus, it is natural to locate this class at the same level of IfcBuilding. PlateGirder and OtherSteelBuiltupElement classes represent objects which are contained in the Bridge class. Those classes are linked with the Bridge class by using IfcRelContainedInSpatial-Structure. In addition, CivilStructureElement, which has subclasses of SteelStructureElement and SteelShapeElement, was added as a subclass of IfcElement. SteelStructureElement class can represent elements such as webs and flanges. SteelShapeElement class represents general steel shapes such as I, H, box, angle, pipe types.

3 VR-CAD with Stereoscopic Vision

3.1 Development of a VR-CAD System

Virtual reality is a realistic simulation by a computer system using interactive software and hardware. The requirements for virtual reality usually include virtual world, immersion, sensory feedback, and interactivity. The virtual world can be realized as a three-dimensional space by using computer graphics. The user can feel immersed in the virtual world by using a special display system. Feedback and interaction can be realized by using a sensor system connected with the virtual world and the user.

3D computer graphics is a computing technique for rendering images of objects in the three-dimensional space. One of the most typical and commonly used 3D computer graphics in research is OpenGL, which is a library of the C language. Since Java was used as a system development language in this research, Java 3D, which is a 3D graphics API for Java 2 developed by Sun Microsystems was used.

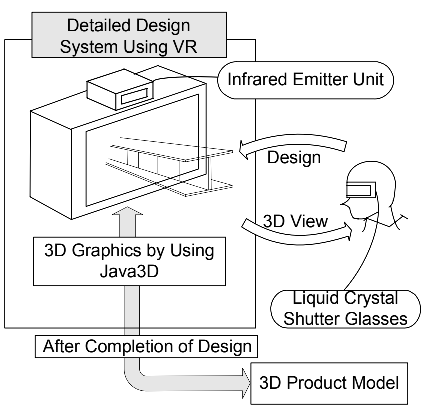

Fig. 2. A system architecture of the VR-CAD

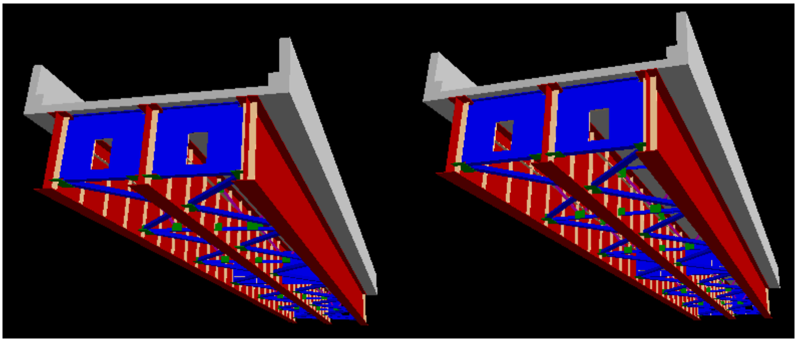

Fig. 3. Computer graphics images of a steel girder bridge for left and right eyes respectively

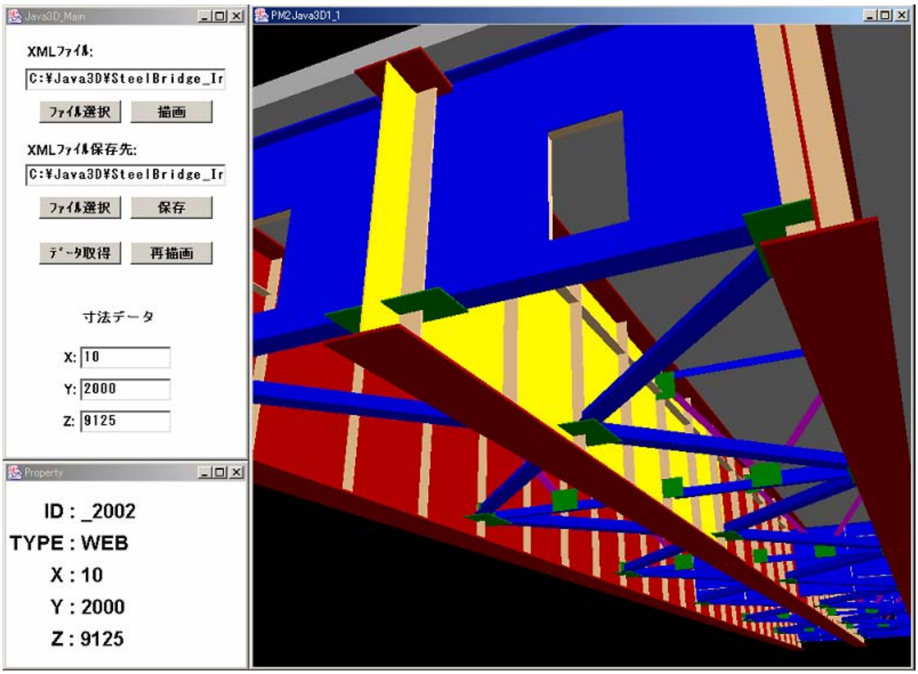

Fig. 4. A screen shot of the VR-CAD system

Although a perspective view image on a 2D display, generated from a 3D model, can be viewed as a three-dimensional image, most viewers cannot feel immersed in the virtual world because the image lacks true cubic effect. It is necessary to generate two different images: one is for the right eye and the other for the left one in order to enable true stereoscopic viewing. Such images can be generated by using Java 3D and can be shown on various VR display systems such as liquid crystal shutter glasses, head mounted display, 3D liquid crystal display without glasses, IMAX, CAVE, etc. CrystalEYES3 of StereoGraphics was used as liquid crystal shutter glasses. The shutters of these glasses synchronize with the computer display showing right and left images alternately at more than 120 Hz by using the infrared emitter unit. More than one viewer can see the images three dimensionally if they wear the glasses.

A VR-CAD system for detailed design of steel girder bridges was developed. The system architecture is shown in Fig. 2. Fig. 3 shows computer graphics images of a steel girder bridge for right and left eyes respectively. Fig. 4 shows the user interface of the developed VR-CAD system. The color of the web of the steel girder changed to yellow and its dimensions and attribute data were shown in the left windows. The user could change the dimensions of any selected element as shown in Fig. 5.

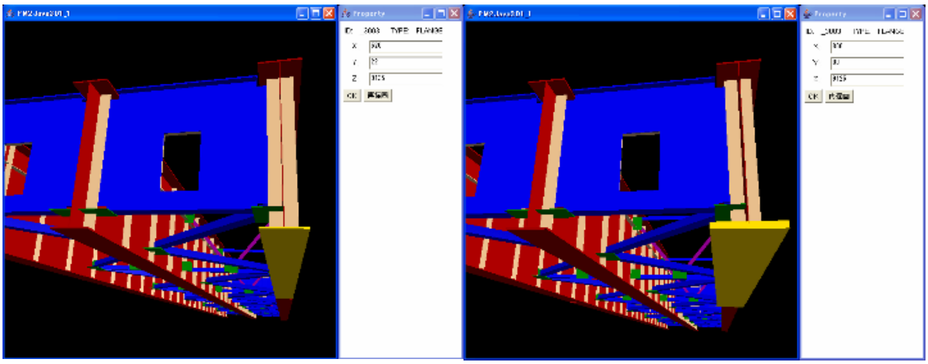

Fig. 5. The user selected the lower flange of the right girder in the left, and changed its dimensions in the data window. Then, the flange was modified in the right figure.

3.2 Observations

The VR-CAD system described in the previous section can enhance the design process effectively by stereoscopic view generation. However, since the computer mouse was used to capture, move, and control objects on the screen, more appropriate user interface would be necessary in order to move objects in the 3D world.

Although multiple users can see the stereoscopic images by wearing liquid crystal shutter glasses, it would not be possible for each user to view the 3D model from each different direction.

4 VR-CAD with a Sensory User Interface

The user interface better than a mouse would especially be needed to plan erection of bridges because the user should make sure that moving girders and members would not interfere with other objects such as buildings, various poles, and other structures. To develop an erection planning support system, FASTRAK of Polhemus was used as a 3D sensor system as well as Java3D, liquid crystal shutter glasses, etc. Fig. 6 shows the general layout of the system. FASTRAK consists of a 3D position measuring sensor, transmitter, and receivers.

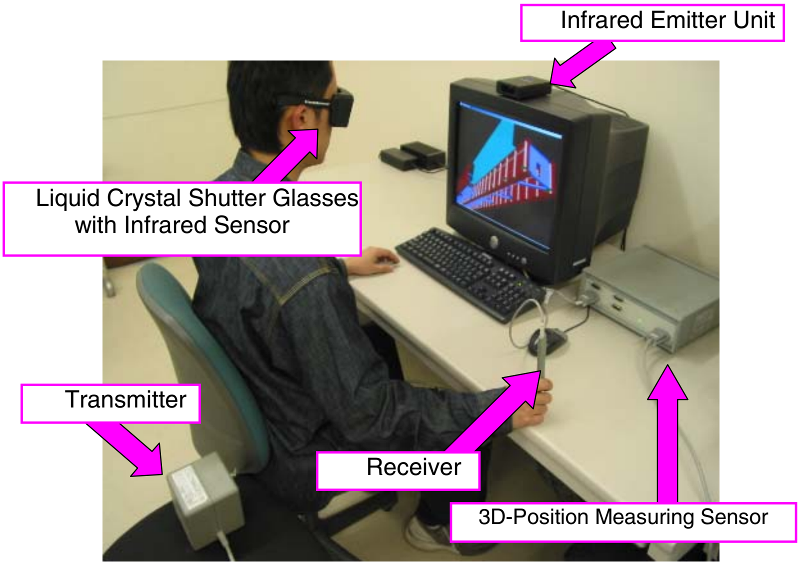

Fig. 6. VR-CAD with the sensor system for bridge erection planning

In the erection planning support system, each member data of steel girder bridge is retrieved from the steel bridge product model and rendered in the virtual world constructed in Java3D. A moving member to be installed at an appropriate location in the virtual world can be simulated by moving the receiver of FASTRAK. Furthermore, the user can feel immersed with stereoscopic views in the virtual world by wearing the liquid crystal shutter glasses.

In this system, if a moving object in the virtual world touches or interferes other objects such as buildings, trees, construction machinery, etc., the color of the moving object changes for giving an alert to the user as shown in Fig. 7.

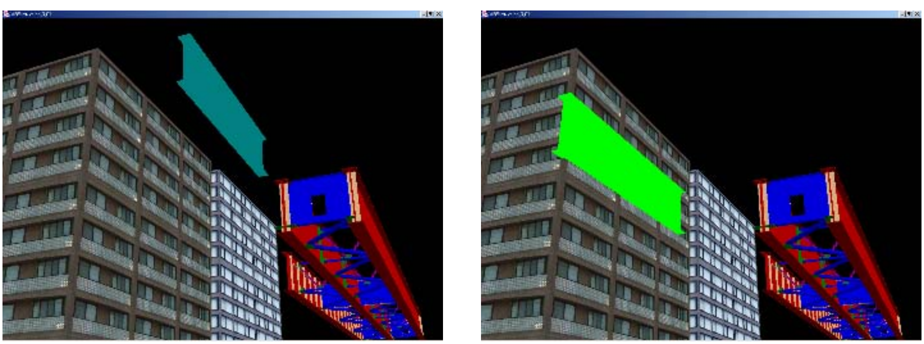

Fig. 7. The user is moving a girder in the virtual world by moving the sensing receiver. In the right figure, the girder touched the building and the system gave the user an alert by changing the color of the girder.

Sensor systems such as transmitters and receivers can realize sensory feedback and interactivity. Within the boundary of such sensor system, the user can change the viewing direction and location by just moving his or her head or fingers without typing commands from a keyboard. Since the radius of the boundary of FASTRAK is about 1m, viewing location is limited to 2m, which is too small considering the size of typical bridges. Thus, the distance in the sensor area was magnified with some factor so that the user can view bridges from any point in the virtual world.

5 A Cooperative Engineering Environment Using HMDs

Bridge erection planning is usually done by two or more engineers and technicians. The VR-CAD system described in the previous section can be used by multiple users if they wear liquid crystal shutter glasses in the sensor area. The system can help the participants discuss how erection work should be done and potential problems and solutions by viewing the stereoscopic image and by moving a receiver corresponding to a moving girder. However, the images all the users are watching are the same as they are all watching the same display. It would be more effective if each user can view the same 3D model from different angle, which could help users identify potentially hidden problems such as interference among the moving girders and surrounding structures, facilities, and construction equipment.

To satisfy all the conditions described above, a cooperative engineering environment has been proposed in this research. In this environment, each user wears a head mounted display (HMD) instead of liquid crystal shutter glasses. A sensory receiver is attached to each HMD so that each user's location and viewing direction are simulated. A prototype system is being developed for two users as shown in Fig. 8.

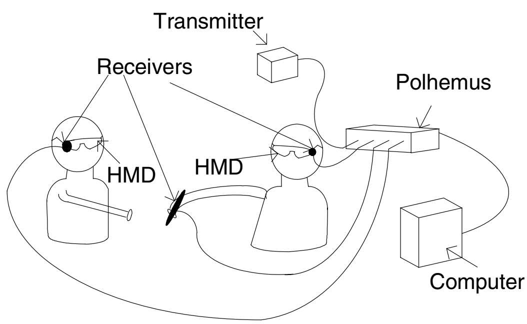

Fig. 8. A proposed cooperative engineering environment for bridge erection planning

6 Conclusion

In this research, a product model for steel girder bridges was developed, based on IFC2x2 of IAI for representing 3D geometry and attribute data of all the members of the steel girder bridge so that interoperability of the data should be realized.

Next, to enhance the user interface of 3D CAD system, which is used to design, control, and view the 3 dimensional product model data, virtual reality with a stereoscopic vision was introduced. A VR-CAD was developed by using the developed product model, Java 3D, liquid crystal shutter glasses, infrared emitter unit, etc. Although the VR-CAD system demonstrated its feasibility and effectiveness, better user interface than a mouse unit was deemed necessary to capture, move, and control objects in the virtual world on the display monitor. Thus, the magnetic sensor system was used for capturing, moving, and controlling 3D objects in the virtual world. The developed system was used for interference checking between moving objects and surrounding structures.

However, in the VR-CAD system, the images for all the users are watching simultaneously are the same. It would be more effective if each user can view the same 3D model from different angle. Therefore, a cooperative engineering environment has been proposed. In this environment, each user wears a HMD instead of liquid crystal shutter glasses. And a sensory receiver is attached to each HMD so that each user's location and viewing direction are simulated. A prototype system is being developed for verification of the proposed methodology.

References

1. Liebich, T. (ed.): IFC 2x Edition 2 Model Implementation Guide. International Alliance for Interoperability (2004)
2. Yaubki, N., Kotani, J., and Shitani, T.: A Steel Bridge Design System Architecture using VR-CAD and Web Service-based Multi-Agents. Proceedings of the Xth International Conference on Computing in Civil and Building Engineering, Beucke, K. et al. (eds.),Weimar, Germany, CD-ROM, 8pp (2004)
3. Yabuki, N., Kotani, J., and Shitani, T.: A Cooperative Design Environment Using Multi-Agents and Virtual Reality. Proceedings of the First Conference on Cooperative Design, Visualization, and Engineering (CDVE), Luo, Y. (ed.), LNCS 3190, Springer-Verlag, (2004) 96-103

A Collaborative Multimedia Editing System Based on Shallow Nature Language Parsing

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Abstract. As the collaborative editing system becomes prevalent, further requirement on content based collaboration is presented by editors. This paper focuses on how to implement content based collaboration. In order to combine the advantage of nature language processing technology in content parsing, we present the shallow nature language parsing technology in collaborative editing system. This technology is based on the segmentation and the text classification. This paper also discusses the reason why the shallow nature language parsing technology is useful in content based collaboration and its further use in collaborative editing system. In addition, it has already been used in our collaborative multimedia editing system which is designed for Chinese teaching material editor. From the result of experiment, it shows that the system really reduces the time in editing collaboration.

1 Introduction

With the progress of cooperative design theory, more collaborative editing systems were designed for this purpose. Such as Real-time Collaborative Editing System [1,2,3,4], Distributed Collaborative Editing System [5], Web Based Collaborative Editing System [6,7,8,9], etc. All these systems have done a lot of works in collaboration to improve efficiency, but all the collaborations focus only on network model and work flow [16,17,18]. The most important problem is that it does not reduce the time in content based collaboration which is more common in editing action. This is because the network model and work flow can't process the content parsing. In order to process content based collaboration, we have to use nature language processing technology. Unfortunately, nature language processing technology is immature. It is so slow in semantic parsing and has a lot of problems in understanding nature language. Is it unfeasible in content based collaboration? Fortunately, not every kind of content based collaboration mentioned by editor need to understand the nature language. So in this paper we introduce the shallow nature language parsing technology [12,15] which parses the nature language and provides some useful middle results. This is useful in constructing collaboration. At the end of this paper, we also introduce a Chinese

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 91–98, 2006.

collaborative multimedia editing system which is designed for Chinese teaching material editor.

2 Collaborative Editing System Model Based on Shallow Nature Language Parsing

Collaborative editing system includes many collaborative managers, such as user manager and project manager. In order to describe the architecture of it, we draw a brief map of a typical web based collaborative editing system model. It is shown in Fig. 1.

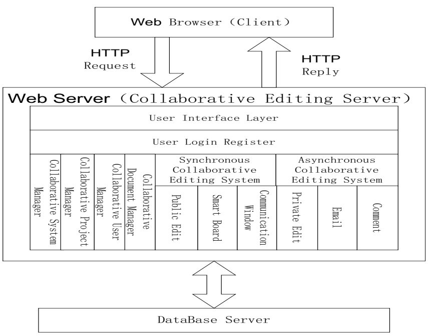

Fig. 1. A typical web based collaborative editing system model

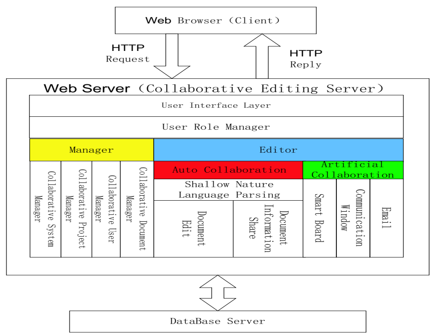

Fig. 2. A collaborative editing system model based on shallow nature language parsing

This typical model focuses more on collaborative management, such as collaborative system manager, collaborative project manager, collaborative user manager and collaborative document manager. In this model, the inter-editor collaboration is based on Email and other communication tools, and nothing can be easily shared between editors. For example, editor A uses a word in his document and considers maybe it is the first time used in the whole book. So editor A must send Email to others and ask for checking whether it is a new word or not. Other editors who received the mail must check their documents and reply it. This kind of inter-editor collaboration which based on network communication is very expensive. In this example, editors need a content based collaboration method to make their editing action more efficiency.

After investigating on editor's editing action, we find that there are four editing actions which need collaboration. There are information sharing, information communication, document feature computing and information tagging. Considering the editing actions of editors, we add content based collaboration in the collaborative editing system. So far, our model is shown in Fig. 2.

In order to combine the advantage of Shallow Nature Language Parsing and the network communication, we add the Role Manager in the system to detail correlative function of every role. For the role of editor, the system uses content based collaboration. For the role of manager, the system uses the network and work flow collaboration.

For the two models mentioned above, we compare their collaborative effects as table 1 shown.

Table 1. Collaborative effects of two models

	Typical Model	**System Model Based On Shallow Nature Language Parsing**
Information Sharing	Inform others by Email and so on	Inform others by Email and auto language parsing
Information Communication	Inform others by Email and so on	Inform others by Email and so on
Document Feature Computing	Inform others by Email and so on	Obtain results by auto language parsing
Information Tagging	Inform others by Email and so on	Obtain results by auto language parsing

From Table 1, we can find that the collaborative editing system model based on shallow nature language parsing has more advantages in text editing. Our basic steps of implementing collaboration are shown below.

1. Parse each document into some metadata which can represent the original document.
2. Compute these metadata to obtain some useful information in collaboration, such as document similarity.
3. Use computing results to implement collaboration.

3 Shallow Nature Language Parsing Technology

Based on the existing collaborative editing system model, we combine technology of Word Segmentation and Text Classification in Shallow Nature Language Parsing to implement the content based collaboration in editing.

3.1 Chinese Word Segmentation Technology

Written Chinese is sequence of character, so there is no gap mark between words, and even though the boundary of words is ambiguous. Researchers have done a lot of work on Chinese word auto-segmentation technology. There are three segmentation algorithms: segmentation algorithm based on lexicon, segmentation algorithm based on statistic model [10,11,12,13,14,15], and segmentation algorithm based on knowledge understanding.

The speed of the first algorithm is fast, but it has some problems in solving ambiguities. On the contrary, the speed of the second algorithm is common, but it has great ability to solve ambiguities. And the third algorithm must be based on a lot of usable knowledge databases.

Based on the research of these three algorithms, we use an algorithm combining lexicon-based and statistics-based approaches for Chinese word segmentation. The algorithm is described as follow:

1. Use the Maximum Matching Method to roughly segment a sentence S.
2. Scan boundaries of every segmentations and find the maximum likelihood segmentation. For any sentence, assume that $W = (w_1, w_2, ...w_n)$ is one of the possible segments, $T = (t_1, t_2, ...t_n)$ is the responding part of speech. Then the maximum likelihood segmentation is $W_{final} = \arg\max_W P(W) = \arg\max_W P(W|T)P(T)$. After using the first order Hidden Markov Model, we can get the following formula.

$$\begin{aligned} W_{final} &= \arg\max_W (\prod_{i=1}^{n} P(w_i|T) \times \prod_{i=2}^{n} P(t_i|t_1, ..., t_{i-1})) \\ &= \arg\max_W (\prod_{i=1}^{n} P(w_i|t_i) P(t_i|t_{i-1})) \end{aligned} \tag{1}$$

   Where t_0 is the beginning of the sentence and $P(t_1|t_0) = 1$.
3. Use rules to parse person's name, geographical name and organization name, and use rules of lexical structure to form compound words and derivative words.

At present, this method can solve familiar ambiguities and identify lexical structure such as person's name, geographical name, organization name and so on. Shown as our testing results, the precise is 97.948%, and the segmentation speed is 200,000 words per minute.

3.2 Text Classification Technology

The task of Text Classification System is: in a given classified system, based on the content it can automatically identify the class which text associates with. In another point of view, in collaborative editing model, we can use Text Classification technology to differentiate similarity and redundancy degree between texts edited by two editors.

We use the Vector Space Model to compute the similarity degree of text. The basic thought of VSM is using vector to denote text: $(w_1, w_2, w_3, ..., w_n)$, where w_i is the weight of the ith feature, commonly choose words as feature. So if want to use text as a vector in vector space, we must segment the text, and the number of segmentation words is the dimension of a vector which denotes the text, and vectors are denoted by frequency of words. We use TF-IDF to show the effect of words in text:

$$W(t, \overrightarrow{d}) = \frac{tf(t, \overrightarrow{d}) \times log(N/n_t + 0.01)}{\sqrt{\sum_{t \in \overrightarrow{d}} [tf(t, \overrightarrow{d}) \times log(N/n_t + 0.01)]^2}} \tag{2}$$

Where $W(t, \overrightarrow{d})$ is the weight of the word t in the text $\overrightarrow{d}$, and $tf(t, \overrightarrow{d})$ is the frequency of the word t presenting in the text $\overrightarrow{d}$, N is the number of chapters in the text, n_t is the number of chapters in the text where the word t occurs, and the denominator is a unitary factor.

We can obtain the similarity degree of two documents by calculating the distance between vectors.

$$Sim(d_i, d_j) = \frac{\sum_{k=1}^{M}(W_{ik} \times W_{jk})}{\sqrt{(\sum_{k=1}^{M} W_{ik}^2)(\sum_{k=1}^{M} W_{jk}^2)}} \tag{3}$$

Where, d_i is the feature vector of the ith text, d_j is the feature vector of the jth text, M is the dimension of feature vector, and W_k is the kth dimension of vector.

For the basic need of teaching material, we use lexical-rank table of Chinese teaching material to compute the similarity degree. We use weight formula as follow to calculate lexical vector:

$$W_t = W(t, \overrightarrow{d}) \times WordLevel(t) \tag{4}$$

Where $W(t, \overrightarrow{d})$ is the weight of word t in the text $\overrightarrow{d}$, $WordLevel(t)$ is the rank of the word t, the higher the rank of a word is, the more difficult it is; and the higher the value of TF-IDF of one word in text is, the better it can show the main content of the text.

In order to find which class the document d_i belongs to, we use the following formula. Assume that there are m classes.

$$SIMC_i = \max_{1 \le k \le m}(avg_{j \in C_k}(Sim(d_i, d_j))) \tag{5}$$

Where C_k is the kth class of the document.

4 Chinese Collaborative Multimedia Editing System

The edit of Chinese teaching material is different with other bookmaking, because it faces to the need of teaching, there are many new words and phonetic notations, and it needs strict access control to choose words and expressions for primary teaching material. These problems can not be solved in typical collaborative editing model.

In our Chinese collaborative multimedia editing system, we use the Shallow Nature Language Parsing to implement automatic phonetic notation tagging, automatic new-word-table generation and automatic statistical computing of document difficulty. Its process is shown as Fig. 3 and 4.

By comparing the result of Chinese word segmentation with vocabulary in database, we can obtain the new words and their phonetic notation of the text.

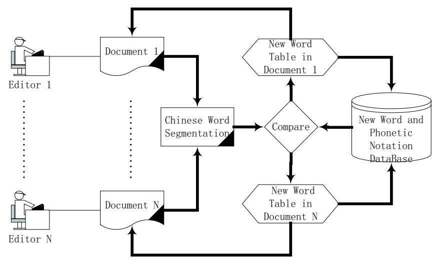

Fig. 3. Automatic new word table generation and phonetic notation tagging

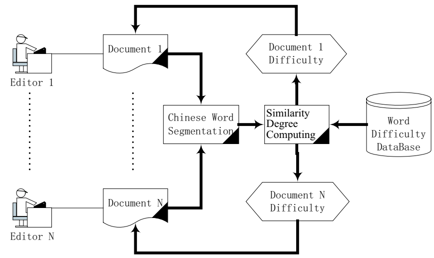

Fig. 4. Automatic statistical computing of document difficulty

Editors don't need to tell others through BBS or Email about the new words from their own chapters, only by clicking a button, they can obtain the information of new words of chapters edited by others, and build their own new-word-table.

We can see from the Fig. 4, first we obtain all words by using the Chinese word segmentation, then we search database for word difficulty, and compute similarity degree between the documents edited by other editors, finally we can obtain this document's vocabulary difficulty and compute the document difficulty.

And thus we can ensure that teaching material of two editors would be consistent in document difficulty, and reduce additional corresponding time of keeping the teaching material difficulty.

5 Experiment

Our experiment is built for testing whether our algorithm can distinguish the difference from the redundancy, the consistency and the inconsistency. In order to simulate the real editing environment, we collect 50 documents from middle school teaching material. Documents are divided into five classes. Each class has ten documents. Class A is for the students in grade one, class B is for the students in grade two, the rest may be deduced by analogy. The result is shown in table 2 and 3.

From experiment results, two kind of similarity degree computation can tell the difference between the consistency and the inconsistency. If documents are from the same class, they will get high similarity degree. But there are also some differences in two tables. In table 2, although the class E is more difficult than class C, the similarity degree between class A and C is lower than the one between class A and E. It shows that similarity degree without word rank can not describe the difference of two classes in detail. The second computation method is good at this. From the result in table 3, the similarity degree shows more detail in which class is more different than others, or in other word, which class is more difficult. Based on this experiment, we choose the latter in computing the similarity degree.

From this experiment, we setup three thresholds which distinguish the difference from the redundancy, the consistency and the inconsistency. If the similarity

Table 2. similarity degree without word rank

	Class A	Class B	Class C	Class D	Class E
Class A	0.543471	0.394674	0.349214	0.337767	0.359759
Class B		0.624663	0.474571	0.475534	0.49316
Class C			0.646572	0.562665	0.555233
Class D				0.685485	0.581703
Class E					0.722925

Table 3. similarity degree with word rank

	Class A	Class B	Class C	Class D	Class E
Class A	0.562471	0.212115	0.115527	0.102218	0.096604
Class B		0.536382	0.272352	0.179814	0.163737
Class C			0.594115	0.242724	0.16439
Class D				0.523257	0.138148
Class E					0.613727

degree is greater than 0.7 and close to 1, then two documents will be the same. We call that the document is redundant. If the similarity degree is greater than 0.4 and less than 0.7, then the documents belong to the same class. We call that the document is consistent. Otherwise we call that the document is inconsistent.

6 Conclusion

This paper presents shallow nature language parsing technology in content based collaboration which can not be solved by current collaborative editing system model. First we use the shallow nature language parsing technology to process the editing text, and then use the network collaborative technology to share editing resource which can be obtained from the first step. Two components in shallow nature language parsing technology were used in Chinese collaborative multimedia editing system. It shows that the shallow nature language parsing technology has more advantages in content based collaboration. In further research, we will focus on the relation between the parsing data and original edit text, and effective sharing of edit resource.

Acknowledgements. The work is supported by The Natural Science Fund of Fujian Province (Project Number: A0310009), Program of 985 Innovation on Information in Xiamen University (2004-2007) and Academician Fund of Xiamen University. And we would like to thank the comments and guidance provided by Dr. Shaozi Li at the University of Xiamen, and Special thanks to Shaoyong Yu, Fan Lin and Jianhua Wang for their contributions to the related research work and preparation of this paper.

References

1. Xiao Qin and Chengzheng Sun, "Recovery support for Internet-based real-time collaborative editing systems", Computer Networks and Mobile Computing, 2001, Proceedings, 2001 International Conference on 16-19 Oct, 2001 Page(s):181 - 188.
2. Claudia-Lavinia Ignat and Moira C. Norrie, "Extending real-time collaborative editing systems with asynchronous communication", CSCWD, 2004, Proceedings, The 8th International Conference on Volume 2, 26-28 May 2004 Page(s):528 - 533.
3. Du Li, Limin Zhou and Richard R. Muntz, "A new paradigm of user intention preservation in realtime collaborative editing systems", Parallel and Distributed Systems, 2000, Proceedings, Seventh International Conference on 4-7 July 2000 Page(s):401 - 408.
4. Qirong Mao, Jinfeng Wang and Yongzhao Zhan, "The optimistic locking concurrency controlling algorithm based on relative position and its application in real-time collaborative editing system", CSCWD, 2004, Proceedings, The 8th International Conference on Volume 1, 26-28 May 2004 Page(s):99 - 105.
5. Irene Greif, Robert Seliger and William Weihl, "A case study of CES: a distributed collaborative editing system implemented in Argus", Software Engineering, IEEE Transactions on Volume 18, Issue 9, Sept. 1992 Page(s):827 - 839.
6. S. Noel and J-M Robert, "Empirical study on collaborative writing: What do co-authors do, use, and like?", Computer Supported Cooperative Work: The Journal of Collaborative Computing, Volume 13, No. 1, 2004 Page(s):63-89.
7. S. Noel and J-M Robert, "How the Web is Used to Support Collaborative Writing", Behaviour Information Technology, Volume 22, No. 4, 2003 Page(s):245-262.
8. Manual R. Salcedo and Dominique Decouchant, "Structured Cooperative Authoring for the World Wide Web", Computer Supported Cooperative Work: The Journal of Collaborative Computing, Volume 6, 1997 Page(s):157-174.
9. Alan Dix, "Challenges for Cooperative Work on the Web:An Analytical Approach", Computer Supported Co-operative Work: The Journal of Collaborative Computing, Volume 6, 1997 Page(s):135-156.
10. Huaping Zhang and Qun Liu, "Model of Chinese Words Rough Segmentation Based on N-Shortest-Paths Method", Journal of Chinese Information Processing, Volume 16, No. 5, 2002 Page(s):1-7.
11. Yuan S. C and Henry T., "Probability Theory", Springer-Verlag New York Inc., 1978 Page(s):324-338.
12. Christopher D. Manning and Hinrich S., "Foundations of statistical natural language processing", MIT press, 1999 Page(s):197-202.
13. Rabiner L. R., "A Tutorial on Hidden Markov Models and Selected Applications in Speech Recognition", Proceedings of the IEEE, Volume 77, No. 2, Feb. 1989, Page(s): 257 - 285.
14. Huaping Zhang, Qun Liu, Hao Zhang and Xueqi Cheng, "Automatic Recognition of Chinese Unknown Words Based on Role Tagging", SigHan Workshop, 19th International Conference on Computational Linguistics, 2002.
15. Steven Abney, "Partial Parsing via Finite-State Cascades", Proceedings of the ESSLLI '96 Robust Parsing Workshop
16. W. Keith Edwards, "Policies and Roles in Collaborative Applications", Proceedings of ACM CSCW'96.
17. Du Li and Richard R. Muntz., "COCA: Collaborative Objects Coordination Architecture", Proceedings of ACM CSCW '98, Nov. 1998, Seattle.
18. M. Koch, "Design Issues and Model for a Distributed Multiuser Editor", Computer Supported Cooperative Work, 3(3-4), Page(s):359-378, 1995.

Formulation and a MOGA Based Approach for Multi-UAV Cooperative Reconnaissance

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Abstract. Multi-UAV cooperative reconnaissance is one of the most challenging research area for UAV operations. The objective is to coordinate different kinds of sensor-bearing UAVs conducting reconnaissance on a set of targets within predefined time windows at minimum cost, while satisfying the reconnaissance demands, and without violating the maximum permitted travel time for each UAV. This paper presents a multi-objective optimization mathematical formulation for the problem. Different from previous formulations, the model takes the reconnaissance resolution demands of the targets and time window constraints into account. Then a multi-objective genetic algorithm CR-MOGA is put forward to solve the problem. In CR-MOGA, Pareto optimality based selection is introduced to generate the parent individuals. Novel evolutionary operators are designed according to the specifics of the problem. Finally the simulation results show the efficiency of our algorithm.

1 Introduction

Unmanned Aerial vehicles (UAVs) plays an important role in air base reconnaissance operations. However, single UAV conducting reconnaissance in complex battlefield will encounter many problems. For example, one UAV alone cannot conduct reconnaissance on targets located in different sites simultaneously. Therefore, coordinating a fleet of sensor-bearing UAVs to conduct air reconnaissance is an important problem for employing UAVs effectively.

The mathematical modelling and solving for multi-UAV cooperative reconnaissance problem is one of the challenging areas in UAV studies. Ryan[1] formulated the problem as a multiple travelling salesman problem(TSP) with time window constraints and solved by tabu search algorithm. Hutchison[2] proposed a method which divided the operations area into identical sectors and allocated the targets in one sectors to a given UAV. Then TSP defined to find the shortest path connecting each target for each UAV is solved using simulated annealing algorithm. Ousingsawat[3] divided the problem to minimum-time trajectory problem and task assignment problem. A* search is used to find the shortest path between two points, then the task assignment problem is expressed as a mixed integer linear program(MILP) solved using the MATLAB optimization

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 99–106, 2006.

toolbox. While in these previous studies, the specifics of reconnaissance mission are not considered thoroughly. For a certain ground target, the imaging resolution on it should reach a certain level for the commander to recognize it or even classify it. Otherwise the reconnaissance is failure. And the information about the target should be timely and reflect the situation in a certain period. If the UAVs are tardy, the reconnaissance mission is also failure. At the same time, the cost to employ UAVs conducting reconnaissance should also be minimized while meeting all the reconnaissance needs.

The main contribution of this paper is to present a mathematical model for multi-objective cooperative reconnaissance problem(MOCRP). The model takes the reconnaissance resolution demands and time window constraints of the targets into account. Then a novel multi-objective genetic algorithm CR-MOGA is proposed to solve the problem. The rest of the paper is organized as follows. Section 2 presents the mathematical model of MOCRP. The proposed CR-MOGA is described in detail in section 3. Section 4 shows the simulation results and section 5 concludes the paper.

2 Cooperative Reconnaissance Problem Formulation

In previous formulations of the problem, such as TSP in [1][2] and MILP in [3], the reconnaissance resolution and time windows of the targets, which are important factors, are not considered thoroughly. And the number of UAVs is often fixed and not be optimized. In this paper, we present a mathematical formulation for the problem, which takes more specifics of the reconnaissance mission into account.

The reconnaissance targets set is denoted by $T_0 = \{1, 2, ..., N_T\}$, where N_T is the number of targets. R_i is the reconnaissance resolution demand of target i. Each target i has a time window $[e_i, l_i]$, where e_i is the earliest time allowed for reconnaissance on it and l_i is the latest time. T_i is the time to begin reconnaissance on target i. An UAV may arrive before e_i, which incurs the waiting time w_i until reconnaissance is possible. No UAV may arrive past l_i. The set $T = \{0, 1, ..., N_T\}$ denotes the extended targets set, where 0 indicates the base that UAVs depart from and return to. $V = \{V^1, V^2, ..., V^{N_V}\}$ denotes UAVs set with different capabilities, where V^k denotes the k-th kind of UAVs set and v_q^k is the q-th UAV in V^k. The reconnaissance resolution is r_k for UAVs in V^k, and for $V = \{V^1, V^2, ..., V^{N_V}\}$, $r_1 < r_2 < ... < r_{Nv}$ holds. TL_k is the maximum travel time permitted, and c_k is the cost to employ one UAV in V^k. s_i^k denotes the time duration for an UAV in V^k conducting reconnaissance on target i. The routes set between target pairs is denoted by $A = \{(i, j)|i, j \in T, i \neq j\}$, which can be calculated by classical routing algorithms such as A*. Each route $(i, j) \in A$ is associated with a distance d_{ij} denoting the length of (i, j) and a travel time t_{ij}^k denoting the travel time for UAV in V^k between target i and j. The decision variable of MOCRP is

$$x_{pij}^k = \begin{cases} 1 & \text{if route } (i,j) \text{ is used by UAV } v_p^k \\ 0 & \text{otherwise} \end{cases} \tag{1}$$

UAVs with different capabilities conduct reconnaissance on all the targets in T_0 such that the following objectives and constraints are met.
Objectives:

- Minimize the total cost of UAVs employed in conducting reconnaissance.
- Minimize the travel distance and total time travelled by the UAVs.

Constraints:

- Each target is reconnoitred exactly once.
- Each UAV departs from the base and returns to the base finally.
- Reconnaissance resolution demand of each target should be satisfied.
- Reconnaissance time window constraints should be observed.
- Maximum permitted travel time for each UAV should be observed.

The MOCRP model can be mathematically formulated as follows:

$$(\mathbf{MOCRP})\ \min \boldsymbol{f} = (f_1, f_2) \tag{2}$$

$$f_1 = \sum_{k=1}^{N_V} \sum_{v_p^k \in V^k} \sum_{j \in T_0} x_{p0j} c_k \tag{3}$$

$$f_2 = \sum_{k=1}^{N_V} \sum_{v_p^k \in V^k} \sum_{(i,j) \in A} f_{ij}^k x_{pij}^k \tag{4}$$

Where $f_{ij}^k = \alpha d_{ij} + \beta(T_i + s_i^k + t_{ij}^k + w_j)$.
Subject to:

$$\sum_{j \in T_0} x_{p0j}^k = 1, \sum_{j \in T_0} x_{pj0}^k = 1, \forall v_p^k \in V^k, V^k \in V \tag{5}$$

$$\sum_{k=1}^{N_V} \sum_{v_p^k \in V^k} \sum_{j \in T} x_{pji}^k = 1, \quad \sum_{k=1}^{N_V} \sum_{v_p^k \in V^k} \sum_{j \in T} x_{pij}^k = 1 \quad \forall i \in T_0 \tag{6}$$

$$e_i \leq T_i \leq l_i \quad \forall i \in T_0 \tag{7}$$

$$If \quad x_{pij}^k = 1,\ then\ \ T_i + s_i^k + t_{ij}^k + w_j = T_j \tag{8}$$

$$w_j = max(0, e_j - (T_i + s_i^k + t_{ij}^k)) \tag{9}$$

$$\sum_{(i,j) \in A} x_{pij}^k (t_{ij}^k + s_j^k + w_j) \leq TL_k \quad \forall v_p^k \in V^k, V^k \in V \tag{10}$$

$$If \quad x_{pij}^k = 1,\ then\ \ r_k \leq R_j \tag{11}$$

MOCRP comprises the routing and scheduling of UAVs. The routing, like the TSP, is concerned with finding an optimal reconnaissance sequence of the targets. While the scheduling, like the Job Scheduling Problem(JSP), specifies the time that the targets are reconnoitered. Therefore, MOCRP should address not only the spatial but also the temporal aspects of UAVs movement. Compared with previous formulation of the multi-UAV cooperative reconnaissance problem, the MOCRP model considers more reconnaissance mission characteristics, and more suitable for real-world applications.

3 CR-MOGA for MOCRP

MOCRP is a typical multi-objective optimization problem(MOP). The optimal solutions to MOP are non-dominated solutions known as *Pareto optimal* solutions. For the given MOCRP problem, two objective vectors $\boldsymbol{u} = (u_1, u_2)$ and $\boldsymbol{v} = (v_1, v_2)$, $\boldsymbol{u}$ is said to dominate $\boldsymbol{v}$ if and only if $\forall i \in \{1, 2\} : u_i \leq v_i \wedge \exists j \in \{1, 2\} : u_j < v_j$, denoted as $\boldsymbol{u} \prec \boldsymbol{v}$. A solution $\boldsymbol{x}$ is said to dominate solution $\boldsymbol{y}$ iff $\boldsymbol{f}(\boldsymbol{x}) \prec \boldsymbol{f}(\boldsymbol{y})$. $\boldsymbol{x_0}$ is Pareto optimal if there is no other solution in the search space that dominates $\boldsymbol{x_0}$. The set of all Pareto optimal solutions is called as *Pareto Optimal set*.

Multi-objective Genetic Algorithm(MOGA) has been increasingly investigated to solve MOP[4][5]. This section presents a MOGA based approach CR-MOGA to find the approximate Pareto set of MOCRP.

3.1 Chromosome Representation

In CR-MOGA, a chromosome is given by an integer string. A chromosome consists of N_V sequences and is represented as $S = \{s_1, s_2, ..., s_{Nv}\}$, where sequence s_i is the reconnaissance targets sequence for UAVs in V^i. Each sequence s_i is represented as $s_i = \{s_1^i, ..., s_n^i\}$, where subsequence s_p^i is the reconnaissance targets sequence for UAV v_p^i and n is the number of UAVs employed in V^i.

To ensure the reconnaissance resolution constraints are satisfied, we cluster all targets in T_0 according to their reconnaissance resolution demands. For target $t \in T_0$, if $r_j < R_t < r_{j+1}$, then $t \in C_j$, $j \in \{1, ..., N_V\}$, which means that UAVs in set $V^1, ..., V^j$ can satisfy the reconnaissance resolution demand of target t, while UAVs in set $V^{j+1}, ..., V^{N_V}$ can not. Then all targets in C_j could appear in one of the sequences in $\{s_i | i \leq j\}$ and could not be in any of the sequences in $\{s_i | i > j\}$. Thus the solution that the chromosome encodes can satisfy the reconnaissance resolution constraints.

3.2 Creation of Initial Population

All completely random generated initial population may be largely infeasible, hence takes a long time to convergence. Therefore, we present an heuristic construction algorithm(HCA) firstly to construct initial feasible solutions. Fig.1 illustrates the details of HCA. Repeat running HCA will generate different feasible solutions for the randomness in step(4).

Cs_k in step(1) is used to store targets that will be reconnoitered by UAVs in V^k. A target t in C_k is added to Cs_i randomly chosen from $\{Cs_1, ..., Cs_k\}$, which ensures that the reconnaissance resolution constraints are met. Steps(6-14) describe how to insert all targets in Cs_k to sequence s_k which is initially null. The cost for inserting a target t as the first target to a new subsequence is:

$$Cost1(t) = -\alpha t_{0t} + \beta l_t \tag{12}$$

The first target in a new subsequence is $t^* = \arg\min Cost1(t)$. Once the first target t^* is selected for the current subsequence, the algorithm selects from the

Algorithm 1. *Heuristic Construction Algorithm*(HCA)
(1) Set all Cs_i=NULL, $i = 1, ..., N_V$
(2) $k = 1$
(3) If C_k=NULL, go to step(6)
(4) For a target t in C_k,
Randomly choose $i \in \{1, ..., k\}$, add t into Cs_i.
Delete t from C_k. Go to Step(3)
(5) $k = k + 1$. If $k \leq N_V$, go to step (3).
(6) Set all sequences s_i=NULL, $i = \{1, ..., N_V\}$
(7) $k = 1$
(8) $r = 1$
(9) s_r^k=NULL
(10)Select the target $t^* = \arg\min_{t \in Cs_k} Cost1(t)$ as in Eq.(12).
Set $s_r^k = (0, t^*, 0)$, delete target t^* from Cs_k.
(11)If Cs_k= NULL, $k = k + 1$, go to step(13).
(12)For a target t in Cs_k,
Select p^* and $q*$ as in Eq.(13), and check the feasibilities.
If all the constraints are satisfied
Insert t between p^* and q^*. Delete target t from Cs_k. Go to step (11).
Else $r = r + 1$, go to step (10)
(13) If $k > N_V$, go to step (14), else go to step (8).
(14) Output $S = \{s_1, s_2, ..., s_{N_V}\}$. Stop HCS.

Fig. 1. Heuristic Construction Algorithm

rest targets the target t which minimizes the total insertion cost between every two adjacent targets p and q in the current subsequence s_r^k without violating all the constraints. The cost of inserting t between p and q in subsequence s_r^k is:

$$Cost2(t, p, q) = \alpha D + \beta W + \gamma O + \eta T \tag{13}$$

Where, $D = \sum_{(i,j) \in \tilde{s}_r^k} d_{ij}$ is the total distance travelled by UAV v_r^k.
$W = \sum_{(i,j) \in \tilde{s}_r^k} (T_i + s_i^k + t_{ij}^k + w_j)$ is the total consumed time of UAV v_r^k.
$O = \sum_{(i,j) \in \tilde{s}_r^k} \max\{0, (T_i + s_i^k + t_{ij}^k - l_j)\}$ is the penalty for tardiness.
$T = \max\{0, W - TL_k\}$ is the penalty for exceeding the maximum travel time.
Here, $\tilde{s}_r^k$ is the subsequence after t is inserted between p and q.

The target t is inserted to the least cost position between (p^*, q^*) if $\tilde{s}_r^k$ is feasible, then steps(11) and (12) are repeated until no more target can be inserted. At this stage, a new subsequence is created and steps(10-12) are repeated until all targets in Cs_k are inserted to sequence s_k.

3.3 Pareto Dominance Based Tournament Selection with Elitism

To find the approximate Pareto set of the problem and avoid bias to any objective, we introduce a Pareto dominance based tournament selection strategy with elitism to generate a new population. Two individuals are randomly selected from the population. Firstly, the feasibilities of the two individuals are checked according to the constraints defined in equations (7)-(10). If the two individuals are all infeasible, one is randomly chosen to be the parent. If only one of the two individuals is feasible, the feasible one is chosen. If the two individuals are all feasible, the objectives of the individuals are computed according to equations(2)-(4). Based on the vector objectives, the non-dominated individual is to be the parent. If none of the two individuals dominate the other, one is randomly chosen.

Elitism mechanism is introduced to avoid losing non-dominated solutions during the optimization process due to random effects. we adopt archiving strategies[5] to CR-MOGA. A secondary population archive is maintained during the evolutionary process. At each generation, an individual in the current population can be copied to archive if and only if that it is non-dominated in the current population and is not dominated by any individual in the archive.

3.4 Evolutionary Operators

Crossover. According to the special chromosome representation described above, we introduce a novel problem specific crossover operator in CR-MOGA. Given two parents, $P1 = \{s1_1, ..., s1_{Nv}\}$ and $P2 = \{s2_1, ..., s2_{Nv}\}$, a random integer p between 1 and N_V is generated. The sequences $s1_p$ and $s2_p$ are exchanged, which results in $C1 = \{s1_1, ..., s2_p, ..., s1_{Nv}\}$ and $C2 = \{s2_1, ..., s1_p, ..., s2_{Nv}\}$. Then the repeated targets are deleted from them. Since each chromosome should contain all the target numbers, the next step is to locate the best possible locations for the missing targets. For a missing target t belonging to C_{pt} to be inserted into a chromosome C=$\{s_1, ..., s_{Nv}\}$, the sequences set that t can be inserted to is $s(t) = \{s_i | i \leq pt \wedge i \neq p\}$. Then t is inserted to the sequence $s_k = \arg\min_{s_k \in s(t)}(\min_{p,q \in s_k} Cost2(t, p, q))$. The crossover operator ensures the feasibilities of the children.

Mutation. Mutation aids CR-MOGA to break away from fixation at any given point in the search space. While using mutation it may be better to introduce the smaller destruction on the good schemas, especially in the MOCRP since the reconnaissance resolution constraints and time windows can easily be violated. A problem specific mutation operator is proposed in CR-MOGA. A randomly selected target t belonging to sequence s_i is inserted to a sequence s_k selected randomly from $\{s_1, ..., s_{i-1}\}$. Then t is deleted from sequence s_i. This mutation operator ensures that the mutated chromosome will still satisfy the reconnaissance resolution constraints and time feasibilities.

4 Simulation Results

we carry out simulation experiments to verify the model and algorithm presented. In our experiments, 3 different kind of UAVs are employed in conducting reconnaissance on 100 targets. The reconnaissance resolutions of the 3 kinds

UAVs are $r = 1m, 5m, 10m$, and the costs of employ one UAV are $c = 100, 10, 1$ respectively. The locations and time windows of 100 targets are the same with those of the customers in the Solomon's instances for Vehicle Routing Problems with Time Window [6]. The reconnaissance resolution demands of the targets and reconnaissance time are generated randomly.

4.1 Good Convergence Trace

Firstly, we compare CR-MOGA with single objective based methods. The two compared methods with similar settings of CR-MOGA but different optimization criteria. One only considers the optimization of cooperative reconnaissance cost(CRC), the other only considers the optimization of UAV employing cost(UEC). Fig.2 shows the convergence trace of the smallest CRC at each generation along the evolution for the CR-MOGA and two single objective based methods. From the results in the figure, we can see that CR-MOGA outperforms both of the two single objective based methods. This superiority mainly derives from the Pareto dominance based selection during the evolutionary process.

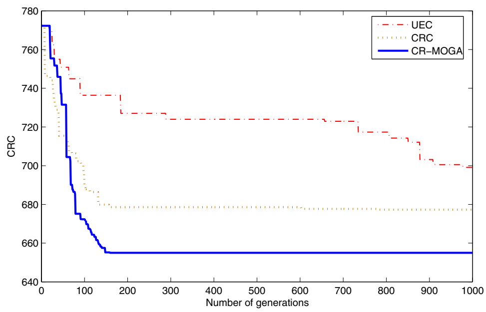

Fig. 2. Convergence trace for CR-MOGA, CRC and UEC

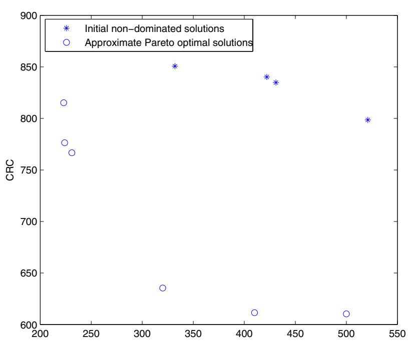

Fig. 3. Approximate Pareto optimal solutions

4.2 Good Multi-objective Optimization Effort

The major character of CR-MOGA is that it tries to find the approximate Pareto set of the problem instead of a single optimal solution. Fig.3 shows the final approximate Pareto solutions find by CR-MOGA compared with the non-dominated solutions in the initial population generated by HCA. From the results we can see that, CR-MOGA explores more search space and optimizes the two objectives greatly.

5 Conclusions

This paper presents a multiple objective optimization mathematical formulation for Multiple UAVs cooperative reconnaissance problem. The proposed MOCRP model takes the reconnaissance resolution demands of the targets and time window constraints into account. Compared with the previous models formulated for the problem, the presented MOCRP model is more suitable for applications. A Pareto dominance based multi-objective genetic algorithm CR-MOGA is presented to solve the special NP-hard problem. The efficiency of CR-MOGA is verified by simulations. Experiment results show that CR-MOGA has good convergence trace in both of the two objectives and outperforms the algorithms with single objective optimization criteria.

References

1. Ryan,Joel L., Bailey,T.G., Moore,J.T., and Carlton, W.B.: Reactive Tabu Search in Unmanned Aerial Reconnaissance Simulations. Winter Simulation Conference, Washington D.C. (1998) 873-879
2. Hutchison,M.G.: A Method for Estimating Range Requirements of Tactical Reconnaissance UAVs. AIAA's 1st Technical Conference and Workshop on Unmanned Aerospace Vehicles, Virginia, (2002) 120-124
3. Ousingsawat,J., and Campbell,M.E.: Establishing Trajectories for Multi-Vehicle Reconnaissance. AIAA Guidance, Navigation, and Control Conference and Exhibit, Providence, Rhode Island (2004) 1-12
4. Van Veldhuizen, D.A., Lamont,G.B.: Multiobjective Evolutionary Algorithms: Analyzing the State-of-the-Art. Evolutionary Computation, Vol.8, No.2 (2000) 125-147
5. Zitzler,E., Laumanns,M., Bleuler,S.: A Tutorial on Evolutionary Multiobjective Optimization, Metaheuristics for Multiobjective Optimisation. Vol.535 (2004) 3-37
6. Solomon, M.M.: Algorithms for Vehicle Routing and Scheduling Problems with Time Window Constraints. Operations Research. Vol.35, No.2 (1987) 254-265

A New Migration Algorithm of Mobile Agent Based on Ant Colony Algorithm in P2P Network

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Abstract. This paper presents our recent research work on Peer to Peer distributed information sharing based on mobile agent. From various perspectives, our work focuses on how to improve information retrieval efficiency in a P2P distributed information sharing system. A new model based on mobile agent is proposed and the new migration algorithm of mobile agent based on ant colony algorithm (ACA) is presented to implement P2P information retrieval. In order to evaluate and validate the model, we built a simulated P2P prototype consisting of a network of peer nodes; mobile agent migrating in the network, making peer nodes communication with each other. The results show some advantages of the proposed approach for the P2P distributed information sharing based on mobile agent.

1 Introduction

With the dramatic increase of services and information on the Internet, an effective technology is demanded for retrieving useful information from huge distributed data sources. The traditional information retrieval technology is based on client/server model, in which all the information is stored in central servers. But in fact, the information is almost in distributed environment, such as Internet or Intranet. In this case, every user can have the information in his computer. So, it is very convenient to construct the platform based on peer to peer(P2P) to share the information between two users.

P2P technology has recently received a lot of attentions, and many P2P platforms have been built for file sharing, distributed computing and storage, search engineering, collaborative working, etc. Different from the traditional client-sever structure, P2P networks are more scalable, cost-effective and fault-tolerant. Existing P2P searching systems are usually based on the following techniques: Centralized indexing[1], Flooding[2], Distributed Hash Table[3,4], Semantic routing[5].

Unfortunately, the P2P systems mentioned above are considered inefficient, although they have gained much success. At first, they don't pay enough attention to peers' interests or even completely ignore, which means peers cannot recommend information to others, even though they have known others' needs by the retrieval history. Then, it generates a significant amount of unnecessary traffic due to little utilization of the retrieval data. As a new paradigm, mobile agent technology is

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 107 – 114, 2006.

expected to reduce network traffic and to enhance efficiency of information retrieval by moving code to remote data centers, filtering them locally in parallel, and returning with a comparatively small result.

In this paper, we present a new approach to mobile agent based P2P information retrieval, using ant colony algorithm and information recommendation services to improve the search efficiency. Ant colony algorithm could help mobile agent make migrating decisions, and information recommendation services could raise the file-sharing level. The remainder of this paper is organized as follows. In Section 2, we introduce the related work. The details of a new migration algorithm based on ACA are presented in Section 3. In Section 4, we describe the simulating results.

2 Related Work

2.1 Problem Description

An important problem about mobile agent-based information retrieval in P2P systems is how to effectively transfer agents to remote place. One possible way is to traverse the remote peers one after another. In this scenario, deciding the optimal migration path is reduced to a traveling salesman problem (TSP). But in practice, we cannot assume that every remote peer provides an agent platform. A more practical alternative is to search for an optimal migration tree rooted at the local peer such that the communication cost is minimized while a user-specified limit of task completion time remains unviolated. Each node on the migration tree represents an agent platform that the agent will visit. Each edge corresponds to a transfer of the agent code. The non-leaf nodes are responsible for spawning agent code and transferring the replicas to their children. The agent replica will examine the data in remote peer and return useful results to the users. Unfortunately, it can be proved that the latter scenario is NP-hard. Computing the exact optimal solution is therefore too computationally intensive to be useful in practice.

In this paper, we formulate the migration problem (MP) of mobile agents as an optimization problem, which searches for an optimal migration tree rooted at the client such that the communication cost is minimized while the task completion time is subject to a user-specified limit.

In this paper we attempt to employ Ant Colony Algorithm (ACA) to obtain an optimal or sub-optimal solution for the migration problem (MP) of mobile agents. We develop a new ACA, and a series of simulations are performed to test the effectiveness and the efficiency of the algorithm.

2.2 Ant Colony Algorithm

In nature ants are seen creating “highways” to and from their food, often using the shortest route. They are able to find the best path between food and their nest by a chemical substance called pheromone. Ants leave pheromone on their trails while moving, and they are able to detect the pheromone concentration. If a path has more pheromone on it, then it will attract more ants, and furthermore, the pheromone will be reinforced. If no pheromone is detected, ants move randomly. Thus, if an ant finds a good path from food to its nest, other ants will eventually follow the path.

Inspired by real ants, Dorigo M. et al [6-8] proposed the *ant colony algorithm* (ACA) to solve traveling salesman problem. In this algorithm, artificial ants move from one place to another according to a particular rule. At the moment t, an ant k transfers from position i to j by the probabilistic formula:

$$P_{ij}^{k} = \begin{cases} \dfrac{\tau_{ij}^{\alpha}(t)\eta_{ij}^{\beta}(t)}{\sum_{s\in allowed_k} \tau_{is}^{\alpha}(t)\eta_{is}^{\beta}(t)}, & j \in allowed_k \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

where $\tau_{ij}(t)$ is the pheromone trail associated with the path from i to j, $\eta_{ij}(t)$ is a heuristic function, $allowed_k$ is a list of positions where k can visit next. α, β reflect the importance of pheromones and heuristic functions.

Each old pheromone decays with time, whereas new pheromone will be laid down. Then, after n periods pheromones are updated by the following rules:

$$\tau_{ij}(t+n)=\rho\cdot\tau_{ij}(t)+\Delta\tau_{ij},\ \rho\in(0,1)\ , \tag{2}$$

$$\Delta\tau_{ij} = \sum_{k=1}^{m} \Delta\tau_{ij}^{k}\ , \tag{3}$$

where (1- ρ) is the evaporation of the trail, and $\Delta\tau_{ij}$ is the increment of pheromone. Dorigo M. had ever proposed 3 models to compute $\Delta\tau_{ij}^{k}$ [8], which are omitted here.

Recent research on ACA shows, ACA is capable of finding good solutions of combinatorial optimization problems. Its major disadvantage is the overlong computing time and premature stagnation. Many researchers have presented improvements to the point, some of which improve the pheromone trails, e.g. MAX_MIN ant system (MMAS) presented by Stutzled T. [9] offers a more direct control over the trails strength by additional trail limits. Another improved algorithm is presented by Huang GR et al [10] based on pheromone diffusion, which makes pheromones not only left on paths that ants have passed but also diffused to paths nearby.

3 Mobile Agent Based Information Retrieval

As mentioned above, one of the most popular P2P applications is the file-sharing system. In such a network, how to retrieve information is very important. ACA provides new ideas for P2P information retrieval like Gnutant. Here we present another approach to P2P search based on ACA.

3.1 Peer Node

Different from other P2P file-sharing systems, peers in our system can not only response local or remote requests, but also recommend information to other peers using retrieval records to predict their interests. Figure 1 illustrates the architecture of a peer node that is composed of the following modules:

- User interface. Responsibilities include: receiving local requests, setting parameters according to user's needs like keywords weight, maximal number of results, etc., and transmitting requests to the request process module.

- Request process module. Responsibilities include: scheduling local and remote requests, submitting current request to the information retrieval module, and making routing decision.
- Information retrieval module. Responsibilities include: checking local files for requests, filtering retrieval history to help request process module make routing decision, and ranking results.
- Recommender. Recommending local resources to other peers according to history records.
- Dictionary manager. Managing the local file index and retrieval records. The file index contains file names, file types, keywords, weights, etc. Retrieval records are updated using some certain policy, e.g. *first-in first-out* (FIFO) or *least-recently-used* (LRU) strategy.
- Shared files. Storing the local shared files.
- History records. Storing information like keywords, time and directions of requests, retrieval results, and recommendations sent and received by the local peer. The purpose of keeping requests from other peers is to help the local peer predict other peers' interests and recommend information accordingly.

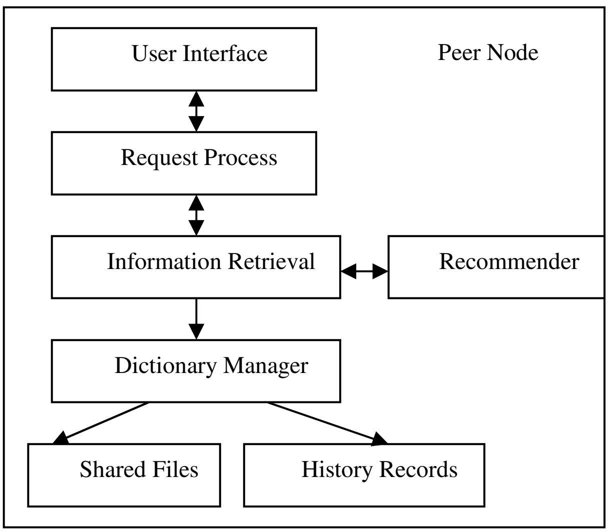

Fig. 1. Peer Node

3.2 P2P Search Based on ACA

After receiving a user query, a peer needs to not only find out local eligible files, but also search remote resources in the P2P network according to the retrieval history.

For semantic reasons, we use the vector space model (VSM) to describe documents and queries, which is also convenient for ranking results. A document d can be described as: ($w_{1,d}$, $w_{2,d}$,… $w_{t,d}$), where $w_{i,d}$ means how important the keyword key_i is to d. In the same way, a query q can be described as: ($w_{1,q}$, $w_{2,q}$,… $w_{t,q}$), where $w_{i,q}$ means how important the keyword key_i is to q. Whether a document satisfies a query is decided by the cosine similarity between the two:

$$\mathrm{sim}(d,q)=\frac{\sum_{i=1}^{t} w_{i,d}\bullet w_{i,q}}{\sqrt{\sum_{i=1}^{t} w_{i,d}^{2}}\bullet\sqrt{\sum_{i=1}^{t} w_{i,q}^{2}}}\ . \tag{4}$$

If sim(d, q) is higher than the presented threshold, then we say d satisfy q.

When searching in the network, routing decisions are made using ACA, and the retrieval history performs a function of pheromone. Peers probabilistically decide where to deliver a query by analyzing history records, which makes search directions tend to peers interested in the query. In our system, $\tau_{ij}(t)$ and $\eta_{ij}(t)$ are computed using the following formulas:

$$\tau_{ij}(t)=\mathrm{Result}_{ij}(q)+\mathrm{Ad}_{ij}(q)\,, \tag{5}$$

$$\eta_{ij}(t)=\frac{\mathrm{C}}{d_{ij}}\,, \tag{6}$$

where $\tau_{ij}(t)$ is the concentration of routing information similar to q from peer i to peer j, $\eta_{ij}(t)$ is the expectation from peer i to peer j, $\mathrm{Result}_{ij}(q)$ is the number of results of previous queries similar to q during the valid period, $\mathrm{Ad}_{ij}(q)$ is the number of recommendations similar to q, and d_{ij} is the network delay.

3.3 Information Recommendation

Today, recommender systems are deployed on hundreds of E-commerce sites. These recommender systems recommend products to customers to keep their loyalty. Similarly, peers in our system can also recommend their resources to others. If a peer often receives queries on a particular subject from another one, then the former could believe the latter is interested in this subject and recommend the latter similar information that the latter doesn't know. After receiving recommendations, peers may only save these useful recommendations, and discard the rest as garbage. Then, when new queries arrive, peers can query the recommender directly.

The recommendation algorithm is as follows:

Step 1. Select the recommended file. The peer providing recommendation services check its local files periodically. If a new file arrived in the last period, or an existing file was queried frequently, then it can be selected as the candidate

Step 2. Select recommended neighbors. First, filter peers that don't know the recommended file, yet have ever sent queries that contained keywords in the recommended file. Second, compute recommendation expectations on each path using formula 7. Third, select M most interested neighbors.

Step 3. Send the recommendation information to the M neighbors.

We predict whether a peer is interested in a candidate file by computing the similarity between them:

$$\mathrm{sim}(d, p) = \frac{\sum_{i=1}^{t} w_i \bullet m_i}{\sqrt{\sum_{i=1}^{t} w_i^2} \bullet \sqrt{\sum_{i=1}^{t} m_i^2}} , \tag{7}$$

where w_i is the weight of the keyword key_i in the recommended file d, m_i is the number of queries from the neighbor p including key_i.

For we make recommendations according to the retrieval history, these recommendations can be considered as complements of earlier query results. On the other hand, because of the improved calculation of pheromone (routing concentration), our retrieval method can be considered as an application based on an improved ACA.

3.4 Mobile Agent

In above sections, we have described our designing ideas such as what components a peer node has, how to search and recommend in the P2P network, etc. Another key point is how peers communicate with each other. In our simulated system, message transmission is executed by mobile agents. If a peer node wants to send a query or recommend some information to other peers, a mobile agent is generated. A mobile agent carries some necessary information to help them finish their tasks, including: agent generator (peer ID), task (to query, reply or recommend), keywords and weight, TTL parameter and visited list (if the task is query), destination (if the task is to reply or recommend), etc. These mobile agents autonomously travel through the network, collect and return appropriate information, make routing decisions according to their tasks until TTL=0 or terminated by some peer.

4 Experiments

We have made a simulation experiment to compare the retrieval efficiency of two ACA-based search methods, one of which using information recommendation services. Two metrics are used to evaluate experiment results: the recall rate [11], which is the faction of the retrieved files during a search process compared to the total online eligible files due to the dynamic characteristics of P2P network, and the number of hops necessary for the first reply to a successful search request [12].

In our simulated environment, there were 35 independent peers, and each one shared 20 files. A shared file contained at most 3 keywords. The number of all keywords was 15. When making routing decisions or recommendations, a peer would select 5 candidate neighbors (i.e. N=M=5). The TTL parameter was fixed at 5.

Initially, searching and recommending were randomly. After the beginning stage, both the search methods reached a steady retrieval level. The simulation results are shown in Figures 2 and 3. Note the simulation was repeated three times, and both of the metrics were average values sampled every 30 requests.

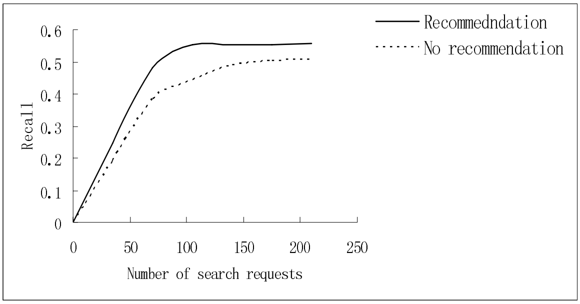

Fig. 2. Recall

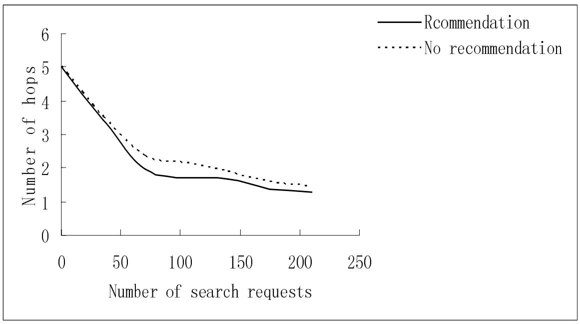

Fig. 3. Number of hops until first reply

One point needs to clarify, advantages of P2P applications based on ACA have been proved by Gnutant to some extent, yet our P2P hybrid information retrieval is much more favorable to P2P file-sharing as it is semantic and positive. From the simulation results, we found the search method using recommendations was able to retrieve resources more precisely and rapidly, since recommendation services helped peers discover where the resources they were interested in timelier.

5 Conclusions

In this paper, we present a new approach to P2P hybrid information retrieval, using ant colony algorithm and recommendation services. Simulation experiments show our search method has good performances on the search success rate and speed. However, because of the small-scale experiment, further researches are demanded on scalability, load balancing, security, etc. In addition, how to make use of more traditional information retrieval techniques into P2P file-sharing systems is another important issue for us.

Acknowledgement

This project is supported by the Natural Science Fund, Science & Technology Project of Fujian Province (Project Number: A0310009, Z0511008, 2001J005), the 985 Innovation Project on Information Technique of Xiamen University(2004-2007), and Academician Fund of Xiamen University, China.

References

1. Napster Home Page. http://www.napster.com
2. G. Kan, Gnutella. In A. Oram, editor, Peer-to-Peer: Harnessing the Benefits of a Disruptive Technology, chapter 8.O'Reilly & Associates, March 2001.
3. S. Ratnasamy, P. Francis, M. Handley, R. Karp, and S. Shenker, A scalable content-addressable network.In ACM SIGCOMM'01, August 2001.
4. F. Dabek et al, Building Peer-to-Peer Systems with Chord, a Distributed Lookup Service. In: Proc. of the 8th Workshop on Hot Topics in Operating Systems (HotOS), Schloss Elmau, Germany, May 2001. IEEE Computer Society.
5. I. Clarke, O. Sandberg, B. Wiley, and TW. Hong, Freenet: A distributed anonymous information storage and retrieval system. In: Faderrath H, ed. Proc. of the ICSI Workshop on Design Issues in Anonymity and Unobservability. Berkeley: Int'l Computer Science Institute, 2000. 43-58.
6. A. Colorni, M. Drigo, and V. Maniezzo, Distributed optimization by ant colonies. In: Proc 1st European Conf Artificial Life. Pans, France, Elsevier, 1991. 134-142.
7. A. Colorni, M. Dorigo, and V. Maniezzo, An investigation of some properties of an ant algorithm. In: Proc. PPSN '92, London, 1992. 509-520.
8. M. Dorigo, and LM. Gambardella, Ant Colony System : A Cooperative Learning Approach to the Traveling Salesman Problem[J]. IEEE Transactions on Evolutionary Computation, 1997, 1 (1), 53 – 66.
9. T. Stutzle, HH. Hoos, MAX-MIN ant system and local search for the traveling salesman problem. In: IEEE Int'l Conf. On Evolutionary Computation. Indianapolis: IEEE Press, 1997. 309-314.
10. GR. Huang, XB. Cao, and XF. Wang, An ANT Colony Optimization Algorithm Based on Pheromone Diffusion. ACTA ELECTRONICA SINICA, 2004, 32(5):865-868.
11. B. Ling, ZG. Lu, Ng Wee-Siong, WN. Qian, and AY. Zhou, PeerIS: A peer-to-peer based information retrieval system. Journal of Software, 2004, 15(9). 1375-1384.
12. O. Babaoglu, H. Meling, and A. Montresor, Anthill: A Framework for the Development of Agent-Based Peer-to-Peer System. In: Proc. 22nd ICDCS '02, Vienna, Austria, July 2002.

Protecting Agent from Attack in Grid Computing

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Abstract. P2P networks provide a basic form of anonymity, and the participating nodes exchange information without knowing who is the original sender. Packets are relayed through the adjacent nodes and do not contain identity information about the sender. Since these packets are passed through a dynamically-formed path and since the final destination is not known until the last time, it is impossible to know who has sent it in the beginning and who will be the final recipient. The anonymity, however, breaks down at download/upload time because the IP address of the host from which the data is downloaded (or to which it is uploaded) can be known to the outside. We propose a technique to provide anonymity for both the client and the server node. A relay node along the path between the client and the server node is selected as an agent node and works as a proxy: the client will see it as the server and the server looks at it as the client, hence protecting the identity of the client and the server from anonymity-breaking attacks.

1 Introduction

The recent P2P retrieval systems can largely be divided into flooding-based and distributed hash table-based models. FreeNet[1] and Gnutella belong to Flooding model and Tapestry[2,3], CAN[4] and Chord[5] to distributed hash table model.

P2P systems are too free and irresponsible to secure reliability as achieved in server-client environment. However it cannot manage the nodes by nature and each node should maintain itself with independent authority that each node must have anonymity. Moreover it must be available for retrieval and must not be excessively expensive(CPU/Bandwidth), and this threshold is different for clients/servers/peers. And Peers are extremely sensitive to bandwidth usage. Hence we propose packet preemptive proxy service techniques that maintain both high speed and anonymity in flooding-based P2P file share systems requiring anonymity.

In a flooding-based model broadcasted retrieval query and ping packet basically provide anonymity but dynamic routing is not implemented so that they do not support anonymity when uploading and downloading. Therefore this may result in unintentional exposure of node information in P2P network in which non-specific majority is participating. Thus attacks, such as denial-of-service and storage overflow, may occur to the exposed node, whether it is malicious or not.

The existing techniques to secure anonymity include MUTE[6], Onion Routing[7,8], Crowds[9] and Mantis[10]. In order for MUTE to protect anonymity, file

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 115 – 122, 2006.

share is made through other clients such as Jondo. However this slows speed in a large capacity file because it transfers file through many nodes. In Mantis, model supplementing this consideration, UDF channel is used without passing through nodes but this requires additional control data communication for UDF channel. Onion Routing uses data encryption to secure anonymity. Client should connect to proxy performing encryption to firstly connect to Onion Routing. Crowds was developed for user privacy while browsing web site and which is similar to MUTE. Client participating in Crowds requests contents not to server but to other client participating in Crowds to get desired contents. Anonymity is guaranteed by this technique.

Our goal is to preserve anonymity and provide retrieval and file share service in a quick and easy way without using additional control data communication for UDP communication and file sending method passing through number of nodes.

2 Related Researches

Techniques to secure anonymity of server and client include MUTE, Onion Routing, Crowds, and Mantis. MUTE does not provide file share service because server is directly connected to client in order to secure anonymity. Passing through many intermediate nodes such as Jondoe it sends data(information/contents). So sending high capacity file such as .avi or .divx will incur sizable waste of bandwidth because it passes through many nodes.

In order to secure anonymous connection Onion Routing uses data encryption to conceal routing header and make statistical computation hard to detect routing path. To make the first connection to Onion Routing, client must make routing path and connect to proxy that encryptizes data. Then client gets to destination following the routing path through Onion routers. Each router releases(removes) encrytized data layers one by one. By repeating this process client knows the next onion router and finally reaches to the final destination. Inversely when getting back it reaches to the final destination by adding encrytized data layer one by one. Although it secures anonymity, it needs proxy between network infrastructure and application and costs a lot for the encryption.

Crowds is developed to protect user's privacy during web browsing. To get contents client participating in Crowds does not directly request contents to server having known the server's address but requests contents to other Jondoes participating in Crowds and anonymity is maintained this way.

Mantis is similar to Crowds but it instantly sends answer without passing through Jondo. Concealing its own IP address, server sends file using UDP but control data communication is necessary to control packet loss aroused in the course of UDP communication between server and client and to control resending. Control data communication is performed by passing through many Jondoes between server and client. Connection among each node is encryptized as Onion Routing.

3 Providing Anonymity

The packet preemptive proxy service model that we propose is based on Gnutella protocol[11]. Packets used here are Query, QueryHit, and Push packets. In this section the basic definition of the proposed model and solution to problems will be covered.

Packet preemptive proxy service model is based on dynamic routing. Using dynamic routing enables to preempt relay node that well understands the relation between server and client and enables the preempted relay node to play proxy role of server and client. In the course of carrying out proxy service, we used Query, QueryHit and PUSH packets which have been used in general flooding based model. The format of each packet is shown on Fig 1. Bold frame indicates packet header.

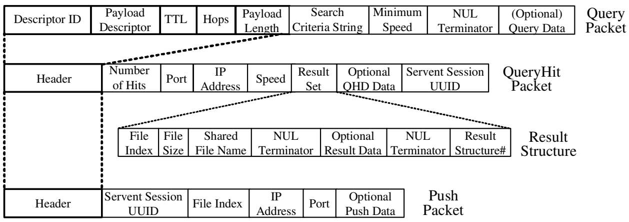

Fig. 1. The Format of Query, QueryHit and PUSH Packets

QueryHit has session UUID value of node which has retrieved contents in QueryHit. Session UUID of node is unique value in P2P network whereas session UUID of Query is original value per retrieval. Using this concept we could make PUSH packet which enables server to send file to relay node.

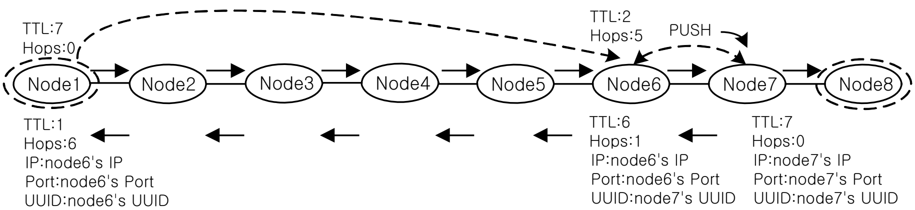

Fig. 2. Contents Download by Switched QueryHit

Assuming that TTL is 7 and overlap sending is not allowed in Fig 2, if node 1 broadcasts Query then it is sent to Node 8 by dynamic routing. QueryHit is sent at Node 7 and Node 6, the first recipient of this packet, replaces IP and Port of this packet into its own IP and Port. Then Node 6 remembers session UUID value of Node 7 to create PUSH packet. The replaced QueryHit is sent to Node 1 by dynamic routing. Since the information of node having retrieved contents is replaced from Node 7 to Node 6, Node 1 requests download to Node 6.

Node 6 that has received HTTP GET request, knows that contents are in Node 7, comparing session UUID value which it remembers with server session UUID value requested by HTTP GET. Node 6 creates PUSH packet and sends it to Node 7. Node 7 has received PUSH packet so that it begins to send file according to Gnutella protocol. Node 6 receives file and simultaneously sends the file to Node 1. Node 1 and

Node 7 are secured with respect to anonymity for Node 6 takes a proxy role between Node 1 and Node 7. If download request is concentrated in a particular relay node, because relay role can be assigned to the neighboring node that it can prevents relay load from concentrating into specific a node.

4 Avoiding Overlapping Preemption

Although there is a preempted relay node which has already been selected double relay node can be selected by overlappingly replacing packet which has been replaced. We solved this problem as described below.

When retrieval is done by Query in Gnutella protocol QueryHit is made. Then TTL value of QueryHit equals to Hops value plus 2 and Hops value equals to 0. And QueryHit's passing through nodes, TTL reduces 1 a time while Hops increases 1 a time. Therefore when nodes receive QueryHit you should replace only QueryHit of which TTL values is over 2 and Hops equals to 0. So if the first node receiving QueryHit replaces packet, the other nodes function as Jondoe without replacing packet. Therefore overlapped preemptive relay node does not exist

5 Case That Server and Relay Node Is in Firewall/NAT Environment

If the IP of QueryHit header is private IP, the concept described in 3 is to be applied, as it is, to the first node receiving QueryHit from server node located in firewall/NAT environment. This is because to receive QueryHit packet means that the server and relay node is connected. Therefore it is solved if the relay node sends PUSH packet to server node. Originally PUSH packet was made to share file with Firewalled Servent

```
If(Is Initial_QueryHit_Packet)
{
   if(Is PrivateIP(MY->IP))
   {
      PONG#1->HostIP=Server->ip
      PONG#1->HostPort=Server->port
      PONG#2->HostIP=Neighbor->ip
      PONG#2->HostPort=Neighbor->port
      send PONG#1,PONG#2 to Neighbor,Server;
      QueryHit_Packet->TTL=QueryHit_Packet->TTL;
      QueryHit_Packet->Hops=0;
      forward QueryHit_Packet to Neighbor peer;
   }
}
```

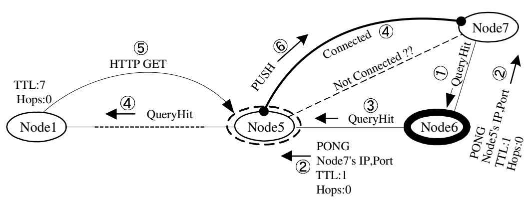

Fig. 3. Algorithms and Process Flow in Case That Relay Node Is in Firewall/NAT Environment

If the first node receiving QueryHit is under firewall/NAT environment, client cannot request service directly to relay node. In this case without replacing QueryHit client sends it to the neighboring node through dynamic routing. So the relay role is to be assigned to the neighboring node. The assigned node conforms to the packet preemptive proxy service techniques we proposed in 3.

Although the assignment is made as shown on Fig 3 if there is no direct connection between the new relay node(node 5) and server(Node 7), how will the PUSH packet be sent to server? To solve this problem the following procedure is to be implemented to firewalled relay node(Node 6).

② Firewalled relay node pretends to receive PING from server and new relay node and send PONG as response value. ③ Then not replacing QueryHit it sends QueryHit to new relay node.

④ New relay node receiving PONG and server try to connect to each other. New relay node replaces packet and sends it to client.

⑤ Client sends HTTP GET to new relay node.

In the long run, Firewalled replay node assigns relay role by not replacing Query-Hit but sending it to the neighboring node

6 Experimentation

To prove the effectiveness of our algorithm, we have built a simulated P2P network with Minism[12]. Minism allows us to generate a random topology for a number of nodes and to simulate packet broadcasting. Things such as what percentage of the original packets reaches the final destination or how many packets are discarded during the propagation can be answered.

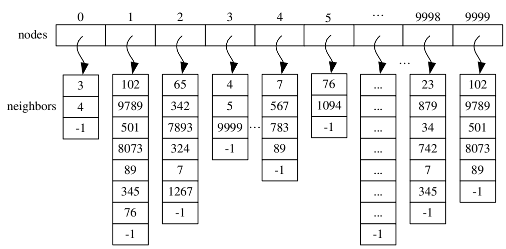

Fig. 4. A P2P network generated by Minism

We have modified the behavior of Minism to implement our algorithm. Especially a routing table is built to trace the movement of QueryHit packet. Fig. 4 and Fig. 5 shows the inner-working of Minism code. Fig. 4 shows a P2P network generated by Minism. The figure shows each node is assigned a number of neighbor nodes: node 0 has neighbors of node 3 and 4; node 1 has neighbors of node 102, 9789, etc. Fig. 5 shows the propagation of Query packet. The "reached" array shows the nodes the Query packet reached at each stage.To implement our algorithm, we have included routing tables that show at each stage which path the Query packet has followed. Fig. 6 shows such tables. At stage 1, the first table shows route(0,3) and route(0,4) has been taken. At stage 2, it shows that route(3,5), route(3,9999), route(4,7), etc. has been taken. The number of nodes participating in P2P network was maximum 10^5, the number of connection maximum 7 and TTL value 5. Network was randomly composed and client broadcasted Query. It was assumed that every node having contents among the nodes receiving Query sends QueryHit and client downloads only one choosing from many QueryHits. Four aspects were evaluated; first, if there is a case that relay node is not preempted or not, second, if double relay node is preempted or not, third, if download requests are concentrated to a certain relay node, and lastly, we evaluated jondo overhead which was chosen as relay node. Fig. 7, 8 shows the average rate of download that did not use relay node among the whole 103 contents downloads. The number of nodes sharing file was set as 10% to 50% of the total nodes and each was evaluated. According to the test result, download without relay node can be made since packet-preemptive proxy service uses TTL and Hops but when the number of node was more than 500 almost every download service was made via relay node. And double preempt was not found.

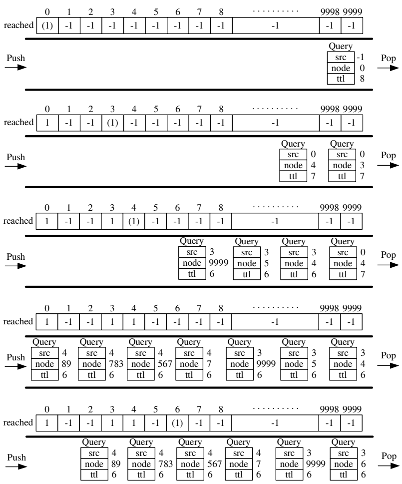

Fig. 5. The propagation of a Query packet

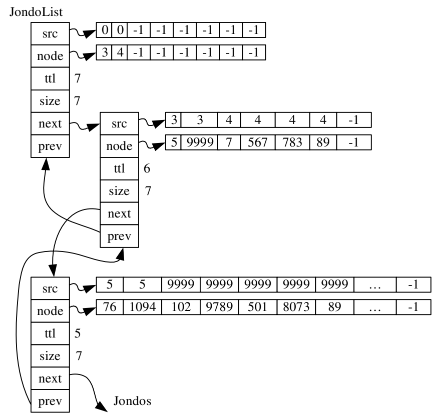

Fig. 6. A routing history table

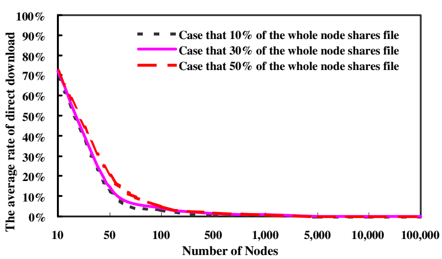

Fig. 7. The average rate of download that did not use relay node

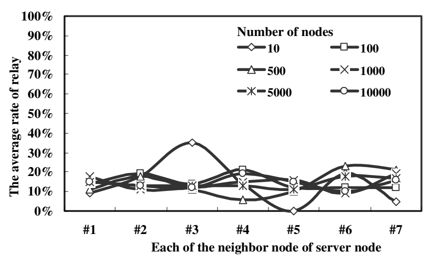

Fig. 8. Rate of relay by 7 neighboring nodes among 103 downloads on specific server

To evaluate whether downloads are concentrated on a specific node it was assumed that retrievable contents are only in specific nodes and simulation was made to find whether there is a case that preemption is excessively made to a specific node among the neighboring nodes. When it was assumed that the most popular contents are only in a specific server, the relay rate of neighboring nodes was evaluated. The test result suggested when the number of nodes was very small the difference was big but in general it displayed uniform distribution. Also it suggested that download relay role was uniformly performed by server's neighboring nodes which may be preempted as relay node.

7 Conclusions

Our aim is to preserve anonymity between server and client without such methods as encryption, control data transfer passing through many jondos for UDP communication and passing through many jondos connected between server and client. The mentioned methods require high cost for encryption or additional control data communication using many jondos for transfer control. Moreover downloading large data aroused heavy network overhead because it passes through many jondos. And download speed will be that of the slowest jondo on the link In order to solve these problems, we proposed and tested packet-preemptive proxy service techniques. Anonymity of server and client was maintained by preempting the first jondo receiving retrieval query response packet as relay jondo. Therefore in the techniques proposed in this paper when sending file it passes through not many jondos but just only one relay jondo. The test results found that complete anonymity was not preserved because occasionally it does not pass through relay jondo in case of very small P2P. Except that, anonymity was fully secured. Therefore if network size is not so small, we evaluate with the proposed techniques anonymity can preserved without encryption technique, UDP communication and file share service technique via many jondos.

References

1. I. Clarke, O. Sandberg, B. Wiley, and T. W. Hong, Freenet: A distributed anonymous information storage and retrieval system, In Workshop on Design Issues in Anonymity and Unobservability, pages 46.66, 2000., http://citeseer.nj.nec.com/clarke00freenet.html.
2. Kirsten Hildrum, John Kubiatowicz, Satish Rao and Ben Y. Zhao, Distributed Object Location in a Dynamic Network, Theory of Computing Systems (2004)
3. Ben Y. Zhao, Ling Huang, Jeremy Stribling, Sean C. Rhea, Anthony D. Joseph, and John Kubiatowicz, Tapestry: A Resilient Global-scale Overlay for Service Deployment, IEEE Journal on Selected Areas in Communications (2004)
4. Sylvia Ratnasamy, Paul Francis, Mark Handley, Richard Karp, Scott Schenker, A scalable content-addressable network, Proceedings of the 2001 conference on Applications, technologies, architectures, and protocols for computer communications table of contents.
5. Ion Stoica, Robert Morris, David Liben-Nowell, David R. Karger, M. Frans Kaashoek, Frank Dabek, Hari Balakrishnan, Chord: a scalable peer-to-peer lookup protocol for internet applications, IEEE/ACM Transactions on Networking (2003)
6. MUTE: Simple, Anonymous File Sharing., http://mute-net.sourceforge.net/
7. Roger Dingledine, Nick Mathewson, Paul Syverson, Tor: The Second-Generation Onion Router, Proceedings of the 13th USENIX Security Symposium (2004)
8. D. Goldschlag, M. Reed, and P. Syverson, Onion routing for anonymous and private Internet connections, Communications of the ACM 42(2), 39-41 (1999).

9. M.K. Reiter and A.D. Rubin, Anonymous web transactions with Crowds, Communications of the ACM 42(2), 32-38 (1999).
10. Stephen C. Bono, Christopher A. Soghoian, Fabian Monrose, Mantis: A Lightweight, Server-Anonymity Preserving, Searchable P2P, Information Security Institute of The Johns Hopkins University, Technical Report TR-2004-01-B-ISI-JHU (2004)
11. The Gnutella Protocol Specification v0.41 Document Revision 1.2., http://rfc-gnutella.sourceforge.net/developer/stable/index.html/
12. Gnutella Developer Forum., http://groups.yahoo.com/group/the_gdf/

An Information Integration Platform for Mobile Computing

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Abstract. An information integration platform is developed to transport messages, files, structural data, semi structural data, and stream media at the same time. The GPS (Global Position System) information of the vehicles can be sent to the control center by wireless communication network such as GPRS (General Packet Radio Service), CDMA (Code Division Multiple Access), Internet and Intranet. The information integration platform control center can then dispatch command and receives information from the mobile terminals. GPS, GPRS, CDMA, Internet, Intranet and M-DMB (Mobile Digital Multimedia Broadcasting) network are all integrated into the platform. Different kinds of data can be sent and received simultaneity. The stream media can replay in time. There are two key technologies in the information integration platform; one is server cluster, other is mobile terminal development.

1 Background

An intelligent traffic system (ITS) has to cope with the computing network and mobile communication networks. Integrated information is the key technology to make Internet, Intranet, WAN (Wide Area Network), LAN (Local Area Network), and M-DMB (Mobile Digital Multimedia Broadcasting) network working harmonically. Because of the demand of transporting massive data in the platform, the bandwidth of the network transmission and the server capability are required more strictly[1][2][3]. The platform is required to meet the rapid increase of the internet clients and server nodes with high dependability, scalability, and other Quality of Service requirements [4][5].

A system structure that focuses on the integration of data and media on the ITS and M-DMB is required to solve the information integration problem. It focuses on the integration of data and media on the ITS and M-MDB, and utilizes the server cluster technology to support the integration platform in order and to keep its high performance. In the following sections, the system structure, the key cluster server technology and the application of the information integration platform will be presented.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 123 – 131, 2006.

2 System Structure of the Information Integration Platform

2.1 The System Structure

The information integration platform consists of the intelligent mobile terminals, software systems, integrated GPS, GPRS (CDMA), Internet (Intranet) and M-DMB networks. See Fig.1 and Fig.2 for more details.

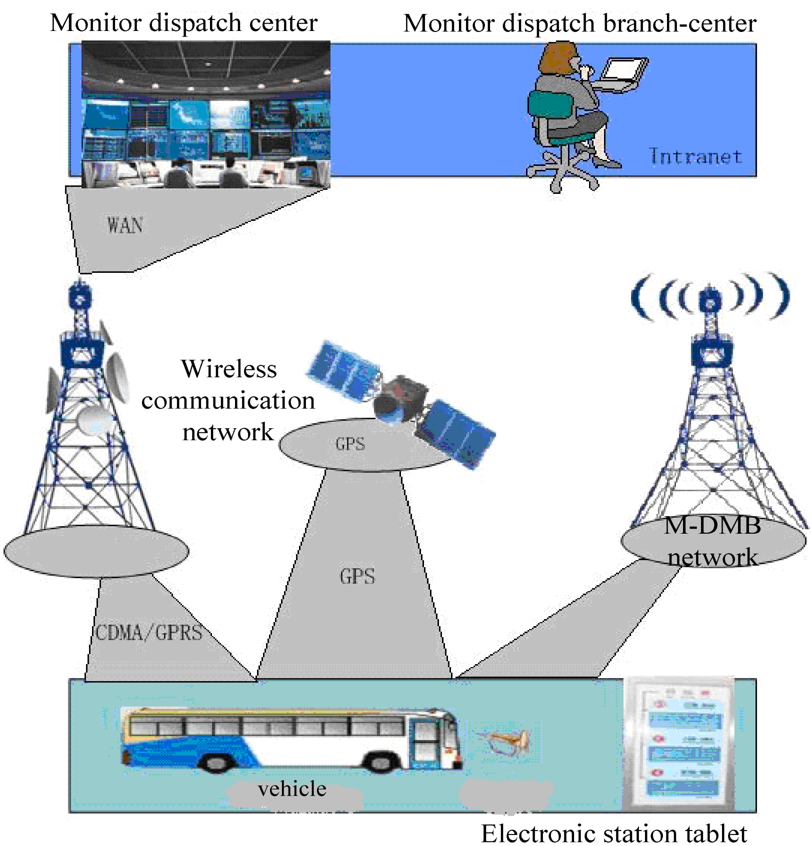

Fig. 1. The information integration platform

In our integration platform, the vehicles' GPS information, driver request messages, and the control center command information are sent by the integrated WAN on GPRS(CDMA) and Internet(Intranet). Different types of information, including messages, data files, stream media, etc can be sent and received freely and safely via public networks. The stream media can be played in real time. The GPS information and driver request are sent from the mobile terminals, and received by the control center in the platform.

The mobile terminals are the interface directly with the users. We have implemented a rich set of functions for them. They have the capability of sending and receiving information in real time. It can convert text to speech, dispatch and manage messages, provide orientation lock and tracking, supports alarm and query, data recording and backup. It is also an auto speech station, wireless transportation and backup device. It integrates the mobile computing, speech recognition, intelligent control, communication, and media streaming.

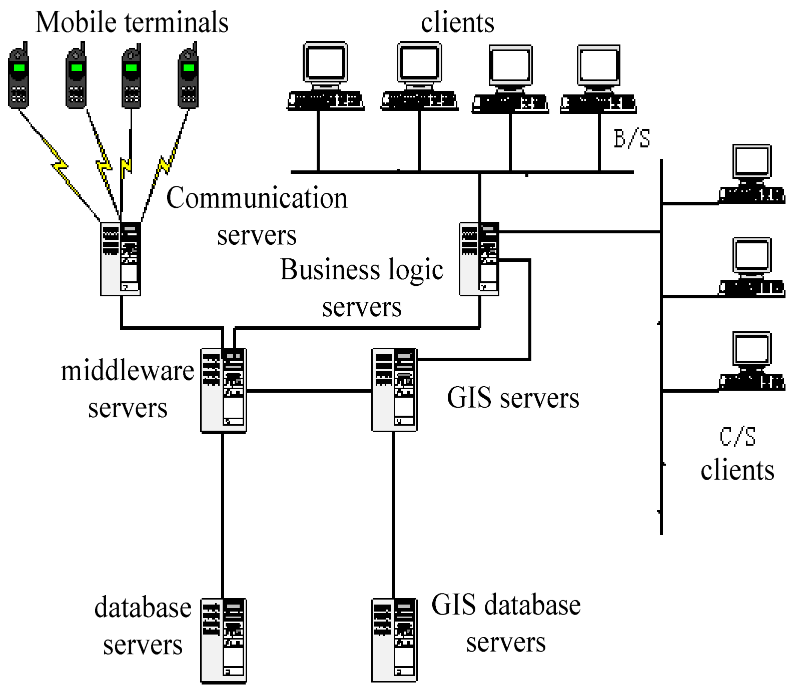

Fig. 2. Structure of the integration platform

2.2 The Platform System Structure

We adopted a multiple layer structure for our information integration platform. The platform is divided into a couple levels: the application level, network level, business logic level and physics memory level. The application level includes the mobile terminals, B/S(Browser/Server structure) clients, C/S (Client/Server structure) clients. B/S client software supports dynamic dispatch, alarm monitor, service, map browsing, query, table and data backup. C/S client software supports map browsing, database management, table print, and so on. The network level comprises wireless communication network, Internet, Intranet, and wireless M-DMB network. The mobile terminals are linked to the wide area communication networks. The B/S clients are connected through Internet and Intranet while the C/S clients are connected to the Intranet. The business logic level includes the platform group wares and middle wares.

The platform software includes the software for communication, application, GIS, Web Server and the interface. The middleware are composed of XML transfer ware, JDBC, and so on. The physical level includes all the databases. The detail can be seen in Fig.3.

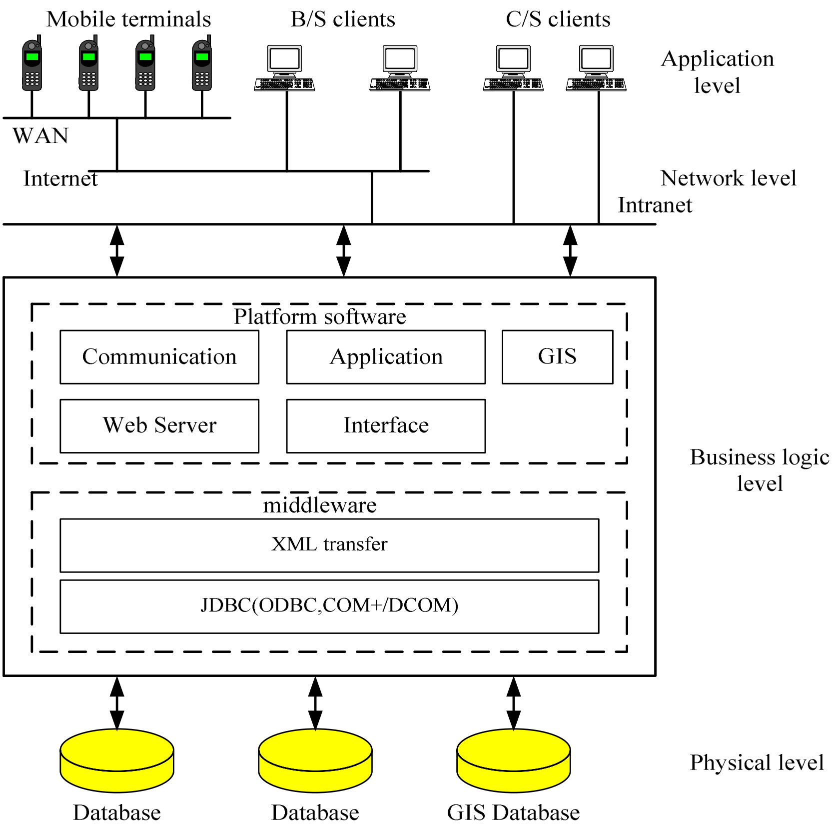

Fig. 3. System structure of the information integration platform

3 Key Technical Issues and Components in the Information Integration Platform

To develop a successful information integration platform, there are some key technical problems we have to face. One of them is to deal with the servers. There are many servers in the platform, including communication servers, middle ware servers, busyness servers, GIS servers, database servers, and GIS spatial database servers. Each server has a branch server cluster. How to use all kinds of server clusters effectively is one of the critical issues in developing the platform.

There are other key issues we had to solve during the development of the information integration platform. The IP load balance and dynamic feedback mechanism of the servers are two of them. They have to solve the following problems:

- To transfer applications into different severs proportionately.
- The servers are hot plug-in. It demands the load balancer to shield the impedimentary servers automatically and adds the new servers into the registration whenever necessary.

The solution we adopted is to make the whole server cluster and the load balancer a high capability virtual server. Its internal construction is transparent to the clients. The following will explain the key elements of the platform.

3.1 The Load Balancer

The balancer, the monitor and the register together form a load balancer as indicated in Fig. 4. The load balancer is responsible for monitoring the load situation of every server and dynamically dispatches to a suitable server for the request task. It provides a server table which contains registered address, the scale weight and the loader of the registered server in the dispatcher. While the balancer receives request from the clients, it will appoint the lightest loaded server to respond to the tasks according to the information and dispatch algorithm in the server table. There are two tasks for the monitor: one is to keep watching the status of each server. If a server fails, it will be removed from the server table to prevent dispatching new task to it. The other task is to collect the load information periodically and to renew the server table in time. The register is in charge of the registration for all the servers. When the register receives a registration request, it will index the information in the server table and finds the

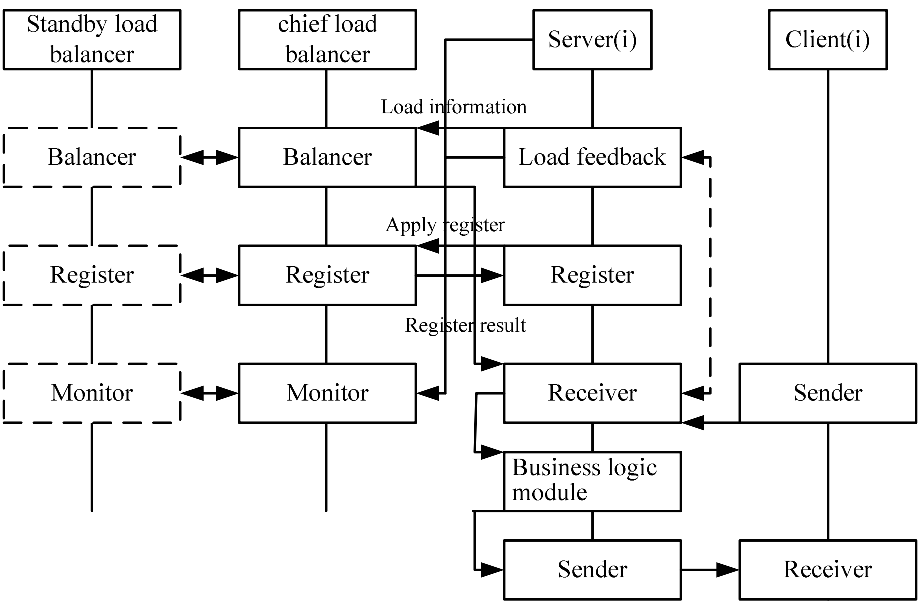

Fig. 4. Components of the load balancer（including the standby balancer）

information in the table. If the server had never been registered before, the new information will be added into the server table.

Serious measure has been taken to assure the security and stability of our information integration platform. In the platform, an auxiliary load balancer is used to insure the safety and stabilization of the whole system. While the master load balancer is running normally, the auxiliary load balancer only receives the request from the clients and backups the server table of the chief load balancer. It does not dispatch anything in the normal case. If the chief load balancer fails, the auxiliary load balancer will begin to dispatch tasks and announce alarm to notice the manager to repair the failure balancer or add a new standby load balancer. That makes the whole system more stability and reliability. The detail relation for the whole cluster system sees Fig.4.

3.2 The Server Cluster

The server cluster is in charge of dealing the client requests and sending response. Each server contains the following components (see Fig.4):

- The receive module. It is responsible for receiving the packed requests from the clients, parsing them and sending the parsed results to the business logic module.
- The business logic module. It is responsible for dealing results from the receive module, including inquiring and retrieving spatial data, operating the geography property database and packaging the data into an XML data stream.
- The send module is responsible for delivering the XML data stream on parsed IP address from the receiver.
- The load feedback module. It records the load condition of its server. After the receive module receives a request task and the send module sends a result XML data stream, all the information will be sent to the load feedback module to renew its load parameters. The feedback of the parameters will then be sent to the balancer.
- The register module is responsible for sending registration request to the load balancer. If the registration is successful, the servers will be initialized, and server table in the load balancer will be updated.

If a server is added into the cluster system, it must register itself first. The register has to execute the registration successfully at the load balancer before the server can be initialized. When the receiver receives requests dispatched from the load balancer, it will send them to the Business Logic model and informs the load feedback module that it has received a new task. The Business logic model will inquire the databases, computes the consequence, and sends it to the client by the sender module. After that the sender will notify the load feedback module that the task has finished. The load feedback module will send back the load information and running condition of the server to the load balancer on time to update the parameters of the server in the server table.

The cluster system is comprised with a communication module, a monitor module, a balancer model, an error handing module, cluster service module, registration module, user right module, XML analysis module, XML synthesize module, etc(see Fig.5).

In Fig.5, there are nine modules in the cluster system. They are communication module, balancer module, cluster service module, user right module, XML synthesize module, monitor module, error handling module, registration module and XML analysis module. The ServerSocketThread.java is used in the communication module to receive the requests from B/S or C/S clients with socket. The CSocketListen.java in

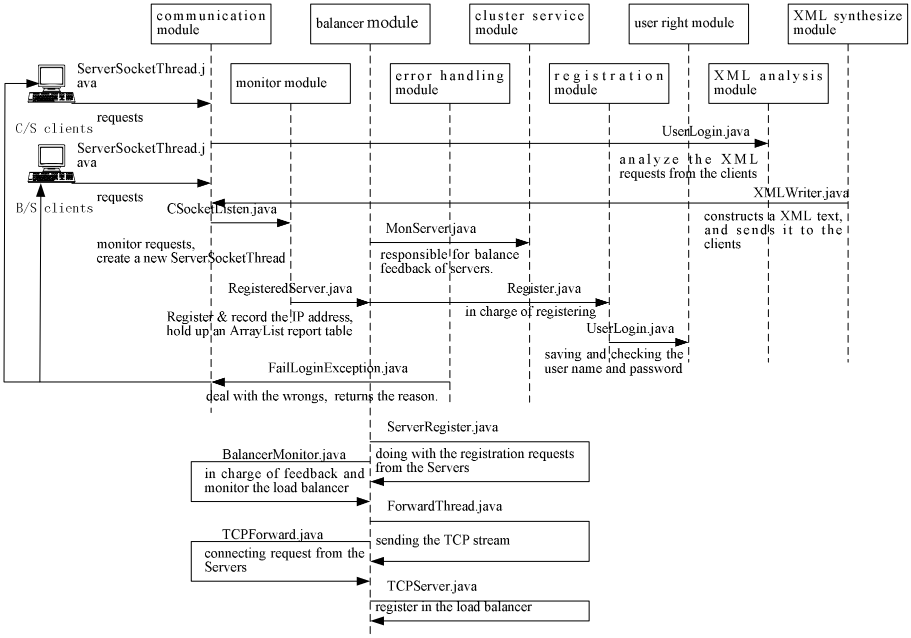

Fig. 5. Modules in the cluster system

the monitor module monitors the requests. It will create a new ServerSocketThread once it receives a request. RegisteredServer.java in the balancer of the cluster server will register the IP address of the servers, and maintain an ArrayList report table. The FailLoginException.java is in charge of handling errors, and will return the cause message of the error. MonServer.java in the cluster service module is responsible for balance feedback of the servers. Register.java in the registration module is in charge of the register for the balancer. The UserLogin.java is in charge of saving and checking the user name and password.

The XML analysis module analyzes the XML requests from the clients and the XML texts. It also constructs the XML text, and sends it to the clients. The Load Balancer is responsible for registration requests from the Servers. IP addresses of the registered severs and the weighting rights are saved. Private Document XMLStreamBuilder(String info, String ip) constructs the XMLStream, if the registration is successful, the message and ip will be sent to the server. There are other tasks preformed in the cluster system such getting feedback and monitoring the load balancer, sending the TCP stream, connecting request from the servers□initializing the TCP connection, and shutting down the TCP connection etc.

4 The Implementation of the Platform

The following will present some implementation results such as the client software interface based on IE browser and a mobile terminal.

4.1 Cluster Server in the Integration Platform

In the integration platform, the cluster server is implemented in each server groups, including the communication servers, business logic servers, Web servers, middle ware servers, GIS servers, database servers and the GIS database server group.

4.2 The Client Software Interface Based on IE Browser

Our client software interface supports the following functions: GPS orientation of the vehicle, the map operations, management and query, replay of track data backup, dispatching and monitor, etc as indicated in Fig.6. The integration platform can support the B/S client software and C/S client software. The B/S client software is developed using JBuilder and Serverlet. The C/S client software is developed using VB.net and Mapx5.0.

4.3 The Mobile Terminal

The mobile terminals are developed using the embedded LINUX system. The GPS, GPRS(CDMA), Internet(Intranet), and M-DMB communication capabilities are all integrated into the terminal (Fig. 7). The terminal has a layered structure. It is divided to the basic hardware level, operation system level, and system application level. The mobile terminals can connect to the integration platform to perform multiple functions such as sending and receiving messages, data files, media, stream, playing MP3 and M-DMB (Fig.8). Many interfaces are provided in the mobile terminal, such as RS232, USB, CAN-Bus, IDE, etc. It supports both local and remote file backup. The graphic user interface is developed in Qt/E-2.3.7.

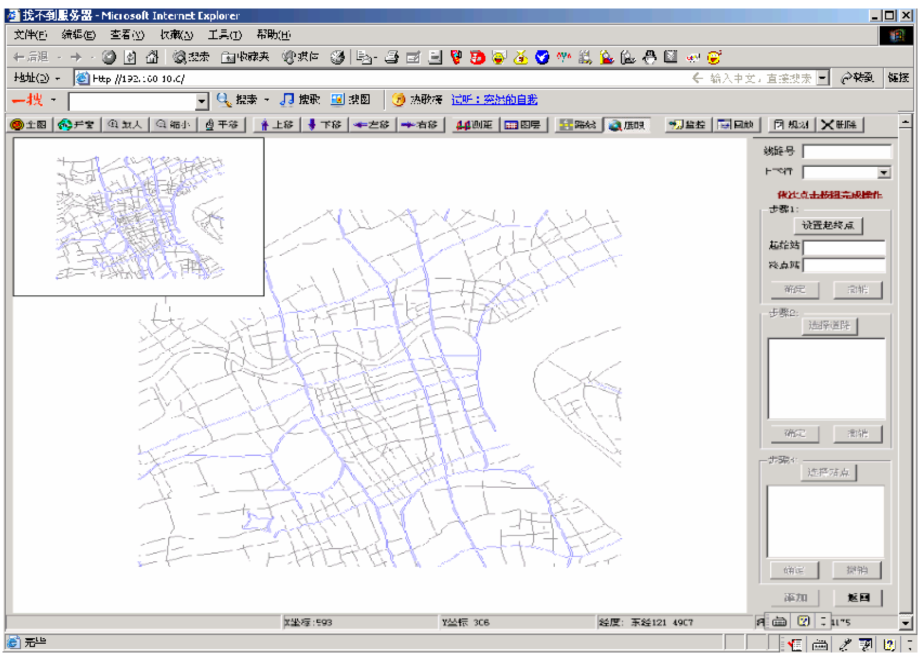

Fig. 6. The client software interface based on IE browser

Fig. 7. Main menu in mobile terminals

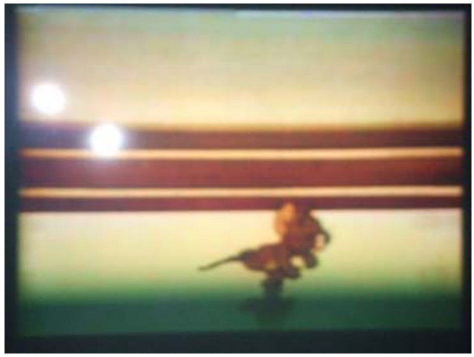

Fig. 8. A mobile terminal playing M-DMB

5 Conclusion

An information integration platform has been successfully developed. It supports the transmission of messages, files, structural data, semi-structural data, and stream media by integrating of GPS, GPRS (CDMA), Internet (Intranet) and M-DMB network communications. Different types of data can be sent and received through the public network. It also supports the stream real time media playing. The components of the platforms include communication servers, business logic servers, Web servers, middle ware servers, GIS servers, database servers and the GIS database servers. The server cluster technology is applied in each server group. The implementation results are satisfactory. Future works include to extend the system dependability, scalability, and other Quality of Service.

Acknowledgments

This work is funded partly by the Young Talent Fund from Shanghai, P. R. China.

References

[1] Mohan C. Application servers: Born-Again TP monitors for the Web. In: SIGMOD, ed. Proceedings of 2001 ACM SIGMOD International Conference on Management of Data. New York: ACM Press, 2001.622.

[2] Object Management Group. The common object request broker: architecture and specification.2.4 ed.,2000.http://www.omg.org/docs/ptc/96-03-04.pdf.

[3] Sun Microsystems Inc. Java remote method invocation specification (RMI). 1998. http://java.sun.com/products/jdk/1.2/docs/guide/rmi/spec/rmi-title.doc.html.

[4] Kindel C, Booch G. Essential COM. 2nd ed., Addison-Wesley, 2001.

[5] Othman O, O'Ryan C, Schmidt DC. An efficient adaptive load balancing service for CORBA.IEEE Distributed Systems Online, 2001, 2 (3).http://www.computer.org/dsonline.

Integration of Collaborative Design and Process Planning for Artificial Bone Scaffold 3D Printer Nozzle

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Abstract. The requirement for high-quality product with reduced cost and time-to-market in multidisciplinary project is demanding. Integration of design and process planning with computer aided techniques can provide a solution to this challenge. This paper describes a reference model of integrating computer aided techniques to aid the concurrent development of a multi-nozzle 3D printer for fabricating artificial bone scaffold at the University of Strathclyde and the Northwestern Polytechnical University. This integration reference model, including design tools such as Material Computation (MC), Computational Fluid Dynamics (CFD), and CAD, and planning tool such as CAM techniques, is employed to support this special 3D printer development. The high precision multi-nozzle development was used as a case study to validate this integration of concurrent design and process planning. CAD tools were used to provide several nozzle design concepts and a rigorous CFD analysis of several nozzle designs under the same boundary conditions were undertaken to refine and evaluate them by research staff from both institutions. This cooperative conceptual design case study demonstrated that it drastically reduced development time and cost in devising nozzle conceptual sketch design and optimizing the nozzle design for 3D printer. This makes it an important step in designing a high precision artificial bone rapid manufacturing machine.

1 Introduction

Concurrent Engineering (CE) is a systematic approach to integrate product development processes that aims to improve the responses to customer expectation [1]. It can provide a collaborative, collective and simultaneous engineering approach during product development process, especially for tissue engineering which requires multi-discipline collaborative effort and needs to satisfy various customers' expectations and technological requirements, including important biocompatible issues. The development of an artificial bone scaffold manufacture machine can provide an opportunity to apply collaborative design and process planning. Erens[2] (1996)

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 132 – 140, 2006.

identified four elementary mechanisms that are used in design: decomposition, allocation, composition, and validation. Development team members should figure out various requirements across multi-disciplines. Modern techniques such as simulation, analysis and Rapid Prototyping have been developed and can be used to support product development. But most techniques need to communicate design data and documents among engineers from different disciplines and regions or countries. An effective collaboration among them is vital to the success. The following describes some basic background information about the subject area.

Extensive experiments showed that the porous structure of Hydroxyapatite (HAP) provides a template for fibrovascular in growth when followed by osteoblast differentiation, resulting in the deposition of new lamellar bone[3]. But it lacks sufficient bioactive substance to support continuous biodegradation of itself and new bone's growth. Researchers have found that Bone Morphogenic Protein (BMP) can induce bone cells to adhere to scaffolds and accomplish its biodegradation and new bone growth[4]. In order to satisfy these requirements, at least 70% porosity and the height of deposit of the internal 3D scaffolds are important aspects with respect to the biocompatibility and bioactivity, promoting the formation of new tissues and the blood vessels[5]. However traditional Rapid Prototyping (RP) technology cannot produce the required microstructure and the level of porosity compound BMP and growth factors skeleton. Because these biomaterials can only maintain bioactive at the human body temperature, Stereolithography, Selective Laser sintering and Fused Deposition Modelling are not suitable to make usable bones as the working temperature is far too high. 3D Printing technology can create parts of any complex geometry using several types of material. Furthermore, it can control efficiently the material composition, microstructure, and surface texture at the ambient temperature. Biomedicine, computer aided design and manufacture techniques are "pushed" and "pulled" each other to improve one special RP machine to compensate above defaults and fulfil above requirements.

Collaborative effort is therefore required to conduct this research project. Its aims in long-term to design and prototype an accurate rapid artificial bone manufacturing machine which satisfies the above requirements. It has been undertaken by two teams distributed in UK and China. Pursuing an integration of collaborative design and process planning, different concept types have been developed. It requires collaboration between scientists and engineers from different discipline background. The concept of an information-oriented integration requires the integration and collaboration of MC, CFD, CAD and CAM systems. Here the ultimate aim is to enable designers and process planners to switch between different aspects of the present jobs and to develop concurrent working patterns, in order to optimise the product and process modelling in terms of cost, time and quality.

In the following, a reference model and the methodology, which support the integration of collaborative design and process planning, are described to provide a better understanding of the approach and illustrate which one is most suitable for the 3D printer developed.

2 Integration of Collaborative Design and Process Planning

In order to realize a collaborative design and process planning[6], a specification of requirements derived from concurrent engineering principles and best practices is essential. There are three key requirements[7] which should be considered. It covers that: previous sequential working procedures need to be broken down and redefined before design and process planning in a collaborative and parallel manner; the establishment of interdisciplinary development team aims at the coordination of decisions in the early stage of product development; an early consideration of a design decision on manufacture can lead to the avoidance of expensive changes during later life-cycle. It is therefore necessary to optimize the design and process planning procedures to enable an integrated method based on above three requirements. 3D printer development project requires the collaboration among engineers from and integration of material, fluid dynamics, mechatronics domains. Here, a nozzle development was a good example to the application of cooperative and integrated design and process planning approach.

2.1 Model to Support an Integration of Collaborative Design and Process Planning

In order to develop the reference model, it is necessary to clarify the types of interdependence existing among the project development process. Erens[2] presented design knowledge decomposition and composition mechanisms which were applied to the product modelling. In fact, design procedure is a mapping process from knowledge to activities. In order to analyze the role of this model in collaborative and integrated design and process planning, the nozzle design, a key component of 3D printer, is explained using the research model in figure 1. Three types of integration have been defined and distinguished, namely a functional domain, a physical domain and a process domain. Each domain has its own product model (see Fig. 1). The

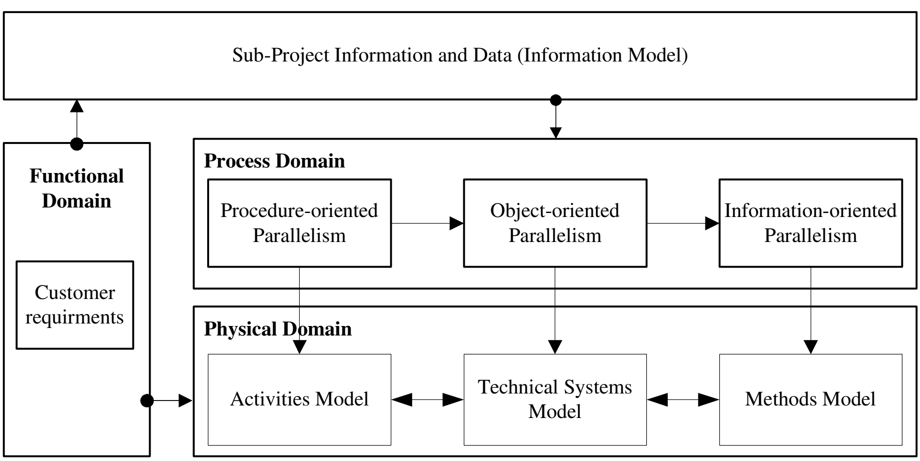

Fig. 1. Reference model for integration of collaborative design and process planning

activities in the functional domain are executed by the customer or market engineers in cooperation with product designers and finally result in the functional requirement baseline.

Nozzle's development process includes three models in physical domain and process domain (the core of the reference model is information model and main technical model, and the activity model that contributes to the framework of reference model with regard to the data). It refers multi-disciplines and research tools, so there is a big and important issue on data exchange and communication among different software tools.

2.2 Methodology for Integration of Collaborative Design and Process Planning

On the basis of the reference model, a method is proposed which describes the application of inter-related partial models. They exchange and communicate data through the information model. Their relationship is a three-stage procedure for developing potentials of integration in design and process planning. Procedure-oriented parallelism, Object-oriented parallelism, and information-oriented parallelism were developed based on Remko's product development process model [2]. The procedure-oriented parallelism is based on activity and information models. Design and process planning procedures are run concurrently by optimizing the flow of information between activities.

Before the procedure-oriented parallelism can be implemented, activities which can be performed simultaneously in the future should be recognized. Primarily in early stages of product development the product itself and possibly individual modules and assemblies can be determined. Thus at these moments only rough planning concerning design objects is possible. When more concrete information is available, the required techniques can be supported during product development, thus facilitating continuous, more precise planning. The information-oriented parallelism, at the start of the development process, is indicated during the product development. They can be selected as required, depending on the application and assuming that the available technical systems and information have been adequately specified. Most of all critical information about the product and the processes can be generated at an early stage by applying these methods.

2.3 Partial Models Integration for Collaborative Reference Model

To explain and clarify the principle of these parallelisms and collaboration during product development, a detailed description of partial models will be described as follows. Extensive literature was reviewed [8] on activities and tasks in design and process planning, in order to establish activity model to ensure suitable efficiency and effectiveness are achieved. Similar to most of research models, here activity model comprises tests in practice, extensive literature research and studies on existing models. Figure 2 illustrates the activity model in details. In fact, activities can be interconnected by means of input and outer information. However, available design information must be on early stage down-stream process planning activities. Similarly, process planning model should be passed to up-stream design activities to facilitate life-cycle oriented decision-making. Thus, it is necessary deploy integrating methods for transmission and feedback of information between physical domain.

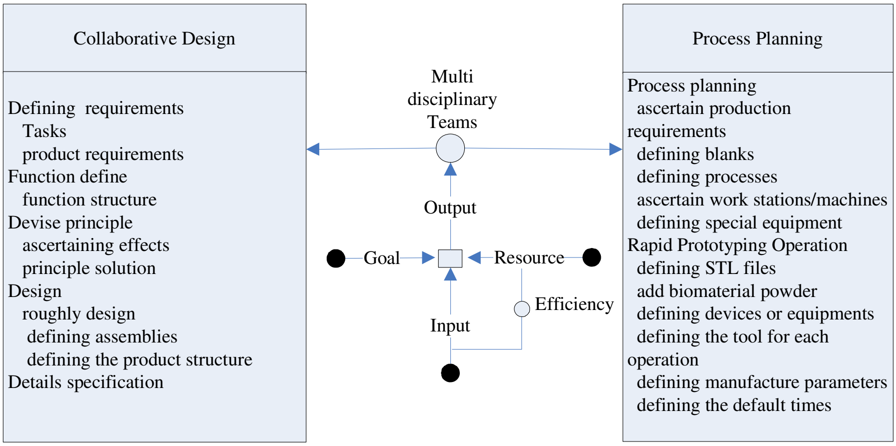

Fig. 2. Efficiency Collaborative Activities model

The technical system model contains the structure of these physical objects within a product (figure 3). All activities in the activity model and all of the information defining products and processes refer at least to one of technical systems.

The information model (figure 4) is, to the extent possible, based on generic resources, application resources and application protocols of the standard for the exchange of Product Model Data. These models are not developed for any specific product development.

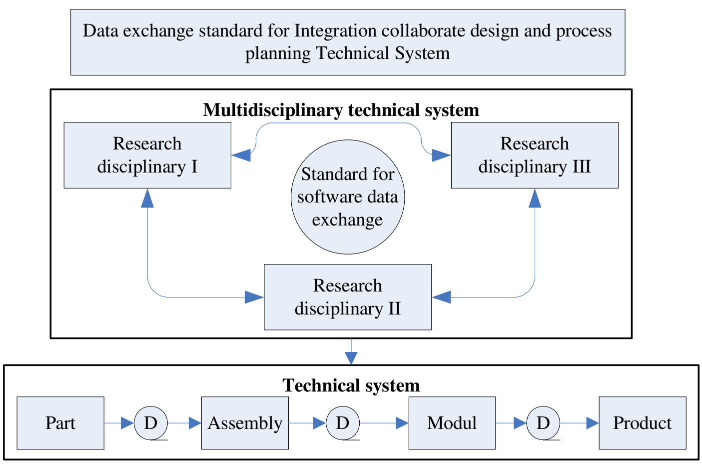

Fig. 3. Technical system model

As for multidisciplinary research, it is complex for different domains using various special tools and software. So at the beginning of project, it is necessary to define above models and clarify the data communication standard or format about different technical tools. A multi nozzle development, the key component of 3D printer fabricating artificial bone research project, is supported by these three models and

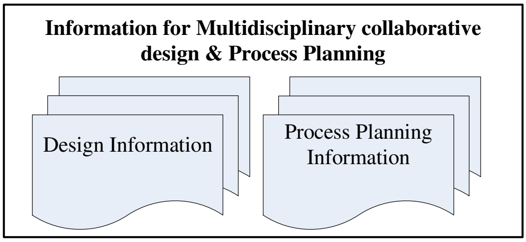

Fig. 4. Multi disciplinary collaborative Information Model

cooperated by specialists in MC, Biomedicine, CAD, CFD, Rapid Prototyping (RP), Product Data Management (PDM), etc.

3 Integration of Collaborative Design and Process for 3D Printer Nozzle Design

Current commercial 3D printer nozzle design did not solve the problem of fabricating HAP scaffold with combining simultaneously BMP and BGF, and no lump will be formed at the tip of a nozzle. Considering biomedical parameters the microstructure of bone porous diameter is from 200 to 500 μm. HAP needs BMP and BGF to handle bone scaffold biodegradation and reconstruction. A new nozzle therefore should be designed to solve these problems. To improve development quality and reduced time-to-market, the integration method of collaborative design and process planning was adopted in multidisciplinary research.

Classical design methodologies, Such as Pahl & Beiz[7] or in the VDI-Guideline 2221[7] provide a systematic and well established approach to design process. These methodologies were analyzed to determine their suitability for distributed design scenarios and recommend for improvement. Two development teams distributed between UK and China have to accomplish these activities using different special tools in CAD, CFD and MC development teams. So corresponding to this activity model, the technical model and initial process plan should be built. Some details about the nozzle design by establishing all collaborative design models as above are discussed below.

3.1 Activity Model for Nozzle Design

For this 3D printer of artificial bone scaffold, the activity model includes design (sketch to computer graphic files), analysis of requirements, detecting overall function structure, general and special function structure, devising the principles, ascertaining effects, compiling documents and so forth. In order to improve development efficiency and effectiveness, at the beginning of development the multidisciplinary teams discussed the goal and then defined function structure including CAD, CFD, and MC, ascertained effects and principle solution, specified the data transfer methods among Pro/E, Fluid, and methyltrichlorosilane (CH_3SiCl_3) thermodynamic evaluation (a MC software deployed by Northwestern Polytechnical University, China) and specified objective of nozzle according to figure 2.

3.2 Nozzle Technical System Model for Nozzle Design

Based on activity model, all concrete software tools had been specified. Through concept sketch design, Pro/E (CAD) was deployed and five concept designs were created shown in figure 5. Fluid 5.5 (CFD) was used to evaluate and re-evaluate pressure, fluid flow & velocity, and turbulence for these conceptual designs. The final suitable nozzle design was then obtained based on the visualization analysis. The same boundary conditions of biomaterial and fabricating process parameters were defined in MC software. According to activity model, the concepts were analyzed to define the purpose and behaviour of this novel nozzle.

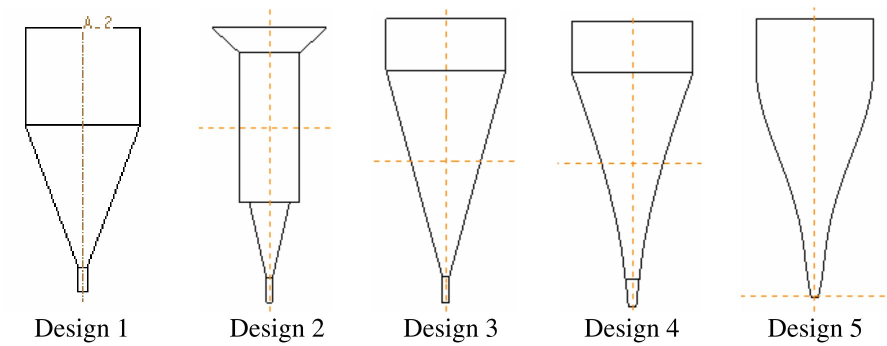

Fig. 5. Five design concepts for a nozzle design

3.3 Process Planning Model for Nozzle Design

In this process planning, it is necessary to ascertaining production requirements, define process and sequence of processes, and ascertainsoftware tools discussed by the activities model. Operations per process should be defined. And then the tool and technological parameters for each operation should also be specified. To satisfy the tasks and product requirements of nozzle activity model and technical system model, it is useful to get the control parameters from analysis.

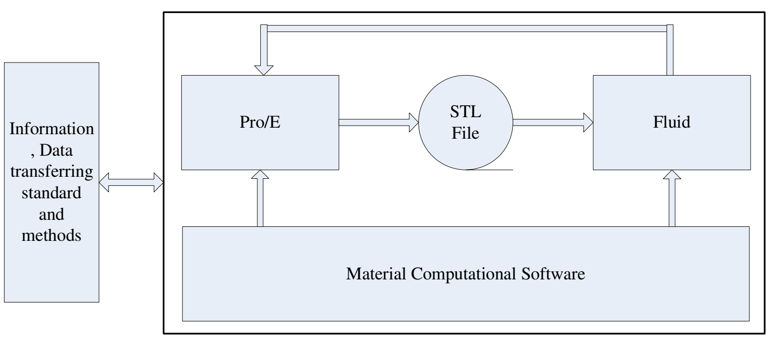

Fig. 6. Methodology for Nozzle collaborative design and process planning

3.4 The Methodology for a Cooperation in Nozzle Design and Process Planning

In this multidisciplinary cooperative project, based on integration design and process planning (as figure 6) the final nozzle design was demonstrated to manufacture the 3D printer for fabricating artificial bone. Its pressure and velocity are stable and high enough to eject fluid uniformly to fabricate 3D scaffolds [9].

4 Conclusion

In this paper, a multi-discipline integration reference model was presented in CE domain. Three partial models namely the activity model, technical system model, and the information model, provided means for helping designers and process planners to improve their multidisciplinary research. It defines the design, along with the required technologies for manufacturing that product. 3D Printer nozzle design, a sub-division project of "3D printer for fabricating artificial bone scaffold", interpreted that activities are carried out simultaneously and performed by interdisciplinary development designers, technology planners and process planners.

Nozzle development demonstrates that integration of multidisciplinary methods, with possibilities for transferring and feeding back information, were deployed to support the main research objectives during process and increase the flexibility. Attempts at integrating design and process planning on the basis of the reference model have been attained. Systematic use of the developed reference model, its partial models, the planning process and execution methods provide a mechanism to exploit existing potential for decreasing development time and costs of new production. The production quality required by the customer is improved by the reshaping of procedures in design and process planning.

Acknowledgments. The authors would like to acknowledge of the support from an Asia-Link project, funded by the European Commission with a contract number: ASI/B7-301/98/679-09 and Doctorate Foundation of Northwestern Polytechnical University (CX200509).

References

1. Mair, R.I., *Advanced composite structures research in Australia.* Composite Structures, (2002) **57**(1-4): 3-10.
2. Helms, R.W., *Product Data Management as enabler for Concurrent Engineering*. Vol. 1. 2002, Edinhoven, Holland: Eindhoven University of Technology.
3. Glowacki, et al., *Biomaterials in cartilage and bone tissue engineering.* Current Opinion in Orthopedics, (2004) **15,** (5): 347-354.
4. Williams, J.M., et al., *Bone tissue engineering using polycaprolactone scaffolds fabricated via selective laser sintering.* Biomaterials, (2005) **26**(23): 4817-4827.
5. Peglow, M., et al., *A new technique to determine rate constants for growth and agglomeration with size- and time-dependent nuclei formation.* Chemical Engineering Science, 2006. **61**(1): 282-292.

6. Marle, F. and J.-C. Bocquet, *A Multi-Project Management Approach for Increased Planning Process*, in *13th International Conference on Engineering Design, ICED 01 Glasgow*. 2001, Professional Engineering Publishing Limited for The Institution of Mechanical Engineers: Glasgow, United Kingdom.
7. Liu.X., *Computer Support for Design Coordination in Concurrent Engineering*, in *Design Manufacturing Engineering Management*. 2001, University of Strathclyde: Glasgow, UK. 69.
8. F.J.O'Donnell and A.H.B.Duffy, *Performance Management ar Design Activity Level*, in *13th International Conference on Engineering Design*. 2001, Professional Engineering Publishing Limited: Glasgow.
9. Y.E.Wang, X.T.Yan, et al., *Optimizing a Nozzle for an Artificial Bone Mechatronic 3-D Printer*, in *MX2006 -- MECHATRONICS 2006 The 10th Mechatronics Forum Biennial International Conference*. 2006: Penn State Great Valley, Philadelphia,USA.

Usability Ranking of Intercity Bus Passenger Seats Using Fuzzy Axiomatic Design Theory

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Abstract. Usability, considering user satisfaction along with the user performance, is one of the key factors in determining the success of a product in today's competitive market. Designing usable intercity bus seats is important for passengers during the long hours of traveling. Comfort, aesthetic, safety, convenience to the body posture, durability, harmoniousness with the seat accessories and operability are expected usability dimensions of seats for both user and the designers. Aim of this study is to identify and rank ten alternative seats of an intercity bus manufacturing company according to these usability attributes. The products are evaluated by five subjects and assessed for each usability attributes by using linguistic variables. Then Fuzzy Axiomatic Design Theory (FADT), which is the combination of second axiom, is used as a multi attribute decision making tool to determine most usable seat design solution. Design range is defined by design engineers and system ranges for seats are obtained from linguistic assessment of five subjects for applying conformance testing in cooperative engineering.

Keywords: Usability, Fuzzy Axiomatic Design, Conformance Testing, Cooperative Engineering.

1 Introduction

Traveling becomes an integral part of human life nowadays. Among the travel options, traveling by bus is preferred commonly as it is economical compared to others. Passengers spend most of their time on seats of bus during the long travel hours. Therefore, seats are an important factor in seating industry to meet customer expectations. Generally the main task of the ergonomic seat design is increasing the seat conformance which is a complex and subjective notation related to a good physical and psychological well being of the interface between the passenger and the seat. Comfort and discomfort, which are not antonymous, are two main elements of seat design. They are related since it is necessary, but not sufficient to be "not uncomfortable" in order for a seat to be comfortable. While comfort is a subjective notation, and is hard to quantify, discomfort is an objective notation and is related to specific methods (e.g. pressure distribution, electromyography or posture analysis). Hence, discomfort is not only a feature of a seat, but also it expresses to what extent the seat is not sufficient [1],[2],[3].

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 141 – 148, 2006.

Therefore evaluation of seat design in literature is mostly related to the discomfort aspect [3],[4],[5],[6],[7]. However, comfort - discomfort related studies are not the only main design factors nowadays. Usability, a holistic view to ergonomic and collaborative product design, is seen as a critical dimension of which importance is increasing swiftly in product design [8],[9]. Usability is defined as effectiveness, efficiency, and satisfaction of a product for achieving specified goals for specified users in a particular environment. Designing usable products is seen a company philosophy for firms in today's competitive business environment [10]. It is an important stage to observe and analyze multi dimensional product usability attributes in product design. Aesthetic, safety, convenience to the body posture, durability, harmoniousness with the seat accessories and operability of seat are also expected features which are important usability factors for bus manufacturers. Manufacturers want to obtain seats from suppliers which satisfy those usability factors.

In this paper it is tried to identify the best seat among ten available alternative seats considering many usability factors for a factory producing passenger buses. Such problems are referred to as multi-attribute decision making problems in concurrent manufacturing. This study uses FADT to solve this multi attribute decision making problem. This paper is organized as follows. In section 2, FADT method is presented briefly. Section 3 discusses the implementation of FADT to cooperative seat usability decision problem, and the study ends in with section 4 with conclusion and discussions.

2 Fuzzy Axiomatic Design for Multi-attribute Decision Making

A key factor in cooperative product design is the optimization of product development decisions such as the costs, the quality and the time required to design a product. These factors are interrelated and an improvement of one factor may result in a decline in the others. Therefore all these issues have to be considered simultaneously to make the product design more successful. Axiomatic Design (*AD*) forms a scientific basis to design and improves designing activities by providing the designer with a theoretical foundation based on logical and traditional thought process and tools. *AD* provides a systematic search process through the design space to minimize the random search process and determine best design solution among many alternatives considering all product development decisions. In the literature, *AD* theory and principles are used to design products, systems, organizations and software [11]. In ergonomics, Helander and Lin (2002) used axiomatic design as a foundation of ergonomic design and demonstrated examples on how axiomatic design can be used for biomechanics design of hand tools and anthropometric design of workplaces [12]. Lo and Helander (2004) proposed axiomatic design as a formal method for usability analysis for consumer products [13]. Karwowski (2005) also emphasized the applicability of axiomatic design for solving complex ergonomics design problems [14].

Design axioms, namely independence axiom and information axiom, are two key stones of *AD*. Independence axiom is related to maintaining the independence of functional requirements (*FR*s), i.e., design solution must be such that each one of *FR*s can be satisfied without affecting the other *FR*s. Therefore, a correct set of design parameters have to be chosen to be able to satisfy the FRs and maintain their independences. Among the design solutions satisfying independence axiom, the design with the smallest information content must be chosen. This is the second axiom, information axiom, of AD. Information content, I, is defined in terms of the probabilities (p_i) of satisfying FR_i below.

$$I_i = \log_2\left(\frac{1}{p_i}\right) = -\log_2 p_i \,. \tag{1}$$

In case of having FRs, information content of overall system,I_{sys}, is defined in formula 2.

$$I_{sys} = \sum_{i=1}^{n} I_i = \sum_{i=1}^{n} \log_2\left(\frac{1}{p_i}\right) = -\sum_{i=1}^{n} \log_2(p_i) \,. \tag{2}$$

Suh (2001) specifies the second axiom as a decision making tool for complex engineering design problems [11]. Design with the smallest "I" is the best design as it requires the least amount of information to achieve design goals. If all probabilities are large enough, near to one, then information content is minimum. Probability of satisfying a FR is specified by design range (tolerance) defined by designer and generating ability of the systems (system range). Fig. 1 illustrates these two ranges graphically. In Fig. 1, overlap between the design range and system range is called common range (cr) and this is the only region where FR is satisfied. Therefore area under common range, A_{cr}, is the design's probability of achieving the specified FRs.

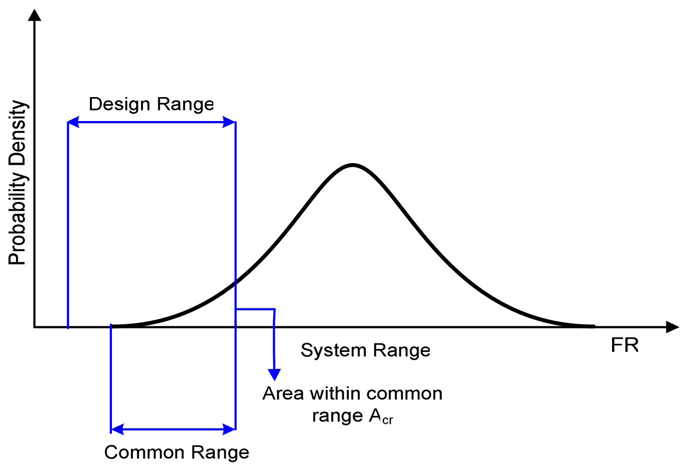

Fig. 1. System range, design range and common range

Many decision making and problem solving tasks are too complicate to be understood quantitatively, however people succeed by using knowledge that is imprecision rather than precise. Fuzzy set theory resembles human reasoning in its use of approximate information and uncertainty to generate decisions. This fact may also be true for engineering decision. System and design ranges may not be defined precisely. If system cannot be defined by using traditional quantitative terms, it is more plausible to use fuzzy linguistic terms. Linguistic terms can be transformed into fuzzy numbers. The fuzzy sets in Fig. 2 are used for converting linguistic terms into fuzzy numbers respectively.

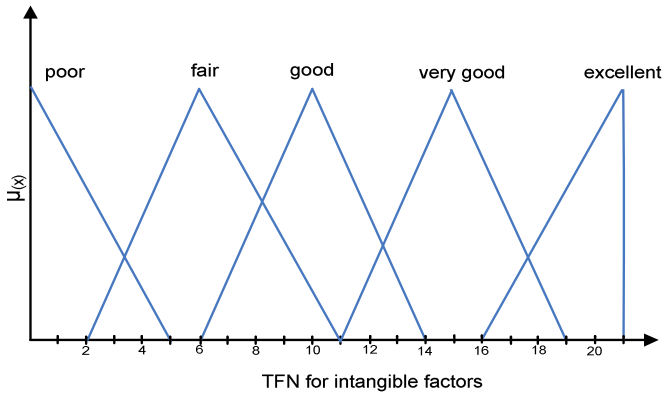

Fig. 2. Fuzzy sets for intangible factors

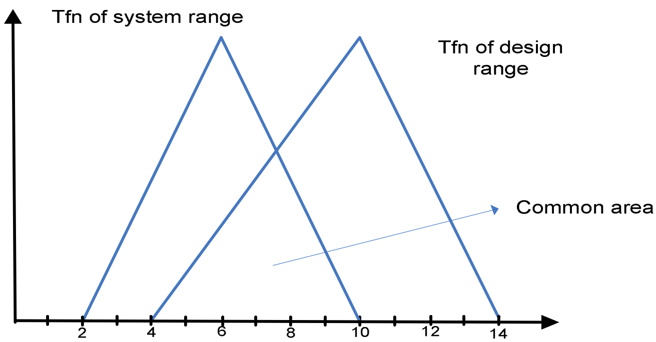

Fig. 3. Common area for fuzzy case

In the case of having system and design ranges in linguistic terms, ranges will be expressed by using “around a number” , “between two numbers” or “over a number”, which can be explained by using fuzzy numbers. Common area in fuzzy case is the intersection area of fuzzy numbers which are ranges of system and design. Fig. 3 shows common area for a triangular fuzzy number (*tfn*). Hence, information content for fuzzy case is defined in formula 3.

$$I = \log_2 \left(\frac{\text{tfn of system design}}{\text{common area}} \right) \tag{3}$$

Fuzzy case of information axiom is successfully applied to different areas such as; information project selection [15], comparison of advanced manufacturing systems [16], transportation company selection [17], and material handling equipment selection [18].

3 Usability Ranking of Intercity Bus Passenger Seats Using FADT

Ten alternative seats used in the manufacturing facility are chosen for usability study. Seats are shown in Fig. 4. 5 subjects, representing a broad range of body sizes, evaluated ten different seats during a short-term seating session. The subjects were volunteers of working age with no health problems. Anthropometric measurements of subjects are taken. Mean stature cm is 1.73, mean body mass is 69 kg, and mean age is 29.

Fig. 4. Alternative seats

Table 1. System range data for alternative seats

S	Comf.	Aesthetic	Safety	Conven. to the body posture	Durability	Harmon. with the seat acces.	Operability
A	Good	Fair	Good	Good	Fair	Good	Fair
B	Very Good	Good	Good	Good	Good	Good	Good
C	Very Good	Good	Good	Very Good	Fair	Fair	Fair
D	Good	Fair	Good	Good	Good	Good	Fair
E	Good	Good	Fair	Very Good	Good	Good	Fair
F	Very Good	Poor	Good	Good	Good	Good	Good
G	Good	Good	Good	Fair	Fair	Fair	Good
H	Very Good	Fair	Fair	Good	Fair	Fair	Fair
I	Good	Good	Fair	Good	Poor	Fair	Good
J	Fair	Fair	Fair	Very Good	Good	Good	Good

As, vibration effect is not considered in the experiment, data collection was conducted in an environmentally controlled laboratory, rather than a bus. In experiment, effects of seat cover are also neglected.

Before starting the experiment, the subjects were given instructions on the method and experimental procedures. The subject is seated and watches a video on a screen in front of him during experiment. Entire procedure took approximately 50 minutes per subject and evaluating each seat took about 5 minutes. Usability factors used in the study are determined through the focus group study performed with both users and designers in order to measure the effectiveness, efficiency, and satisfaction dimensions of usability. Each subject evaluated each seat for each usability dimension by using one of the linguistic terms; poor, fair, good, very good or excellent. A focus group study was performed to aggregate five subjects' assessment opinions. Evaluation results, obtained from focus study is shown in Table 1, which corresponds to the system ranges of usability factors. Design ranges (*DR*) for usability factors are determined by design department of manufacturing facility. *DR*'s in Table 2. Cooperative engineering approach, which makes the decision making process both more effective and more efficient, is utilized by taking the opinions of users and designers into account.

Table 2. Design range data for usability factors

Usability Factors	Design requirements
Comfort	Comfort must be very good
Aesthetic	Aesthetic must be good
Safety	Safety must be good
Convenience to the body posture	Convenience to the body posture must very good
Durability	Durability must be good
Harmoniousness with the seat accessories	Harmoniousness with the seat accessories must be good
Operability	Operability must be good

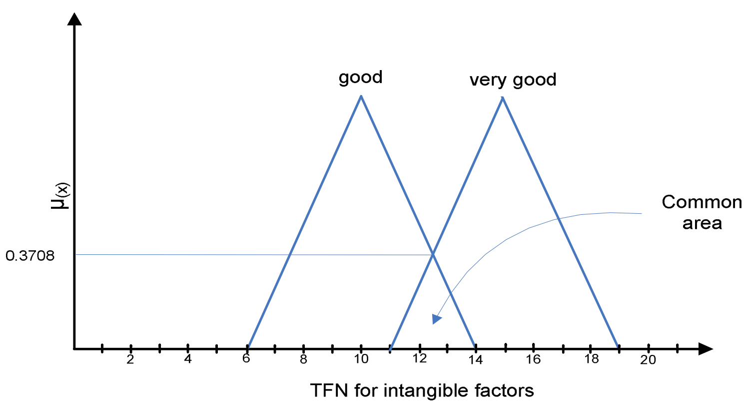

Fig. 5. System and design ranges of seat A for "comfort" criteria

$$\text{Common area} = \left(\frac{14-11}{2}\right) * 0.3708 = 0.5562 \,. \tag{4}$$

$$\text{System area} = (\frac{14-6}{2}) * 1 = 4\,. \tag{5}$$

$$I = \log_2(\frac{\text{tfn of system design}}{\text{common area}}) = \log_2(\frac{4}{0.5562}) = 2.846 \tag{6}$$

A sample calculation for obtaining information content is shown for “comfort” requirement of seat A. *TFN*s in Fig. 2. is used for intangible factors. It is observed from Fig. 5 that system range is good and design range is very good for comfort criterion. Common area and system area are 0.5562 and 4 respectively calculated from formulas 4-6. The value 0.3708 in equality 4, is the height of shaded triangle in Fig. 5 which is referred to as common area. Fig. 5. shows common area of seat A for “comfort” criteria.

Information contents for other usability factors for each alternative seat are given in Table 3. Alternative seat with the minimum information content is Seat B. According to those usability factors, the most usable seat is Seat B and the most unusable seats are F,G,I and J. Usability ranking obtained by using FADT is B>E>C>D>A>H>F=G=I=J. If Table 3. is investigated deeply it can be shown that seat F together with seat B have the minimum information content in total except for “aesthetic” factor. However, seat F is not selected because design range and system range for that factor is not overlapped. In this problem, it is assumed that all usability factors have equal importance. It is also possible to give different importance weights to usability factors to obtain different rankings.

Table 3. Information contents for alternative seats

S	$I_{\text{Comf.}}$	$I_{\text{Aesthetic}}$	I_{Safety}	$I_{\text{Convenience to the body posture}}$	$I_{\text{Durability}}$	$I_{\text{Harmon. with the seat acces.}}$	$I_{\text{Operability}}$	$\sum I$
A	2.846	1.732	0	2.846	1.732	0	1.732	10.888
B	0	0	0	2.846	0	0	0	2.846
C	0	0	0	0	1.732	1.732	1.732	5.196
D	2.846	1.732	0	2.846	0	0	1.732	9.156
E	2.846	0	1.73	0	0	0	1.732	6.31
F	0	Infinite	0	2.846	0	0	0	infinite
G	2.846	0	0	Infinite	1.732	1.732	0	infinite
H	0	1.732	1.73	2.846	1.732	1.732	1.732	11.506
I	2.846	0	1.732	2.846	Infinite	1.732	0	infinite
J	infinite	1.732	1.73	0	0	0	0	infinite

4 Discussions and Conclusion

It is desired in the cooperative approach that designer and user (or customer) be present in engineering application and decision making processes. Such a cooperative approach will increase the success and effectiveness of the decisions made. In this article, a new multi-attribute cooperative decision making tool, FADT, is used for ranking alternative seats considering usability factors. Usability factors presented for this research is almost subjective. Therefore it will be advantageous to use FADT which cover fuzzy aspect. Designer and user requirements are taken into account by using system range and design range concepts which are the key stones of axiomatic design. FADT enables cooperating user and designer requirements into design selection process. In this sense, strength of FADT is very clear. Except for the usability factors, engineering data related to seat (such as pressure distribution) or monetary value of bus seats can be integrated to seat selection process in order to increase the effectiveness of decision process.

References

1. Levrat, E., Voisin, A., Bombardier, S., Bremont, J.: Subjective evaluation of car seat comfort with fuzzy set techniques. International Journal of Intelligent Systems 12 (1997) 891-913
2. Zhang, L., Helander, M.G., Drury, C.G.: Identifying factors of comfort and discomfort in sitting. Human Factors 38 (1996) 377-389
3. Looze, M.P. de, Kuijt-Evers, L.F.M., Dieën, J. van.: Sitting comfort and discomfort and the relationship with objective measures. Ergonomics 46 (2003) 985-997
4. Jianghong, Z., Long, T.: An evaluation of comfort of a bus seat. Applied Ergonomics 25 (1994) 386-392
5. Kolich, M.: Ergonomic modeling and evaluation of automobile seat comfort. Ph.D. Dissertation, Windsor, ON (2000)
6. Kolich, M.: Automobile seat comfort: occupant preference vs. anthropometric accommodation. Applied Ergonomics 34 (2003) 177–184
7. Kolich, M., Taboun, S.M.: Ergonomics modeling and evaluation of automobile seat comfort. Ergonomics 47 (2004) 841–863
8. March, A.: Usability: the new dimension of product design. Harvard Business Review 72 (1994) 144-149
9. Han, S.H., Yun, M.H., Kim, K.J., Kwahk, J.: Evaluation of product usability: development and validation of usability dimensions and design elements based on empirical models. International Journal of Industrial Ergonomics, 26 (2000) 477-488
10. Rubin, J.: The Handbook of Usability Testing: How to Plan, Design, and Conduct Effective Tests. John Wiley & Sons, New York (1994)
11. Suh, N.P: Axiomatic design, advances and applications, Oxford University Press (2001)
12. Helander, M.G., Lin, L.: Axiomatic design in ergonomics and an extension of the information axiom, Journal of Engineering Design 13 (2002) 321-339
13. Lo, S., Helander, M.G.: Developing a formal usability analysis method for consumer products. Proceedings of ICAD, The Third International Conference on Axiomatic Design, Vol. 26 (2004) 1-8
14. Karwowski, W.: Ergonomics and human factors: the paradigms for science, engineering, design, technology and management of human-compatible systems. Ergonomics 48 (2005) 436-463
15. Kulak, O., Kahraman, C., Öztayşi, B., Tanyaş, M.: Multi attribute information project selection using fuzzy axiomatic design. The Journal of Enterprise Management 18 (2005) 275-288
16. Kulak, O., Kahraman, C.: Multi-attribute comprasion of advanced manufacturing systems using fuzzy vs. crisp axiomatic design approach. International Journal of Production Economics 95 (2005a) 415-424
17. Kulak, O. and Kahraman, C.: Fuzzy multi-attribute selection among transportation companies using axiomatic design and analytic hierarchy process. Information Sciences 170 (2005b) 191-210
18. Kulak, O.: A decision support system for fuzzy multi-attribute selection of material handling equipments. Expert Systems with Applications 29 (2005) 310-319

A Study on BDI Agent for the Integration of Engineering Processes

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Abstract. Integration of product design software and automation of their execution can greatly reduce design cycle time and manufacturing cost, and significantly improve product performance, quality, and reliability. The previous approaches are control-driven integration which cannot deal with dynamic change of the environment because the controller executes a sequence of tasks according to the pre-defined workflow. In this paper, we propose a data-driven integration of engineering processes. Each BDI(Belief-Desire-Intention) agent acts autonomously according to the change of the shared data, so the proposed agent architecture can deal with dynamic change of the environment such as user's input parameters.

1 Introduction

Product design organizations use computer software required to execute simulation-based design processes, including commercial CAD/CAE software, internally developed programs, and other design programs. Integration of these programs and automation of their execution can greatly reduce design cycle time and manufacturing cost, and significantly improve product performance, quality, and reliability. Model-Center of Pheonix Integraion[14] and iSIGHT of Engineous Software[15] are the most widely used tools for these purpose.

The previous approaches are control-driven process integration and automation which cannot deal with dynamic change of the environment because the controller executes a sequence of tasks according to pre-defined workflow, as shown in Fig. 1. For example, when the output parameters of task B are set up initially by the user, as shown in Fig. 2, the original workflow is changed to a new one where task C is executed immediately without the execution of task B, and the execution of task A and D are parallel to that of task C. The control-driven process integration approach is not flexible to such a dynamic situation.

To solve this problem, we propose a data-driven process integration and automation architecture, as shown in Fig. 3. An agent takes charge of each task, monitors the change of the shared data, and executes its engineering software when it detects input parameters of its task in the shared data. In this approach, the system does not control

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 149 – 155, 2006.

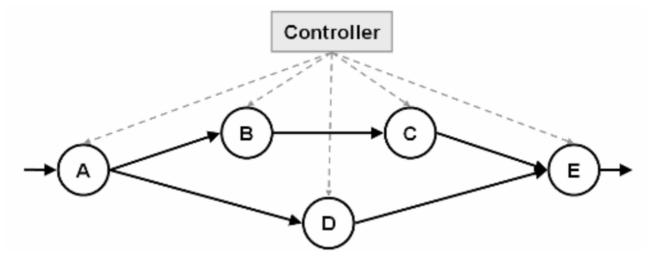

Fig. 1. Control-driven process integration and automation

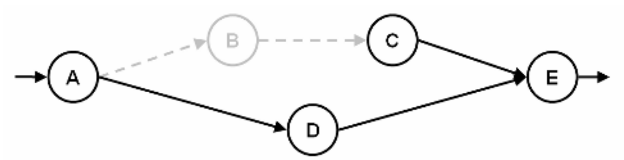

Fig. 2. Workflow changed by user's input

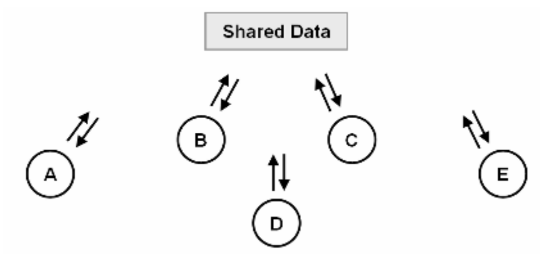

Fig. 3. Data-driven process integration and automation

the execution of tasks directly, but the change of the shared data leads to the execution of tasks. This architecture is flexible to dynamic change of the environment.

2 Agent System for Engineering Process Integration

2.1 BDI Agent

A Belief-Desire-Intention(BDI) agent is a particular type of rational software agent having certain mental attitudes of Beliefs, Desires and Intentions[10]. The beliefs represent the informational state of the agent. An agent can store this information using a database, a set of variables or some other data structure. Desires (or goals) represent the motivational state of the agent. The desires represent the objectives that the agent aims to accomplish or, more generally, the priorities associated with them. The intentions represent the deliberative state of the agent.

VivAce(Vivid Agent Computing Environment)[5] is a BDI agent architecture which is implemented in Java. Fig. 4 shows the internal structure of VivAce agent.

We can attach various kinds of sensors to a VivAce agent through the sensor manager. A VivAce agent perceives its environment through sensors and stores perceived data as a form of the predicate into its world model. The reasoner searches plans which are applicable to a goal selected from goal library and picks up the most appropriate and efficient plan in the context. The actuator executes the selected plan.

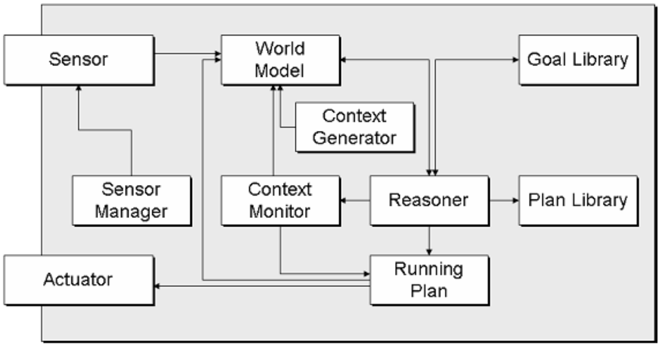

Fig. 4. Internal architecture of VivAce agent

For communication and collaboration among agents, VivAce uses JADE(Java Agent DEvelopment Framework)[16], which is a framework to develop multi-agent systems in compliance with the FIPA(The Foundation for Intelligent, Physical Agents) specifications. Messages exchanged by JADE agents have a format specified by the ACL(Agent Communication Language) defined by the FIPA.

2.2 Architecture of the Proposed Agent System

In this paper, we propose a BDI agent system for data-driven integration and automation of engineering processes. As shown in Fig. 5, the proposed agent system has a JBA(Job Board Agent) and multiple TA(Task Agent)s. JBA creates job data according to user's input, and stores them into job DB(database). It searches one of the job data corresponding to TA's request, sends it to TA, and updates the job DB with the job data received from TA. TA is in charge of autonomous execution of engineering software like a human expert. It requests JBA to send corresponding job data whenever its resources are idle, and performs its task by executing engineering software with the job data through the wrapper[8]. In this architecture, the change of the shared data organizes engineering processes dynamically.

Table 1 shows the representation form of job data. It contains current values of design parameters and current status of task execution. If a parameter does not have any value at that time, it is represented as *null*. The status of task execution can be one of *completed*, *inProcess* and *notHandledYet*. When TA asks JBA for job data, JBA tries to search a piece of job data which is not being processed by other TAs and have all the input parameter values of the task which are not *null*. One of selected job data is enclosed in a message and sent to TA.

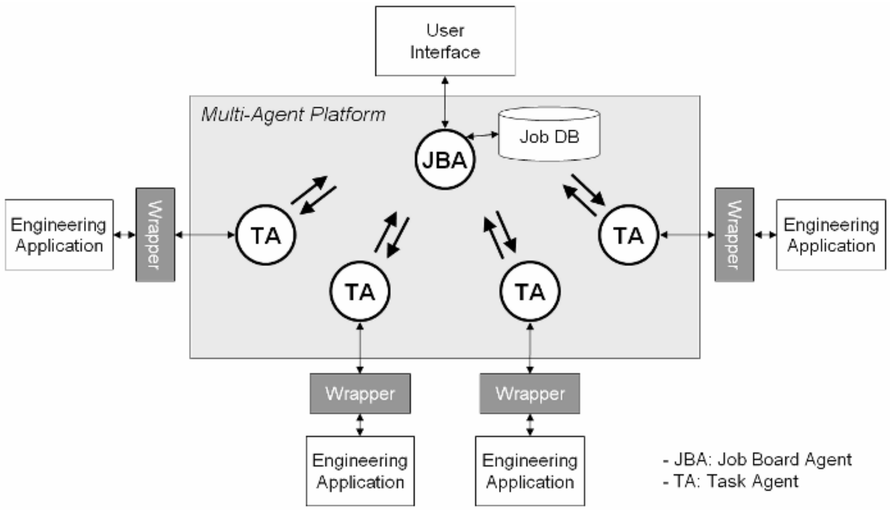

Fig. 5. Architecture of proposed agent system

Table 1. Representation form of job data

Format	(parameters) (status of task)
	Job_i X_1 X_2 … X_n T_1 T_2 … T_m
Examples	Job_1 10 0.5 … *completed* *completed* …
	Job_2 20 0.4 … *completed* *inProcess* …
	Job_3 30 *null* … *inProcess* *notHandledYet* …
	…

Each BDI agent has sensors and plans to act autonomously, as shown in Table 2. JBA and TA have MessageSensor to communicate with each other. Among plans of JBA, CreateJobDataPlan creates new job data according to user's input parameters and SendJobDataPlan sends appropriate job data to TA by its request. TA has JobDataSensor which is continually requesting JBA to send job data for its own task. Among plans of TA, ExecuteTaskPlan executes the attached engineering application with job data received from JBA. UpdateJobDataPlan sends job data updated by the execution of the engineering application to JBA.

Table 2. Sensors and plans of agents

Agent	Sensor	Plan
JobBoardAgent	MessageSensor	CreateJobDataPlan SendJobDataPlan
TaskAgent	MessageSensor JobDataSensor	ExecuteTaskPlan: UpdateJobDataPlan

2.3 Agent Communication for the Execution of Engineering Process

Fig. 6 shows the procedure of task execution and update by message communication between JBA and TA as follows.

① JobDataSensor of TA keeps sending a message for job request to JBA.
② SendJobDataPlan of JBA searches job data which have all parameter values prerequisite to the task and sends the job data to TA.
③ ExecuteTaskPlan executes its engineering software with the input parameters in the job data.
④ When the task is finished, UpdateJobDataPlan sends the updated job data to JBA, and JBA updates its job DB with the new job data.

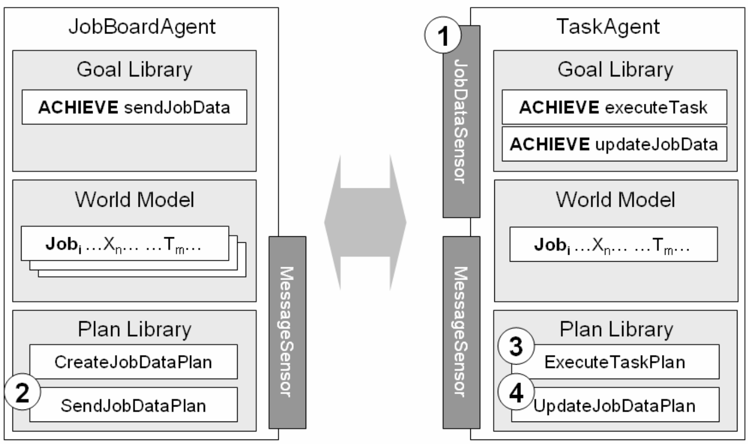

Fig. 6. Procedure of the execution of engineering Task

3 Case study

We implemented a pump design system to verify the proposed BDI agent model. Fig. 7 shows the pump design process. In the preliminary design task, Pre_Pump, an in-house program of KIMM(Korea Institute of Machinery & Materials) calculates representative geometric data such as number of blades, blade angle and thickness using the input parameters such as total head, volume flow rate, and rotation speed. Using these geometric data, 3D blade model is created in CFX-BladeGen in the blade modeling task. CFD(Computational Fluid Dynamics) analysis is done by CFX-BladeGenPlus. Blade modeling task and CFD analysis task are iterated until the result of CFD analysis is satisfied. In the rotor modeling task, 3D rotor model is created in Rhino3.

In our agent system, TA for each task was connected to the engineering software through wrapper. The pump design process was integrated flexibly by the automatic execution of tasks according to the change of job data. In the case that 3D blade model was given initially by user, the agent system was able to deal with dynamic

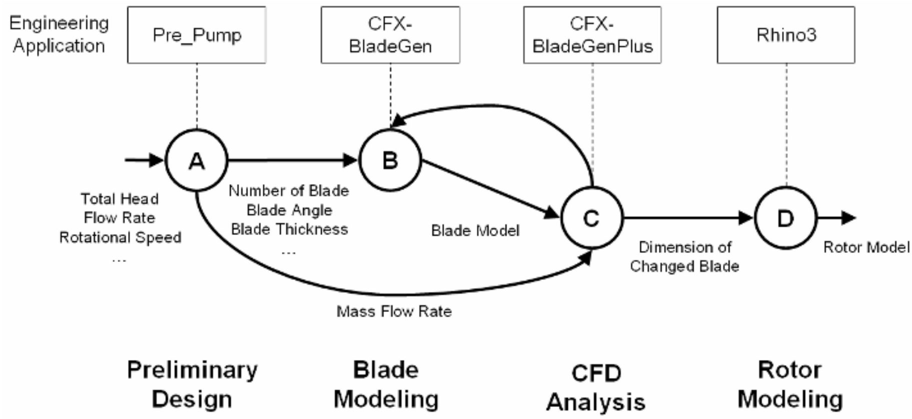

Fig. 7. Pump design process

workflow where the preliminary design task and the CFD analysis task were done sequentially and the rotor modeling task were done separately.

In Fig. 8, (a) shows the graphic user interface of pump design system, (b) shows the result of CFD analysis for blade model, and (c) shows rotor model.

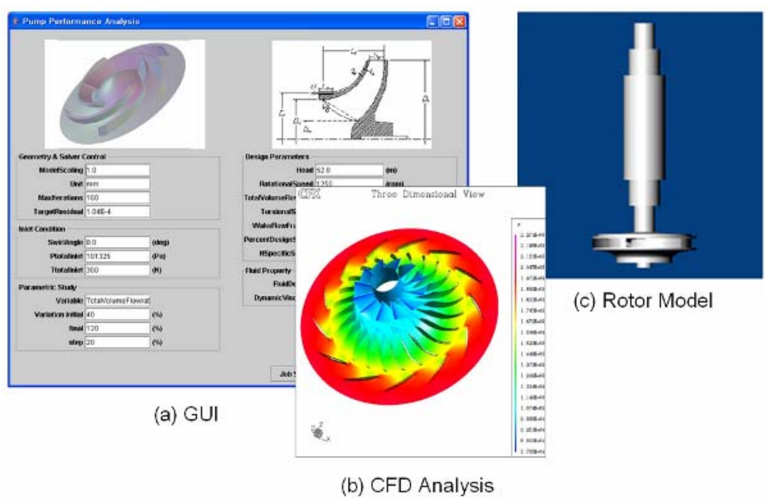

Fig. 8. GUI and result of pump design

4 Conclusion

In this paper, we proposed a BDI agent model for data-driven integration of engineering processes. Each BDI agent executes its task autonomously according to the change of the shared data, so the proposed agent architecture can deal with dynamic change of the environment such as user's input. The advances we can get from the proposed architecture are as follows.

- The agent for a task requests for job data whenever its resources are not in use, so parallel computing and load balancing in distributed environment can be achieved by this feature.
- Tasks are loosely coupled, which means this system is flexible to dynamic change of the environment
- The agent for a task is reusable in other problem.

For more intelligent system for process integration, we keep studying on agent system with ontology and design optimization agents.

References

1. Campbell, M.I., Cagan, J., Kotovsky, K.: A-Design: An Agent-Based Approach to Conceptual Design in a Dynamic Environment. Research in Engineering Desing, Vol.11, (1999) 172-192
2. Chao, K.-M., Norman, P., Anane, R., James, A.: An Agent-Based Approach to Engineering Design. Computers in Industry. Vol.48, (2002) 17-27
3. Cutkosky, M.R., Engelmore, R.S., Fikes, R.E., Genesereth, M.R., Gruber, T.R., William, S., Tenenbaum, J.M., Weber, J.C.: PACT: An Experiment in Integrating Concurrent Engineering Systems. IEEE Computer, Vol.26, (1993) 28-37
4. Han, S.-Y., Kim, Y.-S., Lee, T.-Y., Yoon, T.: A Framework of Concurrent Process Engineering with Agent-Based Collaboration Design Strategies and Its Application on Plant Layout Problem. Computers and Chemical Engineering, Vol.24, (2000) 1673-1679
5. Lee, J.: An Agent Application Framework for Applications Based on the Semantic Web, Journal of Korea Intelligent Information Systems Society, Vol.10, (2004) 91-103 (in Korean)
6. Lees, B., Branki, C., Aird, I.: A Framework for Distributed Agent-Based Engineering Design Support. Automation in Construction, Vol.10, (2001) 631-637
7. Mori, T., Cutkosky, M.P.: Agent-Based Collaborative Design of Parts in Assembly. Proc. ASME Design Engineering Techincal Conferences, (1998)
8. Park, S.W., Lee, J.K., Shin, B.C.: Introduction to Development of e-Engineering Framework for the Automotive Module Design, Proc. CSCWD2005, (2005) 146-151
9. Qian, Z., Xue, C., Pan, S.: FEA Agent for Multidisciplinary Optimization. Struct. Multidisc. Optim. Vol.22, (2001) 373-383
10. Rao, A.S., Georgeff, M.P.: BDI Agents: From Theory to Practice, Multi-Agent Systems, (1995) 312-319
11. Russell, S., Norvig, P.: Artificial Intelligence A Modern Approach. Prentice Hall, New Jersey (1995)
12. Sun, J., Zhang, Y.F., Nee, A.Y.C.: A Distributed Multi-Agent Environment for Product Design and Manufacturing Planning. Int. J. Prod. Res., Vol.39, (2001) 625-645
13. Wooldridge, M.: Agent-Based Software Engineering. IEEE Proc. Software Engineering, Vol. 144, (1997) 26-37
14. Phoenix Integration, http://www.phoenix-int.com/
15. Engineous Software, http://www.engineous.com/
16. JADE, http://jade.tilab.com/

The Usefulness of CSCW Systems in Process-Sensitive Software Engineering Environments

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Abstract. Software creation, development and maintenance are activities that require a great quantity of cooperative work. In the last years, several languages to model the diverse software processes have been proposed. However, these software Process Modelling Languages (PML) have not ended up being standardized nor being implanted by a majority in industry. The so-called Process-sensitive Software Engineering Environments (PSEE) are software engineering environments with support to manage PML. Each PSEE proposed has a PML associated, so there is a clear dependence between the software engineering environment and its modelling language. In this article, the cooperative support that a PSEE should offer is analyzed, and an environment with support for software PMLs is presented. This environment provides workspaces for distributed synchronous collaboration where work teams can develop a software project.

Keywords: CSCW, PSEE, PML, Software Engineering, Cooperative Engineering.

1 Introduction

The statement "Software Processes are software too" [17] made by Osterweil in 1987 has raised an important number of investigations and initiatives around the concept of Software Process. Among these, we can mention the so-called software Process Modelling Languages (PML) as an attempt to represent software processes in all their extension (activities, roles, products, tools, people) [9]. In the last years, some proposals have been made in order to model software processes. However, these proposals have not been adopted as an industry standard and they have not reached a predominant position in the market as a consequence of their use. The software engineering environments with support for the creation and manipulation of software processes models are called Process-sensitive Software Engineering Environment (PSEE).

A PSEE should offer cooperation support to the users who participate in a same software development project. This is an essential point to overcome the difficulties that usually arise due to the complexity inherent to software processes, since software applications are difficult to develop and test. Software applications frequently exhibit unexpected behaviours and undesired results that can originate important problems. This is, above all, due to the fact that software development is usually directed by exceptions and is subject to frequent changes of requirements. Consequently, software

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 156 – 163, 2006.

processes are unpredictable and difficult to model because of the many peculiarities of each process. A high level of cooperation among all the participants of the project is required in order to reduce these problems. Therefore, a basic requirement of PSEEs is the support for cooperative work. Moreover, the increase in the use of the Internet and the proliferation of wireless technologies make groupware [13] an interesting application field in the software development processes.

It is also necessary to take into account the high level of cooperation that is required among the people that participate in specific activities of the software development life cycle because this has an influence in terms of costs. Concretely, it is considered that 70% of the time and effort of developers is used in cooperating with other developers, which, translated into economic terms, results in 85% of the total costs [19].

Some examples of groupware tools that can be useful in different phases of the software development are shown in Table 1. For example, shared editors can be helpful in the creation of source code by several programmers, and Group Decision Support Systems (GDSS) can be used by clients (users) and developers to identify and elicit requirements.

Table 1. Groupware for different software development phases

Software development phase	**Groupware**
Requirements collection	Group Support Systems (GSS) Group Decision Support Systems (GDSS)
Design specification in a high abstraction level	Synchronous systems Distributed electronic meeting systems
Design specification in a low abstraction level	Face-to-face meeting systems
Programming	Shared editors
Installation	Synchronous electronic meeting systems

This article shows how SPACE-DOMAIN [5] can offer a collaborative support in software processes. This system supports software process modelling as well as the realization of specific tasks within a software production life cycle. Taking into account the importance of cooperative work in both functionalities, SPACE-DOMAIN provides shared workspaces for distributed synchronous collaboration. The software processes and the modelling tools (for specific tasks) are defined using system-independent languages based on XML to achieve interoperability.

In the next section we analyze the most significant PSEEs that approach the integration of tools with support for cooperative work. In Section 3, the SPACE-DOMAIN environment and the tools it integrates are described. Finally, we draw some conclusions and show the research work lines that we aim at approaching in the future.

2 Related Work

Traditionally, software engineering environments have lacked support for people communication and for process modelling. The main systems that have tried to bridge this gap have been Spade and Serendipity.

The Spade project [2] has as its basic objective to produce a PSEE. The Spade environment is based on the Slang modelling language, which allows the representation of software processes by means of a notation based on Petri nets. However, the coordination and interaction among users must be provided by means of the integration of new tools [1] since this environment does not offer support for cooperation. In order to approach this limitation, ImagineDesk has been designed [18]. This is a platform to support the design and execution of cooperative applications within Spade. ImagineDesk seeks for fulfilling three aims. In the first place, it provides a high level of abstraction regarding the physical details of the communication. Secondly, it provides support to manage specific collaborative applications as well as the PSEE where these applications are integrated. Thirdly, it has a repository to store data from the collaborative activities. However, the problem of integrating this cooperative platform in an environment that allows the modelling of software processes is not trivial because there are different integration levels [16] that can give rise to inconsistencies and because in many cases it can be necessary that the source code of the modelling tool in which to incorporate cooperative work facilities is available.

Serendipity [12] is an environment that integrates CSCW tools with different cooperation levels (synchronous, semi-synchronous, asynchronous) [10] and process modelling functionalities. Several tools with support for low level collaboration (chat, notes linked to the processes, etc.) can be found in Serendipity. In addition, Serendipity provides high level collaboration by means of tools that warn the users about particular events. Using this type of collaboration, the users receive information about changes in objects of their interest. In Serendipity two languages were created [11] with the purpose of supporting process modelling: EVPL (Extend Visual Planning Language) and VEPL (Visual Event Processing Language). The former one approaches the descriptive modelling of processes by indicating the work to carry out. The latter is used to model the events involved in the execution of the process. In the same way as Spade, a limitation of the system interoperability takes place since the system does not allow the manipulation of software processes that were modelled with other languages or the use of more suitable PMLs for certain projects. Other examples of PSEE that use their own PML are Apel [8], Marvel [3], and Oz [4].

3 SPACE-DOMAIN

As has been stated in the previous section, most of PSEEs were created without support for cooperative work and with the objective of supporting a concrete PML. In order to overcome the problems derived from the dependence of each PSEE with his PML associated and the lack of support for distributed synchronous collaboration, we propose the approach of the SPACE-DOMAIN environment. On the one hand, SPACE-DOMAIN allows the description of software processes according to a PML specified in a XML document. This specification allows the system to support many PMLs in practice. This way, there is not dependence between the PSEE and the PML used. On the other hand, SPACE-DOMAIN allows the realization of software modelling activities in a distributed synchronous collaborative way. This computer-supported collaboration among the participants in the project facilitates the realization of the changes (of requirements) that so frequently appear in software processes.

SPACE-DOMAIN is made up of three components: SICS, Autoolx, and Space-Design. The support for synchronous collaboration has been implemented using JSDT (Java Shared Data Toolkit)[1]. Using this toolkit the SICS (Synchronization Infrastructure for Collaborative Systems) framework was built. This framework provides high level programming abstractions and a set of components (manager of work sessions, definition of work teams, communication tools, etc.) to be used in the development of collaborative applications. On the one hand, the developer can reuse CSCW components in the collaborative system [5, 6]. On the other hand, SICS is an easily scalable infrastructure, since it only needs the execution of a main server. Thus, new collaborative applications can be built in a simple way.

Autoolx is an authoring tool that allows an author to specify model languages by means of XML specifications. In this way, a total independence with the software engineering environment is obtained. Fig.1 shows a specification of MVP-L [15], a software PML, made using this tool.

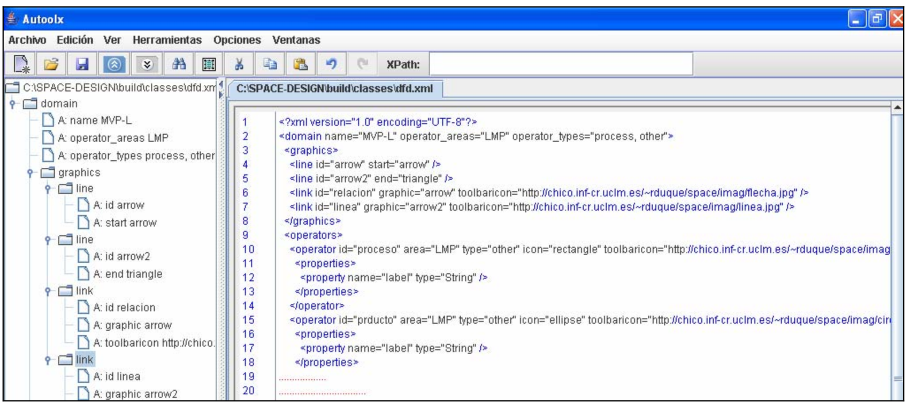

Fig. 1. PML specification in SPACE-DOMAIN

Space-Design (SPecification and Automatic Construction of collaborative Environments of DESIGN) [5] is a CSCW tool to support distributed synchronous collaborative work. The Space-Design system (Fig. 2) has two main functionalities: firstly, this allows the visual modelling of software processes using the language that was specified in Autoolx (see Fig. 1); secondly, this supports the carrying out of characteristic modelling activities of the development life cycle, such as designing the use case model, specifying the behaviour of a class or subsystem by means of a state diagram, etc. These functionalities are carried out in a collaborative way. Thus, Space-Design integrates a number of collaborative tools that have been developed over SICS. These collaborative tools provide mechanisms of awareness, communication, coordination and shared memory. According to [7], such mechanisms are necessary in any PSEE. As shown below, these tools represent an innovation with respect to the ones analyzed in Section 2:

[1] http://java.sun.com/products/java-media/jsdt/

- Structured chat: It is a conventional chat to which we have added some sentence openers (implemented with buttons at user interface level) that are frequently used in modelling tasks ("I think that...", "I can see a mistake in...", etc.). This increases the fluency of communication and facilitates later analysis because the messages sent can be counted and classified easily. Also, these sentences are specified by the user [2] according to the necessities of each situation. This way, a greater flexibility is obtained with respect to the chat tools used in traditional PSEEs.
- Session panel: The names and photos of the project participants are shown in this panel. The colour used for drawing the user's name is also used to draw his/her tele-pointer; this facilitates the user identification and is, consequently, a basic awareness mechanism.
- Whiteboard: It is a shared work surface where users can model different processes or the system by building models graphically in a collaborative way.
- List of interactions: The actions that each user has carried out on the work surface are displayed here. This increases the rest of users' awareness of the work. Moreover, a statistical analysis of these actions is possible since these data are stored in a database. This database can be considered a shared memory because it stores all the actions carried out.

We have seen in Spade how a PSEE needs the use of an external platform (ImagineDesk) to offer collaboration support. This causes problems of integration and of component reengineering. The Serendipity environment solves this problem but it does not take into account some facilities as the Structured chat or the List of interactions.

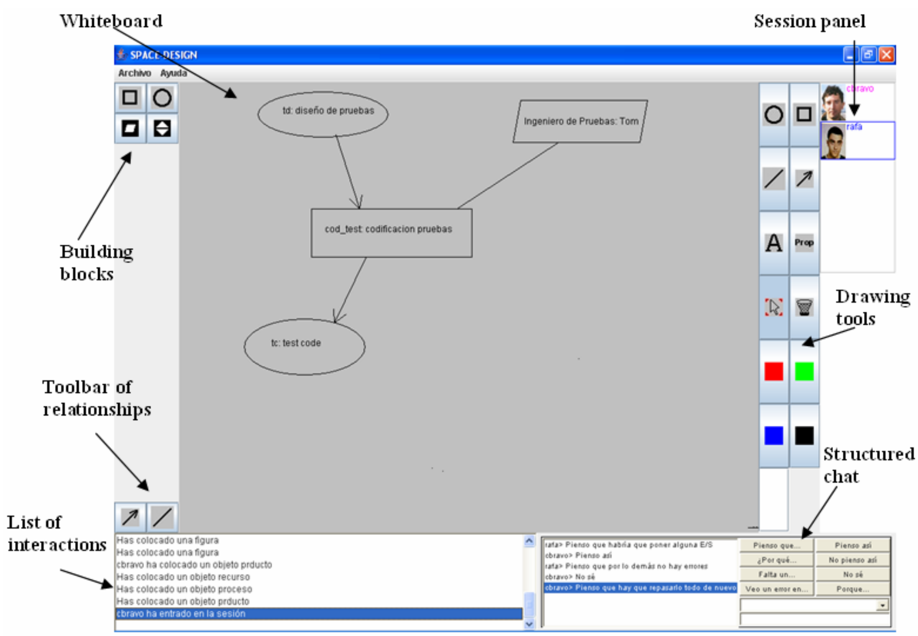

Fig. 2. Example of Space-Design using the MVP-L modeling language (the user interface is in Spanish)

In Space-Design the software PML to be used is specified in a XML document that contains the different elements of the language, their relationships, their properties and their graphic representation. Fig. 1 shows the definition of the MVP-L language, used in the Space-Design example of Fig. 2. This language defines the set of building blocks that the user can use to model the software process according to the language entities. These building blocks are included in the modelling toolbar of Space-Design. Also a toolbar of relationships allows the users to create associations among the different language entities. This Space-Design ability to be adapted to any PML specified in XML makes the Space-Domain environment a powerful PSEE, so that this can support the language that better adapts to the necessities of each project, to possible standards or to market tendencies. This is illustrated in Fig. 3, where a software process is represented in a language based on Petri nets as well as in E3 [14], an object-oriented language.

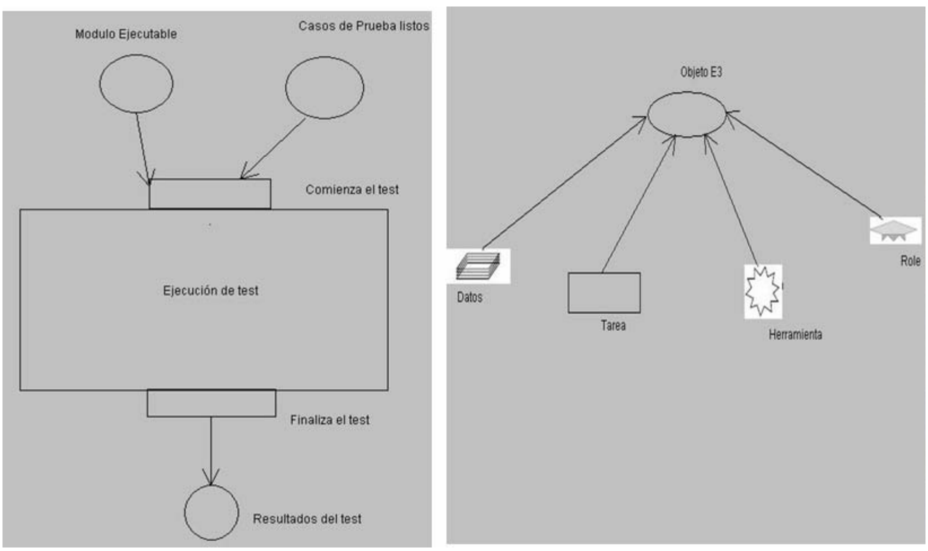

Fig. 3. Models built with Space-Design using a PML based on Petri nets (left) and E3 (right)

4 Conclusions

Software development is an activity directed in many cases by exceptions and changes. This dynamism makes the software processes difficult to be predicted and the developed products difficult to be validated. In order to overcome these changes and difficulties, any PSEE should provide cooperation support mechanisms among all the members that participate in a project. The necessity of offering CSCW support involves additional difficulties to the creation of PSEEs, which also have ambitious objectives themselves. Among these difficulties we can identify the necessity that the CSCW tools are fully integrated in the PSEE and, in this way, they are not seen as an external system.

It is important to highlight that at present each PSEE has its own PML associated. The fact that there is not a standard language to model software processes is a serious risk since the PSEE can be out of the market or obsolete in the case of a de facto or de jure eventual standardization. Regarding this, SPACE-DOMAIN proposes the use of the XML standard as a mechanism for representing modelling languages, which allows this environment to reach a high interoperability degree.

CSCW tools are destined to play a decisive role in the analysis and improvement of software processes. In relation to this, the SPACE-DOMAIN environment stores in a database all the interactions carried out by the users. This information allows, for instance, the study of previous development processes to derive ways of approaching present or future activities. Among the data that should be stored, the users' messages sent with the communication tools, the number of interactions carried out in the shared workspaces, the duration of the collaborative tasks, and the agreements and disagreements in the GDSS tools can be found.

With respect to future work, we are approaching two work lines. We are designing new collaborative tools to be incorporated in SPACE-DOMAIN in order to cover more widely the software project life cycle. In particular, we aim at integrating a collaborative source code editor into SPACE-DOMAIN. Additionally, we are defining a specification to link a PML with the set of collaborative tools to be used in each process or sub-process. This way SPACE-DOMAIN could run the PML and this specification to offer dynamically a PSEE with specific software engineering modelling and edition tools for the different activities of a software life cycle. These specifications will follow the MOF[2] meta-modelling standard.

Acknowledgments

This work has been supported by the Consejería de Educación y Ciencia, Comunidad Autónoma de Castilla-La Mancha (Spain), in the PBI-05-006 project.

References

1. Bandinelli S., Di Nitto E., and Fuggetta A.: Supporting cooperation in the SPADE-1 environment, IEEE TSE, 22, 12, 1996.
2. Bandinelli S., Fuggetta A., Ghezzi C.: Software Process Model Evolution in the SPADE Environment, IEEE TSE Special Issue on Process Evolution, 19, 12, 1993.
3. Barghouti, N.S.: Supporting Cooperation in the Marvel Process-Centred SDE. In Proceedings of the 1992 ACM Symposium on Software Development Environments, ACM Press, 1992, pp. 21-31.
4. Ben-Shaul, I.Z., Kaiser, G.E.: A Paradigm for Decentralized Process Modeling and its Realization in the Oz Environment. In 16th International Conference on Software Engineering, May 1994, pp. 179-188.
5. Bravo, C., Gallardo, J., García-Minguillan, B., Redondo, M.A. (2004): Using specifications to build domain-independent collaborative design environments First International Conference Cooperative Design, Visualization and Engineering (CDVE'2004) Cooperative Design, Visualization and Engineering. Luo, Y. (Ed.), Lecture Notes in Computer Science (LNCS 3190), pp. 104-114, Springer Verlag (Berlin)

[2] http://www.omg.org/mof

6. Bravo, C., Redondo, M.A., Mendes, A.J., Ortega, M.: Group Learning of Programming by means of Real-Time Distributed Collaboration Techniques. In: Lorés, J., Navarro, R. (eds.): Invited and reviewed papers from Interacción'2004. Springer-Verlag (2004)
7. Dias, M., Araujo, R., Borges, M., Favela, J., Rodriguez, J: Supporting Software Processes with Groupware. In:Segundo Encontro de Computación, 1999, Hidalgo (1999)
8. Estublier, J., Dami, S., Amiour, M.: APEL: a Graphical Yet Executable Formalism for Process Modeling. Automated Software Engineering 5, 1(January 1998), pp. 61-96.
9. Fuggetta, A. (2000): Software Process: A Roadmap. 22nd Int. Conf. on Software Engineering (ICSE'2000), Future of Software Engineering Track, June 4-11, Limerick (Irlanda). ACM
10. Grundy, J.C., Hosking, J.G., Mugridge, W.B.: Low-level and high-level CSCW support in the Serendipity process modelling environment. Proc Sixth Australian Conference on Computer-Human Interaction, IEEE CS Press, Hamilton, November, 1996,69-77.
11. Grundy, J.C., Hosking, J.G., Mugridge, W.B.: Supporting inconsistency management for multiple-view software development environments. IEEE Transactions on Software Engineering, vol. 24, no. 11, November 1998.
12. Grundy, J.C., Hosking, J.G.: Serendipity: Integrated Environment Support for Process Modelling, Enactment and Work Coordination. Automated Software Engineering: An International Journal, 5(1), pp. 27-60, 1998.
13. Hiltz, S., Turoff, M. (1992) Virtual Meetings: Computer Conferencing and Distributed Group Support. Bostrom, R., Watson, R. & Kinney S. (Eds.) Computer Augmented Teamwork: A Guided Tour. New York: Van Nostrand Reinhold, 1992, pp. 67-85.
14. Jaccheri, M.L., Picco, G.P., Lago, P.: Eliciting Software Process Models with the E3 Language. ACM Transactions on Software Engineering and Methodology 7(4) October, 1998.
15. Lott, C.M., Rombach, H.D: A MVP-L Solution for the Software Process Modeling Problem. Proceedings of 6th International Software Process Workshop, Hakodate, Japan, October 1990.
16. Nitto, E., Fuggetta, A.: Integrating Process Technology and CSCW. In the Proceedings of 4th European Workshop on Software Process Technology, Leiden, Olanda, April 1995 (Lecture Notes in Computer Science n. 913).
17. Osterweil, L: Software Processes are Software Too. Proc. of the 9th International Conference on Software Engineering, Monterey, CA. IEEE Computer Society Press. 1987.
18. Pozzi, S., Di Nitto, E: ImagineDesk: a Software Platform Supporting Cooperative Applications. In the Proceedings of ACM 1994 Computer Science Conference (CSC94). Phoenix (AZ), Mach 1994.
19. Tangqiu Li, Zongkai LinXiamen: Something We Learned about Computer Supported Cooperative Work in Software Engineering. COMPSAC 2004 Presentation Slides (http://conferences.computer.org/compsac/2004/Slides/panel-2-Li.ppt).

A Framework for Real-Time Collaborative Engineering in the Automotive Industries

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Abstract. Today, many different companies are involved in the automotive engineering process. The OEM, subcontractors and suppliers all need to collaborate and access the same data. Specialized applications are used in the process of designing vehicle electrical systems. These applications use proprietary data formats and do not support collaborative engineering. Thus collaboration methods are limited to turn-taking, split-combine and copy-merge. To become application independent and stay future-proof, a new trend is the transformation of data from the proprietary data formats to the Extensible Markup Language[1] (XML). This will allow new ways of viewing, editing and analyzing the data using new and existing applications and tools that use XML as a data model. This paper presents a novel software framework that allows easy enhancement of any such applications with the ability of collaborative real-time editing. Support for heterogeneous applications, a new flexible plug-in architecture and easy application integration are some of its key features.

Keywords: XML, Collaborative Engineering, Real-time Collaboration, Software Engineering, Groupware, CSCW, Vehicle Electrical System.

1 Introduction

The development of vehicle electrical systems is a complex and tedious process. Many different companies such as subcontractors and suppliers are involved in designing and building the cable loom of a car. In order to support the engineers, a number of applications such as Logical Cable[2], Catia[3] and LDorado[4] are used to design circuit diagrams and electrical components. The electrical components and component symbols that are used in the design are administered in a so called Cable Library System (CLS). The cable loom design is split into different modules where each module design contains one or more diagram sheets. A number of companies such as the supplier or manufacturer of the cable loom, different subcontractors and

[1] Extensible Markup Language (XML) 1.0 (Third Edition) W3C Recommendation, http://www.w3.org/XML/, 4th February 2004

[2] Logical Cable (LCable), http://www.mentor.com/products/cabling_harness/index.cfm

[3] Catia 3D, http://www.3ds.com/home

[4] LDorado, http://www.ldorado.harnesslab.de

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 164 – 173, 2006.

the OEM (e.g. Volkswagen) are involved in the cable loom design. Thus a tight collaboration between the involved companies and the OEM is required. For the exchange of data between the OEM and the subcontractors today a so called construction data management system (CDMS) is used. Such systems are used for storing and retrieving development artifacts. For example, a copy of the CLS library (containing all electrical components that are required for designing a circuit diagram) is retrieved by the subcontractor via the CDMS. The subcontractor then uses this library to design the wiring diagrams. Problems occur here for example, when one subcontractor works with an older version of the CLS than other involved parties. When exchanging the wiring diagrams, conflicts can occur that need to be resolved manually. The process of integrating changes made by subcontractors into the overall design, the management of the design data in CDMS and an error checking procedure are time consuming and expensive. These and other problems reduce the productivity of the engineering process. To overcome these problems a synchronization mechanism would be helpful, which ensures that all companies involved in the design process, work with up to date data. In the design process a system that supports real-time collaborative engineering would allow all parties to work on a single source. Additionally the OEM would always be able to see the current status of work and check the design for errors at all times. This could lead to a better quality and higher productivity.

The development of complex applications such as a symbol editor or a wiring diagram editor is a difficult and time consuming task. Since already various single-user applications exist it would be much simpler and user friendly to enhance the existing applications with real-time collaboration functionality, instead of developing new collaborative applications. One of the advantages is, that users do not have to learn and adapt to a new application but can use their familiar application with enhanced functionality. The goal of our research is to develop a software framework that allows the enhancement of any type of single user editing system or application, using XML as a data format, with the ability of collaborative real time editing. The trend is set by the Verband der Automobilindustrie VDA (Automotive Industry Association) to use XML as the new data format for the design and exchange of vehicle electrical systems. In the automotive industry the Scalable Vector Graphics[5] (SVG) format is used to visualize and exchange wiring diagrams. Other XML based languages exist or are in development to model the logic and other data that is needed in the vehicle electrical system design. These are for example KBL[6] and Elog[7]. The KBL (Harness Description List) XML format (VDA recommendation 4964) is a subset of the AP212 ISO Specification[8] for vehicle electrical systems. It defines a data model and an XML schema for the exchange of harness design data between the OEM and the suppliers. Elog is a XML format currently under development by the VDA and will be used to represent the electro-logical model of a vehicle electrical system including views (sheets), electrical components, wires and connectors. As

[5] Scalable Vector Graphics 1.0 Specification. W3C Recommendation, http://www.w3.org/TR/SVG/, 2001
[6] KBL, Kabelbaumliste (Harness Description List), VDA recommendation 4964, http://www.ecad-if.de/kbl.html
[7] Electrological Model, ELOG, VDA, http://www.ecad-if.de/elog.html
[8] AP212, Electrotechnical Design and Installation, ISO Standard 10303-212.

XML is becoming the standard interchange and data format not only in the automotive industries, a software system that supports real-time collaborative editing of XML documents could lead to a general solution for many application areas. The collaborative editing framework for XML (CEFX) we present in this paper, will allow enhancing applications that use XML as a data model, but is not limited to these.

The paper is structured as follows. In the next section prior work in supporting collaborative use of single-user applications and the CEFX approach are discussed. Section 3 discusses the CEFX framework architecture, the system components and how single-user applications can be extended by CEFX. In Section 4 the consistency model that is applied in the default implementation of CEFX is briefly discussed. In section 5 requirements, limitations and future work is discussed and in the last section research findings and contributions in this paper are summarized.

2 Collaborative Systems

Collaborative systems that allow the enhancement of a single-user application with collaborative functionality are typically classified into collaboration-transparent systems and collaboration-aware systems. Systems that provide methods to share a single-user application without changing the application are called collaboration-transparent. The applied methods are unknown to the application and its developers. Collaboration-aware systems integrate collaboration mechanism by changing the application so that the application is aware of these. This allows a tight integration of collaboration functionality into an existing application. The problem with the collaboration-aware approach is, that it requires access to the source code of an application which in some cases may not be possible for “of the shelf” software products. The collaboration-transparent approach does not require access to an applications source code. Two types of collaboration-transparent systems can be identified: application independent (generic) and application dependent systems. Application independent systems do not know the shared application. They work on basis of transmitting low-level input/output data such as key-strokes, mouse movements and display pixel data. Application dependent systems are used to enhance a specific application with collaboration functionality and have knowledge of the application specific data model or the application API (Application Programmers Interface).

Examples for application independent and collaboration-transparent systems are application sharing environments such as NetMeeting, VNC or Netviewer. They allow sharing the view of any single-user application among a group of users. Such systems only support strict WYSIWIS and are useful and effective for tightly coupled collaborative work, where independent interaction is not wished or not required. Multi-user free interaction where each user can individually for example work on a different part of a shared document is not supported.

An example for an application dependent system is the CoWord system by Xia, Sun et al. [10]. This systems makes use of the application specific API in order to integrate collaboration functionality into the Microsoft Word product. The user actions performed on the word document are thereby intercepted and translated by the Adaption Layer into operations for the Operational Transformation (OT) Layer which is responsible for maintaining the consistency of the shared document. The collaboration system underlying CoWord is collaboration-transparent, supports relaxed WYSIWIS and can also be used in a collaboration-aware system design. For the collaboration-transparent approach CoWord requires the execution environment and the single-user application to provide a suitable API which can be used to intercept and replay user input events and whose data and operational model are adaptable to that of the underlying OT technique. If an application and the execution environment provide a suitable API the greatest effort lies in implementing the translation of the user actions into operations required by the OT Layer.

Other collaboration-transparent systems such as the one presented by He et al. [12] use a similar technique as in CoWord to enhance a single-user application with collaborative functionality. Low-level I/O events such as keyboard and mouse events are intercepted and translated into semantic commands. A so called Communicator collects high-level messages (such as CAD commands and model data) and low-level messages and transmits those over the network to the other collaborating sites. There they are translated into execution environment GUI commands or application specific API calls.

The Intelligent Collaboration Transparency (ICT) project [14] also uses a similar technique as the above systems to enhance single-user applications with collaboration functionality. In addition to the CoWord approach the aim is to support sharing of familiar heterogeneous single-user editors.

The main problem of all of these systems is the effort of translating user actions into application semantic commands. For each single-user application that is to be enhanced, a translation layer has to be implemented. Because this is a difficult and time consuming task, the second generation of the ICT project (ICT2) uses a difference algorithm instead [13]. This new approach has shortcomings in the performance and the applications can not be heterogeneous but must be semi-heterogeneous. That is their interfaces can differ but the writing style must be the same.

The Flexible JAMM [15] (Java Applets Made Multi-User) project uses a different approach. Single-user applications are enhanced by replacing selected single-user components of the shared application with multi-user versions. This approach requires the underlying execution environment to meet certain conditions such as capabilities for process migration, run-time component replacement, dynamic binding and user input events interception and replay. The common interface of applications extended by JAMM is Java Swing and Java Object Serialization (JOS). In contrast to the other mentioned systems, the JAMM system does not require the development of a translation layer in order to convert user actions into application semantic commands or API calls as long as an application is based on Swing and all application classes are serializable. Although the number of Java Swing based applications has increased in the last years, the number of single-user applications that fulfill the mentioned requirements is small.

The CEFX approach is based on a common interface: the XML Document Object Model (DOM). If a single-user application uses a DOM internally, a suitable application API is not required in order to integrate CEFX into an existing application. Such single-user applications can be easily extended without the effort of implementing a translation layer. Another advantage is that heterogeneous applications can be used to collaboratively work on a shared document because they share a common interface, the DOM. The number of existing and emerging XML applications and thus the number of single-user applications using XML as data model (native XML applications) is growing. Today the majority of these applications are general XML editors or specialized SVG graphic editors9. Another example for an application that extensively uses the DOM is OpenOffice. OpenOffice uses OpenDocument10, an XML format, as native file format. An increasing number of applications exist that do not necessarily use XML as their internal data model, but provide a DOM API that allows directly accessing and manipulating the internal data. These applications can also be extended by CEFX with relative small implementation effort.

In the case where an application does not base on XML and does not provide a DOM API, CEFX can also be used. This can be achieved by using similar methods as in the Transparent Adaption approach of CoWord or other transparent approaches. In this case it would be necessary to implement a DOM translation layer for converting user actions into XML operations for the CEFX collaboration layer. Technologies such as XML binding can dramatically reduce the time and effort of translating an internal data structure to the XML data model.

3 A Flexible Framework Architecture

Single-user applications that are extended with a collaborative framework are usually tied to its consistency model and conflict resolution strategy. Adjustments can become expensive and time consuming. In order to support as many different application types as possible, the consistency maintenance algorithm of a collaborative framework therefore has to be very flexible in the selection of conflict resolution strategies. Depending on the application type the required strategies may vary. For example, in one case a priority based conflict resolution strategy, where the user with the highest priority wins makes sense. In other cases a multi-versioning approach would be better. The CEFX framework allows an easy integration into existing applications (supporting the collaboration-aware and the collaboration-transparent approach) and an easy extension of the framework itself with new features or enhanced concurrency control algorithms. This flexibility is made possible by the plug-in architecture of CEFX. In the automotive industry it is required that all documents used in the design process are always accessible via a central site. This is supported by the hybrid software architecture of CEFX, discussed in the next section.

3.1 A Hybrid Software Architecture

The Collaborative Editing Framework for XML is based on a hybrid-architecture. The hybrid architecture is a mixture of both the centralised and the replicated architectures. Each site holds a client and a server process as well as a partial or complete copy of the shared data resource. Additionally a server site exists holding both the shared data resource and a server process.

[9] For a list of native SVG editors refer to: http://www.w3.org/Graphics/SVG/SVG-Implementations

[10] OASIS Open Document Format for Office Applications (OpenDocument). OASIS Standard May 2005.

All operations are executed locally before they are sent to the other sites to be executed, just like in the replicated architecture approach. Additionally the operations are also sent to the server site; there they are executed as well. The remote client sites execute the received operations only if necessary; that is if they have an interest in the operation. Next to the better responsiveness as in replicated systems, the hybrid approach has the advantage of having always a central site that holds the current correct version of the document. If a new site joins the session, a copy of this version can be obtained easily. It also can be used for synchronisation issues. Users working on a very large document may not interfere with each other, but if they do at any point, the system will know if their local version is up to date or not. The system can then, if necessary, either obtain a new copy from the server site (if for example too many changes have been made) or simply execute the operations on the relevant document part. In that case it is not necessary to obtain a copy of the whole document but only a copy of the relevant part.

3.2 The DOM Adapter

The Document Object Model (DOM) API is a common interface to the XML model tree. Applications that allow editing of XML documents usually own a DOM in order to manipulate their data model. Implementations of DOM exist for nearly all modern programming languages and operating systems. When developing a framework that allows enhancing existing XML applications with collaborative functionality, it makes sense to use this common interface as an entry point to these applications. The connection between an application and the CEFX framework is the DOM Adapter (DA). In the case of a collaboration-aware integration of CEFX, it provides a DOM interface (by derivation) to the application that is exactly equivalent to the application's original DOM interface. Neither the application code manipulating the DOM nor the DOM object itself, need to be changed. The DA is programmatically provided with a reference to the original DOM and replaces it with a version generated by the DA. In the collaboration-transparent approach, the DA is integrated into the used translation layer (TL) (DOM/DOM TL if a DOM API is provided by the application, otherwise DOM/API TL) instead of the application. The generated DOM implements all methods of the original version and integrates control structures that forward modification events to the CEFX controller. These modification events are then analyzed by the CEFX controller and delegated to the corresponding handlers for synchronization and awareness issues. In a single-user application the document that is to be edited is stored for example on the local file system. When the user opens a document, the document is parsed and initialized by the application. The DA provides functions for parsing and initializing a document as well. It checks if the document is currently open in a collaborative editing session. If it is not part of a session, a new session is created. If the document is already opened in a session, the DA carries out the corresponding actions to connect the application with that session. The CEFX framework provides functions to retrieve information on documents in open sessions and to connect to those sessions. The controller instance of the CEFX framework analyses changes made to the document of an application. It generates events and delegates these to the corresponding modules or plug-ins of the framework. CEFX provides a set of default implementations for concurrency control including conflict resolution strategies and awareness widgets. These default implementations can be extended, or replaced with completely new implementations. For this the CEFX framework defines a set of extension points. An extension point declares a contract (using XML and programming language interfaces) that extensions must conform to. Other plug-in implementations that want to connect to that extension point must implement that contract in their extension.

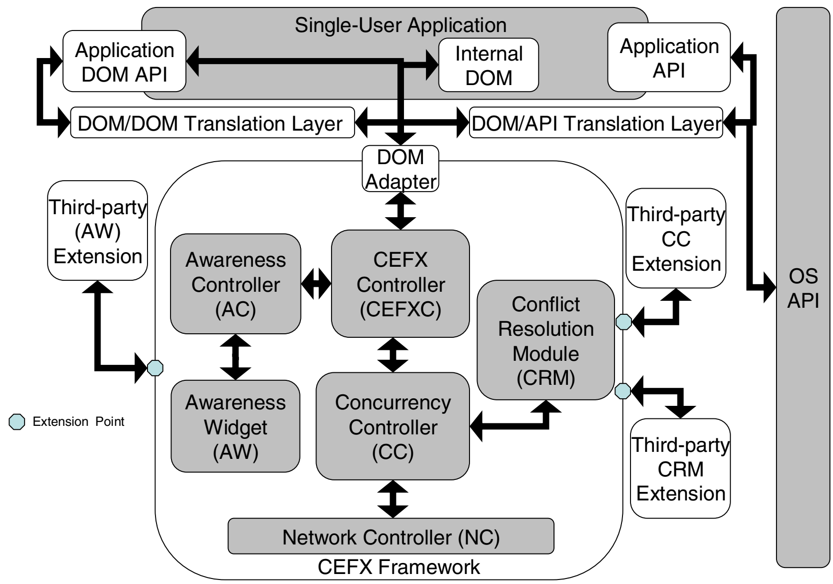

Fig. 1. The basic CEFX plug-in components and their interrelation. Plug-ins using extension points to extend the framework functionality are named third-party extensions in this figure.

The basic CEFX plug-in components, next to the DOM Adapter are the Concurrency Controller (CC), the Conflict Resolution Module (CRM), the Awareness Controller (AC), a set of Awareness Widgets (AW) and the Network Controller (NC). The CC of the framework is responsible for maintaining the consistency of the document and uses the NC module to transmit and receive editing events to and from remote sites. The CRM implements the rules that are applied if a conflict occurs. That is, how the system will react in that case. This could be for example on basis of a priority based or a no-operation conflict resolution scheme (CRS). A single-user application does not know the notion of remote sites. In order to give a user a feedback of what other users are doing, so called awareness mechanisms need to be integrated into the application. Awareness mechanisms are also necessary to alert users of conflicts that can not be resolved automatically. For this integration, the framework offers methods to register own listeners and awareness widgets that get notified by the framework of events from remote sites. These listeners are registered with the AC. The AC is responsible for receiving and dispatching events from and to the application and remote sites. The events can for example contain information on mouse movements, locking events or other control events that need to be visualized to the user in some way or the other. Figure 1 shows an overview of the basic CEFX framework components and their interrelation. An application can use the default framework components such as awareness widgets or provide its own and register them with the framework using the extension points. The default awareness widgets themselves define extension points that allow extending them with new functionality. For functionality such as changing the conflict resolution strategy or selecting a part of a document that is to be locked, the framework offers control structures and extension points that can be used to configure the current concurrency controller and conflict resolution strategy implementations. The default concurrency controller and conflict resolution plug-ins define extension points as well in order to extend them with additional functionality.

4 Consistency Maintenance

For the synchronisation of XML documents in a real-time collaborative environment a consistency maintenance algorithm is required that supports the hierarchical structure of XML documents. A number of research groups have developed excellent consistency maintenance algorithms for hierarchical data models. The default implementation for consistency maintenance of XML documents provided by CEFX was inspired by the work of [2], [3], [5], [7], [8], [9] and others. A detailed discussion of our consistency maintenance algorithm for XML documents goes beyond the scope of this paper. Thus we can only give a very brief overview to its functionality.

In contrast to other, more general, consistency maintenance algorithms, the algorithm used here is based on XML as a data model. The finest level of granularity in this approach is an XML element node. Working on, for example character level, is not supported. If this is required an XML Schema could be used that defines a element node for each required granularity level, in this case for example character, word, sentence, paragraph, section, chapter and document. A character element node would contain only one character. A word element node would contain an ordered list of character nodes and so on. An important advantage of using XML as the data model is the hierarchical structure. Insert, delete and move operations can be performed on a higher semantic level such as a paragraph or a section. This increases the efficiency because there are fewer operations transmitted over the network and can help to enforce the semantic consistency of a document [2]. The basic set of operations used in the CEFX concurrency control algorithm is insert, delete, move and update. Additionally to support optional locking, lock and unlock operations are used. Each XML element node within a document is assigned a universal unique id (UUID). This allows addressing a node very quickly and unambiguously. This reduces the processing time in comparison to algorithms that use a positional addressing scheme (e.g. [5]).

5 Requirements, Limitations and Future Work

If the collaboration-aware approach is used to enhance a single-user application, access to the source code of an application is required. Additionally the single-user application is required to use XML as internal data model. These requirements are met by a range of open source XML and SVG editing applications and some applications used in the automotive industry. If the collaboration-transparent approach is used, a translation layer (TL) has to be implemented that connects to the provided application API. If an application provides a DOM API the development of the TL is straightforward. Currently a prototype of the CEFX framework is being developed by the authors. The next step is to enhance an existing application with collaborative functionality using the CEFX framework. For this we will integrate our framework into an existing application for the design of electrical symbols, using the collaboration-aware approach. These electrical symbols are then stored in the CLS and used in the design of wiring diagrams. Future plans are to integrate this framework into an application for designing and editing of wiring diagrams.

6 Conclusions

This paper contributes a novel collaborative framework concept that allows an easy enhancement of single-user applications with real-time collaborative functionality. CEFX provides the following novel features:

- Flexible plug-in architecture allowing third party developers to extend CEFX with new awareness widgets, concurrency control mechanisms and conflict resolution schemes. This allows the framework to perfectly adapt to the requirements of the process workflow. Applications that use CEFX will profit from new third party developments as well, without the necessity of changing source code.
- Support for collaborative work using heterogeneous applications. This is especially helpful in the automotive industry, where different tools are used to manipulate, analyze and check the same data (in our case the vehicle electrical systems)
- Flexible consistency maintenance algorithm for XML documents supporting optional locking of document parts. This allows adapted working schemes and privacy support (not discussed in this paper)
- A novel approach to the extension of single-user applications by making use of the DOM as a common interface. The CEFX approach simplifies the integration of the collaborative framework into an existing single-user application supporting both, the collaborative-aware and the collaborative-transparent approach

Although the number of applications using XML as a data model today is relatively small, we assume that with XML becoming more popular the number of XML applications will increase. CEFX provides a way to easily enhance such applications with collaborative functionality and we believe that its features promise a broad user-acceptance.

References

1. Chen, D. Sun, C, Jia, X. Zhang, Y. Yang, Y. Achieving convergence, causality-preservation, and intention-preservation in real-time cooperative editing systems. ACM Transactions on Computer-Human Interaction, Vol.5, No.1, March, 1998, pp.63-108
2. Ignat, C. Norrie, M. C. Tree-based model algorithm for maintaining consistency in real-time collaborative editing systems. ACM. Fourth International Workshop on Collaborative Editing Systems, New Orleans, Louisiana. 2002
3. Molli, P. Skaf-Molli, H. Oster, G. Jourdain, S. Sams: Synchronous, asynchronous, multisynchronous environments. In Seventh International Conference on CSCW in Design, Rio de Janeiro, Brazil, 2002
4. Ellis, C.A. Gibbs, S.J. Concurrency Control in Groupware Systems. In Proceedings of the 1989 ACM SIGMOD international conference on management of data. ACM 1989
5. Davis, A. Sun, C. Lu, J: Generalizing Operational Transformation to the Standard General Markup Language. Proceedings of ACM 2002 Conference on Computer Supported Cooperative Work, Nov 16-20, New Orleans, Louisiana, USA.
6. Lamport, L. Time, clocks and the ordering of events in a distributed system. Mass. Computer Associates, 1978
7. Sun, C. Ellis, C. Operational Transformation in Real-Time Group Editors: Issues, Algorithms, and Achievements. Proceedings of the 1998 ACM conference on Computer supported cooperative work , Seattle, Washington, 1998.
8. Galli, R. Data Consistency Methods for Collaborative 3D Editing. Ph.D. thesis, Universitat de les Illes Balears, Palma de Mallorca, Spain, Nov. 2000.
9. Ionescu, M. Marsic, I. An arbitration scheme for concurrency control in distributed groupware. In Proceedings of The Third International Workshop on Collaborative Editing Systems, pages 32–42. ACM, 2000
10. Xia, S. Sun, D. Sun, C. Chen, D, Shen, H.: Leveraging single-user applications for multi-user collaboration: the CoWord approach. Proceedings of ACM 2004 Conference *on Computer Supported Cooperative Work,* Nov 6-10, Chicago, IL USA
11. Wilkinson, N. Using CRC Cards: An Informal Approach to Object-Oriented Development. SIGS Books, New York, 1995.
12. He, F. Han, S. Wang, S. Sun, G. A road map on human-human interaction and fine-function collaboration in collaborative integrated design environments Computer Supported Cooperative Work in Design, 2004. Proceedings. The 8th International Conference on
13. Lu, J. Li, R. Li, D. A state difference based approach to sharing semi-heterogeneous single-user editors. CSCW'04 workshop on collaborative systems (IWCES-6) and application sharing systems. Nov. 2004, Chicago
14. Li, D. Li, R. Yu, Y. Yang, Y. Using Familiar Single-User Editors for Collaborative Editing. Proceedings of the 36th Annual Hawaii International Conference on System Sciences (HICSS'03)
15. Begole, J.M.A. Flexible Collaboration Transparency: Supporting Worker Independence in Replicated Application-Sharing Systems.[Ph.D. Dissertation. Virginia Polytechnic Institute and State University, Blacksburg, 1999

An Intelligent Tutoring System for Construction and Real Estate Management Master Degree Studies

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Abstract. Three e-learning Master degree studies were introduced at Vilnius Gediminas Technical University since 1999. In order to increase the efficiency and quality of e-learning studies, an Intelligent Tutoring System for Construction and Real Estate Management Master Degree Studies (ITS-CREM) was developed. ITS-CREM consists of six subsystems: Domain Model, Student Model, Tutor and Testing Model, Database of Computer Learning Systems, Decision Support Subsystem and Graphic Interface. ITS-CREM is briefly analyzed in the paper.

1 Introduction

The e-learning Master degree studies "Real Estate Management" was introduced at VGTU in 1999, Master degree studies "Construction Economics" from 2000, and Master degree studies "Internet Technologies and Real Estate Business" from 2003 (see http://odl.vtu.lt/). There are currently 220 master students from all over Lithuania studying in these three e-learning master programs.

Different multimedia and communication means are used during these studies, namely: electronic format of textbooks, video and audio, as well as computer-software, computer learning systems, intelligent testing systems, intelligent tutoring system, computer conferencing, computer networks, a discussion forum and 'face-to-face' contact. There are currently 220 master students from all over Lithuania studying in the above e-learning master programs. In order to increase the efficiency and quality of e-learning studies, an Intelligent Tutoring System for Construction and Real Estate Management Master Degree Studies (ITS-CREM) was developed.

ITS-CREM is used for the whole master degree study programme, while traditional ITSs are used only for a single subject or module. In this specific case, ITS-CREM was adjusted to two master degree study programmes: Real Estate Management and Construction Economics.

This paper is structured as follows. Following this introduction, Section 2 describes an Intelligent Tutoring System for Construction and Real Estate Management master degree studies. In Section 3 we have provided a description of the System Architecture. Finally, some concluding remarks are provided in Section 4.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 174 – 181, 2006.

2 An Intelligent Tutoring System for Construction and Real Estate Management Master Degree Studies

The Intelligent Tutoring System for Construction and Real Estate Management Master Degree Studies (ITS-CREM) consists of six subsystems: Domain Model, Student Model, Tutor and Testing Model, Database of Computer Learning Systems, Decision Support Subsystem and Graphic Interface. The subsystems are briefly analysed below.

Domain Model contains information and knowledge that the tutor is teaching. During three semesters in the master student's courses, students complete seven core modules and five optional modules. An elective choice is made from 21 modules within the "Real Estate Management" Master's degree Program and 17 modules within the "Construction Economics" Master's degree Program and students should optionally pass 5 examinations. During the fourth semester master students write a final thesis. After registration, students mark sections of optional modules they want to study in the electronic questionnaires. The system also offers study materials to students according to the repetitive key words in different optional modules (see Fig. 1). A mixed approach is also possible and available. The received information is used for action plans, i.e. "mini curricula" that are used to lead the learner/student.

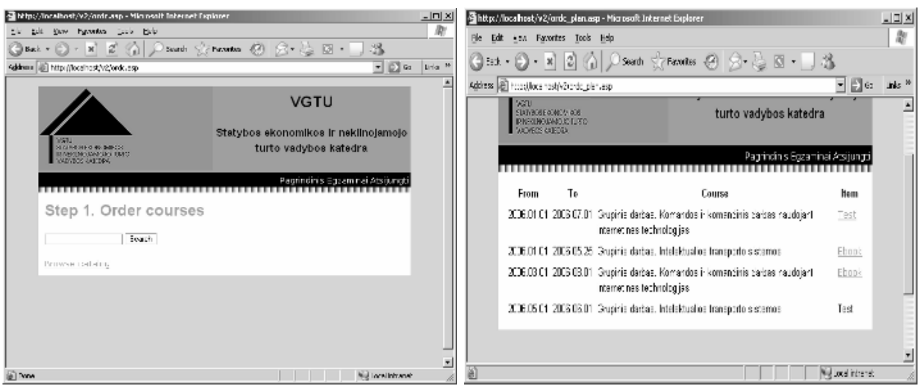

Fig. 1. Search of information for optional module according to repetitive key words (*left*) and selected material for optional module with defined schedule (*right*)

Much data had to be processed and evaluated in carrying out the multivariant development and multiple criteria analysis of an optional module. Numbers of feasible alternatives can be as large as 100,000. Each of the alternatives may be described from various statistical (the repetitive key words) and qualitative perspectives. The problem arises, how to perform a computer-aided development of the alternative optional module variants, based on this enormous amount of information. To solve this problem, new methods of multiple criteria multivariant development and multiple criteria analysis of an optional module was developed by authors (see http://odl.vtu.lt/proj1/md_of_ opt.htm). The development and multiple criteria analysis of an optional module is carried out in 5 stages: forming the table of optional module alternative paragraphs codes; rejection of inefficient versions; computer-aided development of optional module variants based on codes of paragraph alternatives; development of optional module versions; development of a summarised decision making table of all optional module versions obtained; multiple criteria analysis of the developed optional module versions, determination of priority and utility degree of alternatives.

The *Student Model* stores data that is specific to each individual student. The Student Model is used to accumulate information about the education of a student, his/her study needs, training schedule, results of previous tests (if he/she has studied earlier in the above-listed e-learning MSc programmes or qualification improvement courses) and study results. Therefore, the Student Model accumulates information about the whole learning history of a student. The Student Model starts by assessing the student's knowledge of the subject or what the student already knows. Student Model uses that data to create a representation of the student's knowledge and his/her learning process and represents the student's knowledge in terms of deviations from an expert's knowledge. On the basis of these deviations the system decide what curriculum module, or chapter (subchapter) of a module should be incorporated next, and how it should be presented (text, multimedia, computer learning system, etc.). Since the purpose of the Student Model is to provide data for the Tutor Module, all the gathered data should be able to be used by the Tutor module.

Decision Support Sub-system is used in mostly all components of the ITS-CREM (Domain Model, Student Model, Tutor and Testing Model, and Database of Computer Learning Systems) by giving different levels of intelligence for these components. Decision Support Sub-system was developed by applying multiple criteria decision making methods developed by authors [1, 3], i.e. a method of complex determination of the weight of the criteria taking into account their quantitative and qualitative characteristics; a method of multiple criteria complex proportional evaluation of the alternatives; a method of defining the utility and market value of an alternatives; and a method of multiple criteria multivariant design of an alternatives. Decision Support Sub-system aids and strengthens some kinds of decision processes. The Decision Support Sub-system is a computer-based system that brings together information from a variety of sources, assists in the organization and analysis of information and facilitates the evaluation of assumptions underlying the use of specific models. The Decision Support Sub-system comprises of the following four constituent parts: data (database and its management system), models (model base and its management system), user interface and message management system.

The Database of Computer Learning Systems enables the use of the following Web- based computer learning systems [1-4]: construction, real estate, facilities management, international trade, ethics, innovation, sustainable development and building refurbishment, etc. The above systems have been developed by using multiple criteria methods [1, 3] as were developed by the authors.

The created Database of Computer Learning Systems (CLS) is innovative since it contains a CLS with three integrated subsystems: a Decision Support Subsystem, Knowledge Subsystem and Devices Subsystem. For example, a Real Estate's Knowledge and Device-based Decision Support System (KDDSS-RE, see http://dss.vtu.lt/realestate/) consists of a Decision Support Subsystem, Knowledge Subsystem and Devices Subsystem. Major KDDSS-RE functions include creating and maintaining customer's personalized real estate objectives, preferences, and evaluation criteria;

participation of various stakeholders (buyers, sellers, brokers, etc.) in joint determination of criteria (criteria system, values and weights) defining real estate; market signalling, providing device-based data about the indoor microclimate and allergens causing allergy in the building; searching for real estate alternatives, finding alternatives and making an initial negotiation table, completing a multiple criteria analysis of alternatives, making electronic negotiations based on real calculations, determining the most rational real estate purchase variant, and completing an analysis of the loan alternatives offered by certain banks.

The use of multiple criteria computer learning systems in solving various problems encountered in the course projects and thesis was also aimed at determining: student's knowledge that is acquired at the university, student's general level of education, student's keenness of mind, student's ability to quickly and adequately respond to changing situation.

The Domain Model presents frames to the student. *The Tutor and Testing Model* provide a model of the teaching process and supports transition to a new knowledge state. For example, information about when to test, when to present a new topic, and which topic to present is controlled by this model. The Tutor and Testing Model reflect teaching experiences of associate professors or professors. The Student Model is used as input to this component, so the Tutor and Testing Model's decisions reflect the differing needs of each student in optional modules.

The Tutor and Testing Model formulates questions of various difficulties, specifies sources for additional studies and helps to select literature and multimedia for further studies and a computer learning system to be use during studies.

A student can select the level of difficulty at which the teaching takes place. For example, the chapters of modules with mathematical orientation (i.e. mathematical methods used for the estimation of market or investment values) are quite difficult for some students.

Traditional testing systems evaluate a learner's state by giving them a mark and do not provide a possibility to learn about one's own knowledge gaps or to improve knowledge in any other way. The Tutor and Testing Model compares the knowledge possessed by a student (test before studies) and knowledge obtained by a student during studies (test after studies) and then it performs a diagnosis based on the differences. By collecting information on a history of a student's responses, the Tutor and Testing Model provides feedback and helps to determine strengths and weaknesses of a student's knowledge, and his/her new knowledge obtained during studies is summarized and then various recommendations and offers are provided. After giving feedback, the system reassesses and updates the student's skill's model and the entire cycle is repeated. As the system is assessing what the student knows, it is also considering what the student needs to know and which part of the curriculum is to be taught next.

Also, there are options for selection of the following question in a test, which depends on the correctness of answers to the previous questions. Correct answers lead to more difficult tasks, incorrect – to easier ones.

The obtained knowledge is the difference between the possessed knowledge (test before studies) and the final knowledge (test after studies). The Tutor and Testing Model also explains why one or another answer is correct/incorrect and offers certain additional literature and multimedia related to the incorrectly answered questions.

By applying ITS-CREM, a tutor does not renew tests for every learner. Questions are saved in a question database and hundreds of test alternatives are developed casually. The question base of the Tutor and Testing Model accumulates the following information: questions according to modules, possible answers to a question, evaluation of the correctness of possible answer versions. An incorrect answer is evaluated by zero and a correct is evaluated by one (see Fig. 2 (*right*)); intermediate answers score from 0 to 1, the difficulty of a question is determined on the basis of the results of previous tests taken by other students (see Fig. 2 (*left*)), links to the study material that is related to the question and time allocated for testing.

The developed ITS-CREM helping us to collect, organize numerical information in the form of tables, graphs, and charts, analyze and interpret of numerical data and make informed decisions. Applying the System is possible: to find interesting patterns that identify the student's behaviour on the system; to store students interactions and feedback with the ITS, in order to maintain past memory experiences and then derive new paths of teaching.

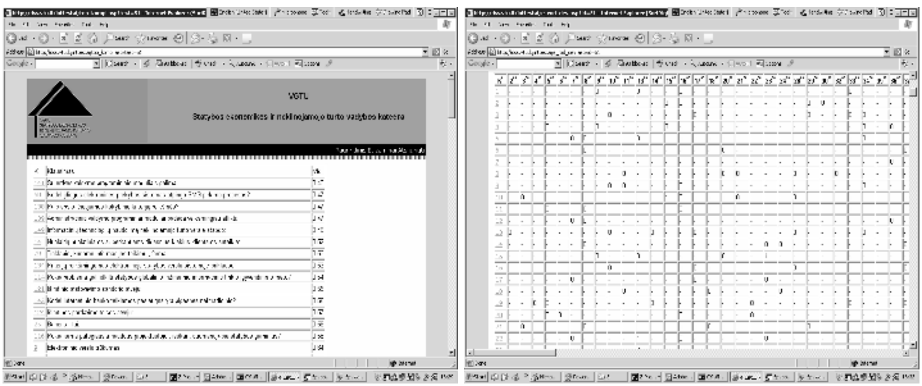

Fig. 2. Questions sorted according to difficulty (*left*) and information on the correctness of an answer (right)

The system provides information on testing process in a matrix and graphical form: information on correct and incorrect answer, time distribution to every question, number of times a student has changed an answer to each question of a test, etc. Also the complex parameters are presented, where not only the correctness of the answer is evaluated, but also the time required for student to answer as well as the doubts of selection. Evaluating the answer by a complex parameter, the knowledge assessment may even change.

By having such a question data base, it is also possible to create tests in a non-random way, but to individualize tests for each student according to the number of questions, their difficulty and proportion of questions from different topics. The received test results are saved in the results data base.

By using statistics provided by the Tutor and Testing Model, students can see the question's difficulty, average the evaluation of the whole group and learn about their position in the group before and after studies. Saving the data on a question's difficulty provides the opportunity of giving easier questions first of all and later moving on to more complicated ones. Similarly the topics can be selected – from the simpler to the more difficult by repeating the most complicated topics.

Therefore, on the basis of the compiled question's base, questions for tests are formulated not randomly; they are individually adjusted to each student according to the number of questions, their complexity and the proportion of questions from different modules. It is also possible to give easier questions at the beginning and then proceed to more complex questions. Similarly, it is possible to select the taught subject from easier to more complex and to repeat subjects that are not yet mastered.

A modern intelligent tutoring system can implement its functions effectively only when users have active dialogue with a computer by using means for dialogue organisation, which is determined by how the information is provided and how the information and commands are interchanged. Therefore, the system-user dialogue is important, as well as the *interface* (dialogue system) because they help one to have comfortable and effective dialogues. This system has a graphic interface: icons in windows opened in the computer screen show data, models and other objects available in the system. By applying the graphic interface a user can control data, knowledge, models and subsystems and review results on the computer screen or have them printed.

In order to clarify a number of issues related to the e-learning Master degree studies process (first and foremost the student motivation, efficiency of advertising, issues related to the quality of study materials, reaction of social environment, etc.) a survey and statistical analysis was conducted [2]. The survey and statistical research analyse in more deatail the composition of the student body by emphasis the problems of the learning process, the social, economic, moral issues related to the labour market integration of trained professionals, etc. An analysis of the ITS-CREM was performed by a designed questionnaire. The letter was attached to the questionnaire was as follows "We would like you to draw on your experience and expertise to help us to test whether the ITS-CREM can also meet *your* needs as a student. Please read through the following questions circling your response". A more complete study is underway to study the satisfaction of students.

Since it is impossible to cover the body of students from last six years, we selected 125 respondents from those who have already completed their e-learning studies (16 respondents) and those who are still studying (109 respondents).

The e-learning Master degree studies are very popular – over the period of 5 years the number of students has risen 6,7 times [2]. Students examination time by using ITS-CREM has decreased 3 times. According to performed a survey and statistical analysis these are the main advantages of ITS-CREM: convenient form of studies, an opportunity to get acquainted with new information technologies, saving of time, increasing quality of studies, fast communication, flexible choice of optional module, good professional training, etc.

3 System Architecture

The architecture of ITS-CREM consists of six main components: Domain Model, Student Model, Tutor and Testing Model, Database of Computer Learning Systems, Decision Support Subsystem and Graphic Interface. We have carefully studied the requirements of Lithuanian stakeholders in developing e-learning services. By reflecting on these requirements, our design of the ITS-CREM, aims at a system with the following features: accessibility, reliability, effectiveness, modularity and extendibility, easy to use, and multimedia. These features are described below.

The services provided by the system are widely accessible, by using Internet to reach a wide range of life long learning students and are on-line updates of information and maintenance of the services. ITS-CREM can be unreliable either inherently (unreliable primary data) or become unreliable within the system. The level of reliability depends on the reliability of databases and subsystems as well as the 'quality' of the students' learning process. In general, the system is considered reliable if it functions properly during the moments when needed by the student and if (when performing the set functions) it retains the necessary operational values for a required period. Also the system deals with multiple students at different locations.

The system is installed in a server, which runs on *Windows XP Server* and *Internet Information Services* and is based on the client/server model. HTML, ASP and ActiveX internet technologies are applied in the system.

The system provides a student-friendly interface to facilitate easy use of the teaching services. It provides an introduction to the system, a comprehensive window-based menu of services, and other relevant information about the university and its facilities management services.

The information in the database and knowledge base can be represented in different ways; i.e. it can be digital, textual, graphic, audio, video and combined. Since all the above-mentioned data and knowledge presentation forms can represent the same learning material in different ways then the most effective one has to be selected.

Together, these features and properties allow an open and flexible framework for providing services that are suited to both life long learning students. To achieve the above goals, the structure of the system must be well designed. For this purpose, we have chosen a client/server model. This model is a concept that is used for describing the interaction between two entities in a computer system, i.e. the student and the server. The main function of the Web Page Interface is to provide the student with an easy way to access the available services. Modules within this component provide functions that implement the services.

One of the system's components provides a channel for the stakeholders to market the latest required information and allows the stakeholders to maintain and update the information on-line. Updating and maintaining data in the database can be a difficult and arduous task. By having easy use of this component, the maintenance cost can be reduced. The Teaching Editor's Module provides the means for the teachers to edit date, which contains digital, textual, graphic, formula-type, audio, video, and combined data. To handle the complex interactions among students, teachers and the server, a synchronization mechanism are needed which coordinates accesses to the system data so as to maintain consistency. Otherwise, problems may occur because, for example, files can be corrupted, updated information may get lost and appointment books can be out of order.

4 Conclusions

The traditional Intelligent Tutoring System (ITS) model contains four components: the domain model, the student model, the teaching model, and a learning environment or user interface. Subsystems (Domain Model, Student Model, Tutor and Testing Model, Database of Computer Learning Systems, Decision Support Subsystem and Graphic Interface) of the Intelligent Tutoring System for Construction and Real Estate Management Master Degree Studies (ITS-CREM) created by authors are similar to typical subsystems of Intelligent Tutoring Systems (ITS). We believe that ITS-CREM has several advantages compared to traditional ITS:

- ITS-CREM is used for the whole master degree study programme, while traditional ITSs are used only for a single subject or module. In this specific case, ITS-CREM was adjusted to two master degree study programmes: Real Estate Management and Construction Economics.
- The created Database of Computer Learning Systems (CLS) is innovative since it contains a CLS with three integrated subsystems: a Decision Support Subsystem, Knowledge Subsystem and Devices Subsystem (see http://dss.vtu.lt/realestate/).
- The created Decision Support Subsystem is innovative since it contains a multi-variant development and multiple criteria analysis module, which allows to make multi-variant development and multiple criteria analysis of various alternatives (e.g. of an optional module). This subsystem is briefly described in http://odl.vtu.lt/proj1/md_of_opt.htm.

References

1. Kaklauskas, A., Ditkevičius, R., Gargasaitė, L. Intelligent tutoring system for real estate management // International journal of strategic property management. Vilnius: Technika, 2006, Vol. 10, No. 2, p. 113-130.
2. Rimkuviene, S., Lepkova, N. Analysis of experience and efficiency of distance learning Master's degree programme in construction economics and property management. Journal of Civil Engineering and Management, Vol X, No 1. Vilnius, Technika, 2004, 51-60 p.
3. Zavadskas, E., Kaklauskas, A., Vainiūnas, P., Gikys, M.: Property management in post-graduate Internet studies in Vilnius Gediminas Technical University. 4th Baltic region Seminar on Engineering Education, Lyngby, Copenhagen, Denmark. 1-3 September 2000. – UICEE. Seminar proceedings, edited by Zenon J. Pudlowski and Hans Peter Jensen. pp. 83-86.
4. Zavadskas, E., Kaklauskas, A.: Efficiency increase in research and studies while applying up-to-date information technologies. Journal of civil engineering and management. – 2000, Vol. VI, No. 6, p. 397-414.

Visualizing Space-Based Interactions Among Distributed Agents: Environmental Planning at the Inner-City Scale*

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Abstract. Since from the 1980s, computer science and artificial intelligence have focused on environmental planning, with high interest in analysing real and virtual cognitive agents at work. This is true for procedures, long-range planning, operational planning, as well as factors and scenarios of future events, future risks, multi-agent organisation, and resource-based planning.

This long-range, large-scale, strategy-driven interest has generally prevented short-term planning, low-scale and detailed planning from being explored with an intelligent-planning approach. This paper shows a case of small-scale inner-city planning for environmental and development issues in an urban context, with a sustainably sound approach.

In this concern, a system architecture has been set up, to support the interaction of local social, economic, financial agents by a web-based geographic interface able to visualize, share, channel substantial information in the planning process with a space-based approach. The details of setup methodologies and results are analyzed, trying to find potentials and critical characters of a georeferenced cooperative work, particularly attentive to the role of space-based cognitions and discourses in multi-agent interactions.

1 Introduction

Looking at *problem-solving* and *problem-setting* issues, cognitive science has recently generated an innovative need of non-expert knowledge, to integrate traditional expert knowledge in the quest for situational solutions and representations. At the foundations of such emerging need was the awareness of a greater generality, complexity, ductility of common knowledge toward general cognition tasks.

Integrated groups of expert and non-expert *knowledge workers* have then appeared in the typical interactive arenas of multi-agent cognitive processes of strategic planning -for example largely in planning non-immediate futures. In this expansion of cognitive agents' sphere, experts remained in one side and non-experts on the other side –the second ones being mere providers of cognitions whose processing and use is delegated to others. However, just the widening of strategic planning experiences has

* Within a joint study and research work, part 1 was written by D.Borri, parts 2, 3, 4 were written by D.Camarda.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 182 – 191, 2006.

highlighted the limits of a narrow distinction between expert and common cognitive agents. On the contrary, the efficacy of fully integrated spheres of cognitive agents has been pointed out [15].

Levels and natures of agents' social affiliations are only partially explorable. Thus, knowledge generated and processed in *forums* is never 'native' but partially 'transformed' and framed within social structures that knowledge itself produces and by which is produced. 'Contingent' transformations of cognitions induced by agents entering -often unexpectedly- into *forums* are linked to the tendency of those agents' cognitions to adapt, positively or negatively, to autochthonous agents' cognitions and expectations. This tendency is even explainable through the need of cognitive environments and 'intelligent' cognitors to adapt their cognitions, so as to activate various and significant interactions without a blocked confrontation [7].

Therefore, given the above mentioned aporias linked to the social and political frameworks of forum cognitions, why forums are regarded as useful for complex problems? More 'isolated' cognitions that the ones generated in forums, for example expert ones, are more 'native'? We could reply by confirming the usefulness of cognitive spheres integrated with expert and non-expert knowledge. Or we could even postulate the impossibility of an isolated elitarian cognitor [10]. Dealing with cognition spaces clearly requires peculiar architectures. They are open, interworking, wide rooms, large enough to contain the possible maximum number of agents concurring to forums in 'realistic' conditions of 'concurrence' [5][14].

Such forums are equipped with wide and rapidly and easily accessible (multi-indexed) memories, with the possibility of accessing exogenous or endogenous *frames* to continuously contextualize and clarify cognitive processes [6]. Previous experiences of our research group show the initial greater (e.g., temporal) efficiency of wide groups of agents interacting implicitly (by automated routines) in comparison with agents interacting explicitly by continuous external mediation, and meanwhile the greater efficacy implicitly interacting agents in the final stages of the process [13].

Starting from these reflections, the paper tries to explore issues and problems with particular reference to the city of Cerignola in southern Italy, whose municipality has set up a participatory process to draw a inner-city regeneration plan. After the present introduction, the second chapter describes the architecture of the planning process, arguing on the methodologies of building up the multi-agent system and its operational structure. The third chapter focuses on results of the interaction process, following particularly the effects in terms of the efficacy of space-based representation, in relation to the dynamics of cognitive and substantial contents. Brief final considerations und up the paper.

2 Methodology and Process Architecture

The context of study is Cerignola, a 60000 residents city of Apulia, in southern Italy (fig.1).

The planning process was organized in the articulated NW quadrant of the urban area, starting just adjacent to the inner core and extending till the border of an important highway road (fig. 4). The quadrant is full of decaying physical as well socio-economical characters, ranging from old buildings and neighbourhoods to abandoned environmental and historical resources, to unemployed living groups. In order to start a process of revitalization, a public grant was made available to the municipality, provided that the revitalization involves the leverage of private capitals and is managed by a public-private partnership.

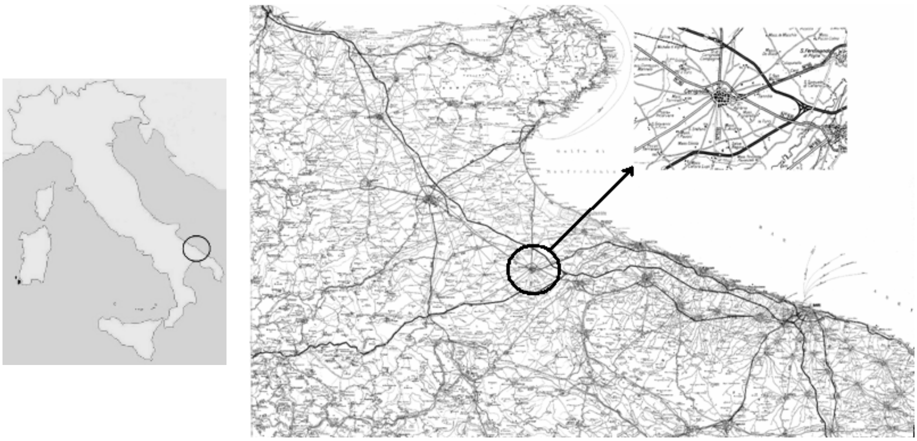

Fig. 1. The city of Cerignola in the national and regional context

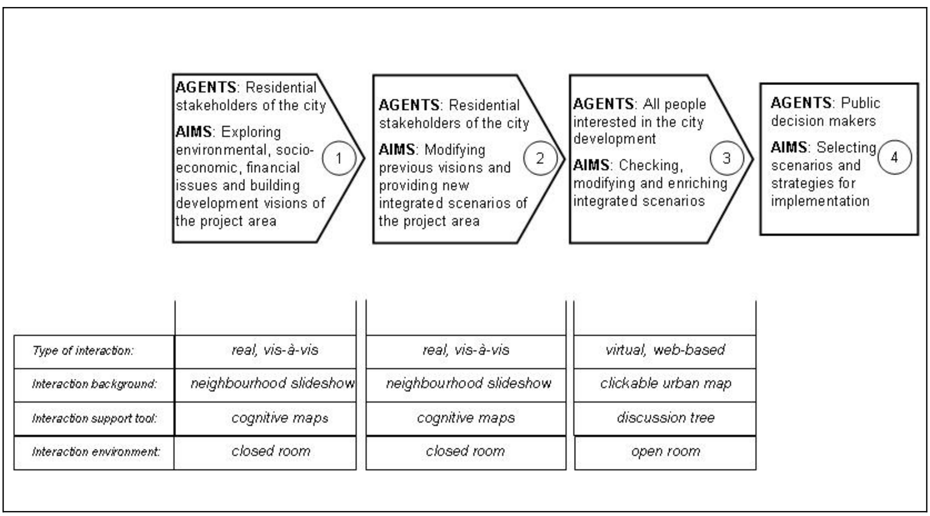

Fig. 2. The process layout

Therefore, the whole plan cannot be but funded on a diffused process of recognition of local resources and existing (or potential) conveniences. This is nowadays intended as a process of involvement of stakeholders, exchanging views and strategies within a broader framework of public governance [12]. Operationally, the layout can be sketched out as a cognitive multi-agent interaction, facilitated and supported by a human- and IT-based (hybrid) platform aimed at easing the identification of development scenarios and fostering more aware public decisions and policies. This layout is synthesized in fig.1, as a micro-scale evolution of the layout used in a previous regional experience [3].

The forum process is structured in two parts, pointing at a final non-forum decision-making step. The first part of the forum is developed using real, face-to-face interaction approaches, whereas the second by means of a virtual, web-based approach. The two parts are set up consecutively in two different environments, namely closed room and open room (fig. 2).

The first part of the process occurs in a real municipal room and is developed in two rounds, refining forum results using a variant of the classical *Delphi* technique (steps 1 and 2) [9]. City stakeholders, inhabitants, institutions, entrepreneurs, associations are invited to join the forum process through public advertisement. Grouped in the same room, they draw development visions in a first forum meeting (step 1), and such visions are the basis for a subsequent interaction round after some days (step 2), finally leading to a set of integrated planning scenarios for the second stage. In this first stage the interaction platform is a human-mediated cognitive mapping of issues, potentials, criticalities by participating agents, as happened in similar experiences [6]. Before accessing the forum, agents are asked to fill a questionnaire describing their residential and social characters, and interests in the area, so as to help the interpretation of contributions.

Case studies show that scenarios are the ultimate expression of agents interacting in ad-hoc protected environments (closed room), convened only because of their interests, frequently (unconsciously) selecting knowledge exchanges basing on speaking abilities, social rank, presence duration in the room [12]. Under these conditions, integrated scenarios are unlikely to be a real-world outcome, for some reasons (fig. 3).

As a matter of facts, in a closed-room configuration agents start interacting as a small group, progressively accepting new comers (and some leavers) who may change shape and characters of knowledge exchanged. The level of knowledge

- Agents come in and out, with asynchronous times of interaction: therefore existing frames need to be continuously rebuilt in order to allow effective interaction.
- Average agents do not have ‘strong’ interests, then their utility function gives low preference to participation: averagely they do not participate to forums.
- Agents represent organizations to which they report agreements after the forum: agreed visions may then be challenged and cancelled
- Being less influenced by other agents, interacting agents show different reactions in open room than in closed room
- In environmental planning, community agents hold interests (and are willing to deliver contributions) that are commonly space-rooted and geo-referenced.
- Geo-referenced concepts are critical in cognitive mapping.

Fig. 3. Characters of real-world interactions

achieved (cognitive frames, agents' roles, agreements reached), built as group knowledge, is likely to be highly structured, and each new comer has to face a transition period before being able to contribute substantially and coherently – i.e., to synchronise cognitive frames [15]. When real joining occurs, there are basic reasons needing to be explored, and questionnaires are aimed at that purpose. By the way, ad-hoc closed-rooms forums are often affected by biases, as said before, also because the difficulty in having participation may lead to unrealistic –yet demagogically used- results [8]. A move toward open-room forum is then desirable.

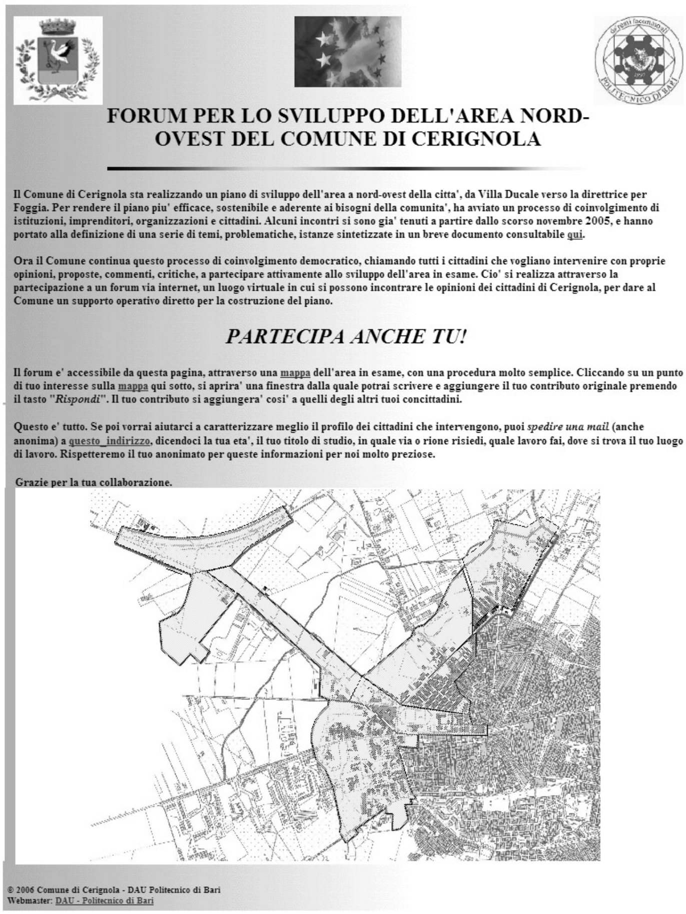

Fig. 4. The forum website

In order to add more visions and refine development scenarios, a further *Delphi* round is added to the process. New agents are called into the forum arena, this time possibly representing interests coming from the local community at large and involved in the process casually, during their normal day life. Further, participating agents give original contributions without necessarily reporting to reference organizations and power or hierarchical influences on each other are absent because contributions are anonymously and democratically delivered. This new forum situation, ideally represented by a public plaza or *agora*, has been operationally set up as a virtual web-based forum (step 3), aiming at allowing an open-room interaction, especially in comparison with the closed condition of the first stage of the process. The forum is addressed by an access webpage, through which stakeholders can participate to several discussion lists, concerning issues and problems corresponding to several zones of the inner-city area. Distributed agents can interact at any time and all contribution are then visible and categorized in the form of concept trees for each zone. Agents leave messages to as many discussion lists as they like, delivered with reference to the selected urban neighbourhood by using a clickable city map (fig. 4).

Also, contributors are invited to send a message to the server, indicating their residential and social characters and interests in the area, so as to better contextualize contributions in contributors' frames and facilitate interpretations [6]. In this way, visions emerged in closed-room steps are visualized, commented and amended by more cognitively unconstrained agents.

Scenario outcomes are then submitted to decision agents (municipal managers), so as to support evaluation and final deliberation.

3 Results and Discussion

In the first part of the process there was a fair participation, but agents' representativeness was highly polarized on building professionals and developers[1]. The (little) presence of citizens and associations did not prevent the debate from falling on mainly the profitability, convenience, financial and procedural issues involved by regeneration. In particular, in the first forum interaction (step 1), not even discussions on the physical aspects of building rehabilitation was reasonably dealt with, and structural socio-economic and environmental issues were substantially underconsidered. In the second interaction (step 2), the presence of a single but combative resident of the area allowed a slight enrichment of issues debated, yet they did not prove sufficient to challenge the social-disinclined structure of the vision emerged, while worsening its readability and manageability within the process (fig. 5)[2].

As a matter of facts, this general situation was not unexpected, since it was not rarely reported in literature [8]. Locally potent stakeholders are recurrently interested in influencing public decisions because of profit or working reasons, so prevailing on simple citizens, generally disaffected to public arenas also because of the difficulty in competing with experts on a formal-language basis. In this concern, interaction architectures are today increasingly articulated by allowing also non-formal (gesture, sketch, graphic) or computer-aided interactions [2][11][13].

[1] Participants to step 1 were (staff excluded): 15 professional engineers and architects, 3 housing developers, 4 farmers, 2 students; participants to step 2 were: 19 professional engineers and architects, 5, housing developers, 3 farmers, 2 students, 1 community citizen.

[2] This figure shows the great dispersion of the cognitive map. It proved to be quite unmanageable within the process, notwithstanding the contribution of single concepts -that are left intentionally untranslated because of this reason.

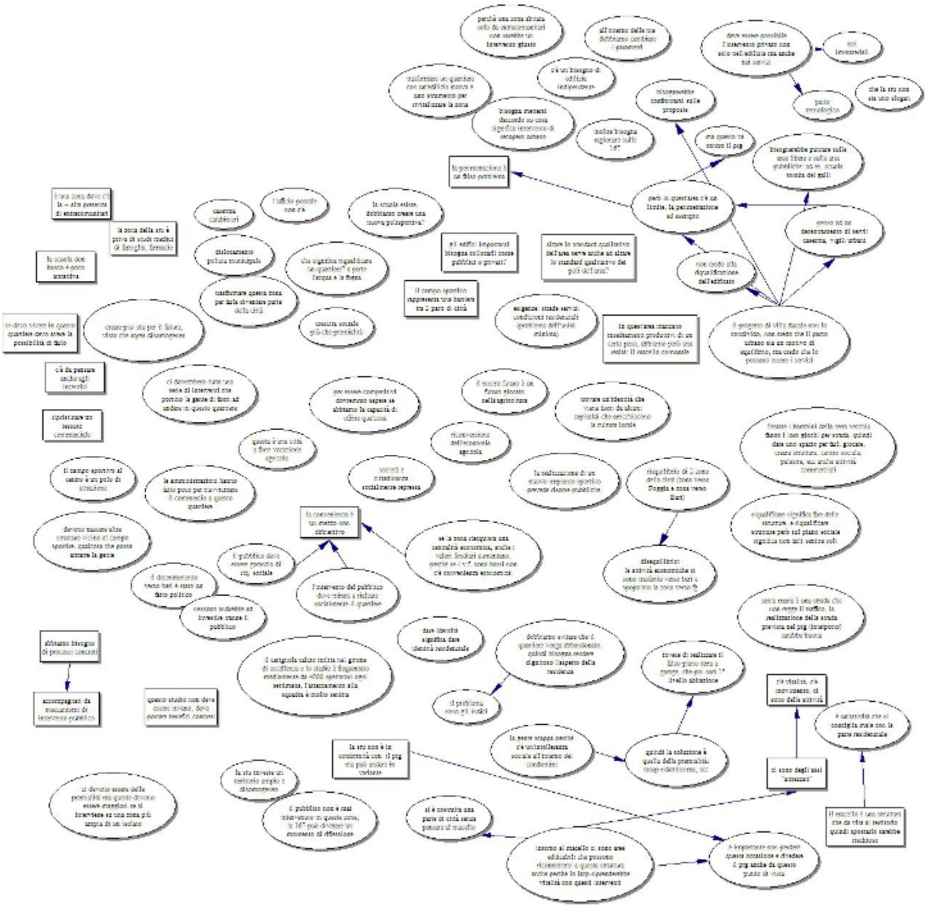

Fig. 5. The scattered cognitive map drawn in the forum first part

In this logic, the second part of the process (step 3), that was set up remotely and allowed geo-referenced contributions, revealed interesting outcomes in terms of process efficacy (fig. 6). First, the visualization of a clickable geographic representation of the city stimulated agents to express their views with an area-based orientation, so focusing issues on selected subjects and zones. Secondly, agents entering the forum in subsequent times were in turn themselves encouraged to deliver new or refined contributions on the same area, following the thread of views previously expressed (fig. 7). Third, by generally having a less dispersed contextualization of issues, comments tended to be deepened, so depicting issues in tendentially both positive and negative aspects.

In comparison with steps 1 and 2, scenarios envisioned in step 3 are less assorted but more focused and manageable. In fact, experience on building architectures to support decision-oriented interactions has often shown the paradoxical difficulty of synthesizing the complexity of issues at hand without loosing the richness behind that complexity [16]. The possibility of letting the interaction itself selecting contributions

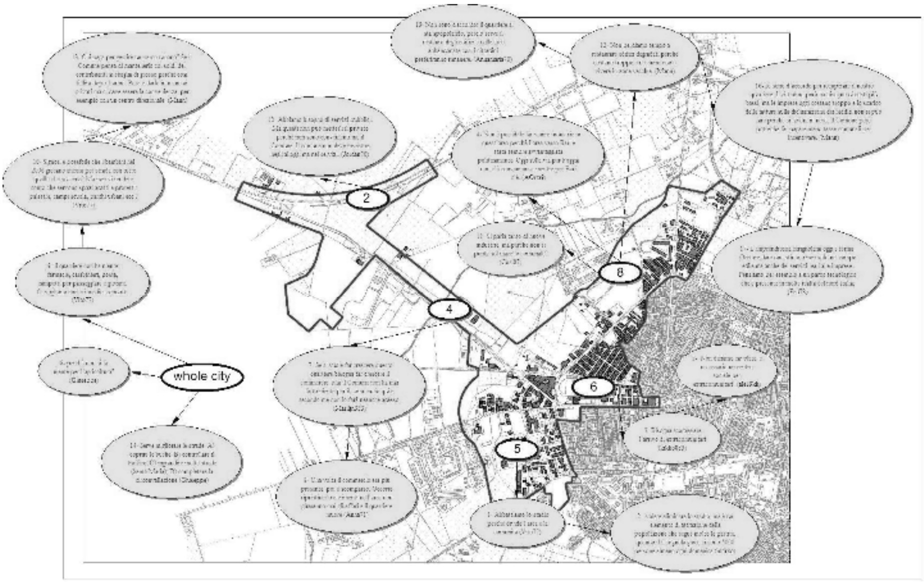

Fig. 6. The compact space-based cognitive map drawn in the forum second part (numbers are city zones)

Zone 8

I. Let's waste no time in rehabilitating decaying buildings because they are too expensive and people are unwilling to live in old areas
  A. I do not agree: the area is loosing population, so the rehabilitation of buildings and derelict lands is needed, so that citizens will stay
  B. I agree to revitalize our neighbourhood. However, citizens need lower prices, but today's enterprises are too expensive and so are recovered buildings: the municipality could low taxes as an incentive
    1. Local enterprises are not working today. A stimulus is needed not only in the housing field, but also in services. Let's consider, for example, a technology park like in many northern Italian areas

II. We talk so much of new industries, but why shouldn't we consider our local butchery?
    III. It is not possible let industries come to this area because the area toward Bari has always been preferred politically. Today, setting up industries on the road to Foggia has no convenience, while for Bari there is.

Zone 2

I. We need public services. But these services cannot be set up by the private sector because they are not convenient: only the municipality can do it. The municipality should not invest in housing but in services.

Zone 4

I. If we want to let this area grow the commerce sector must be increased. But the municipality has never done anything for the commerce and I think nothing will be done in the future
  A. Once the commerce was more present, then it has disappeared. It is necessary to restore it, otherwise it in the area there will never be business again and the neighbourhood will die

Zone 5

I. Let's demolish the stadium because it splits up the area and the community
  A. You want to eliminate the stadium, but it is an element of attraction of the population that attends the games very much. When Cerignola football team plays there are at least 5000 people every Sunday

Zone 6

I. We need to disincentive the arrival of non-EU migrants
  A. Don't say nonsense: a social center is necessary for non-EU migrants!

Zone 'whole city'

I. An improvement of the road network: A) fill up the holes; B) check the traffic; C) enlarge road sections (Santa Maria); D) complete the road bypass

II. Why nothing is planned for the agriculture?

III. The area doesn't have anything: pharmacies, policemen, mail offices, leisure lands to walk and play on. Medical doctors are even absent
  A. Is it possible that in 2006 children still play on the streets with all the dangerous events that happen? But don't you realize that proper and protected spaces are needed, e.g., gyms, fields school, urban parks etc.?
    1. Who pays to manage an urban park? If the municipality thinks of maintaining it with the money of taxpayers it is wrong, because then it'll fail after 1 year only. You can let private companies manage it but there must be a convenience, e.g., with a directional center.

Fig. 7. Synthesis of the resulted visions in the second part

without discretional influence (e.g., black-box computer filtering or human interpretation) has been increasingly investigated [4][13]. Now, the present process seems to show that in environmental-planning scenario building, a structural geo-based interaction platform can be very useful in this context. In particular, a contextualization on small inner-city areas proves to be more suitable for a geographic platform than broader areas, in environmental planning processes. In fact, unreferenced issues at a micro-scale environment risk to be too general and therefore hardly useful, whereas in large-scale territories characters are fairly to highly differentiated, so making also general contributions essential [1]. In the present case-study, this usefulness is pretty sketchy, due to the small number of agents involved, yet its potential is rather evident.

4 Concluding Remarks

The present paper has dealt with the building up of a system architecture oriented to support multi-agent interactions in an environmental planning process of an inner-city area, with a particular reference to space-based visualizations.

The process was built on a multi-stage interaction, where forum spaces were represented by both closed and open rooms, in order to allow a more democratic, articulated and less unconstrained development scenarios. In the open-room session, that was developed as a virtual web-based process, a prominent role was played by a geo-referenced point of access to the discussion arena, that allowed a deeper and more articulated visualization of scenarios.

Admittedly, due to mainly contingent reasons (a delay in setting up the web-based system, a fickle outreach, publicity and organization due to the administrative *enpasse* created by the 2006 Italian national elections) there has been little participation of people to the virtual forum up to today (the forum is still on line) and, therefore, it is not possible to speak in terms of proper scenarios. As a result, it is more realistic to speak of a number of connected ideas and concepts, sometimes general visions, perhaps a bit fragmented. However, the trend emerging is clear and points at a more significant consolidation of issues at hand, at least in comparison with a traditional face-to-face and closed-room forum.

In this framework, the integration of the two kinds of approach, supported by a structural geo-based architecture, is able to generate more manageable scenarios and therefore allow more aware and effective public planning decisions.

References

1. Barbanente, A., Monno, V.: Immagini Strategiche e Informazione Geografica per la Gestione Ambientale del Bacino dell'Ofanto. Proceedings of the Third National Conference on Informatics in Urban and Regional Plannig, Pisa, June 5-7 (2003)
2. Bloom, P., Peterson, M.A., Nadel, L., Garrett, M.F. (eds.): Language and Space (Language, Speech, and Communication). Bradford Books, Cambridge (1999)
3. Borri, D., Camarda, D., De Liddo, A.: Mobility in Environmental Planning: An Integrated Multi-agent Approach. Lecture Notes in Computer Science, Vol. 3675 (2005) 119-129

4. Borri, D., Camarda, D., Grassini, L.: Distributed Knowledge in Environmental Planning: Hybrid IT-Based Approaches in Scenario-Building Contexts. Group Decision and Negotiation (2006, forthcoming)
5. Borri, D.: Intelligent Learning Devices in Planning. Seminar on Computational Models in Design and Planning Support. Center for Advanced Spatial Analysis, University College London, London, September (2002).
6. Borri, D., Camarda, D., De Liddo, A.: Envisioning Environmental Futures: Multi-Agent Knowledge Generation, Frame Problem, Cognitive Mapping. Lecture Notes in Computer Science, Vol. 3190 (2004) 230-237
7. Damasio A.: Looking for Spinoza: Joy, Sorrow, and the Feeling Brain. Harcourt, New York (2003).
8. Forester, J.: The Deliberative Practitioner: Encouraging Participatory Planning Processes. MIT Press, Cambridge (1999)
9. Friend, J., Hickling, A.: Planning under Pressure: The Strategic Choice Approach. Butterworth-Heinemann, Oxford (1997)
10. Gardner, H.: Intelligence Reframed: Multiple Intelligences for the 21st Century. Basic Books (1999)
11. Kendon, A.: Gesture: Visible Action as Utterance. Cambridge University Press, Cambridge (2004)
12. Khakee, A.: Participatory Scenarios for Sustainable Development. Foresight, Vol.1 (1999) 229-240
13. Khakee, A., Barbanente, A., Camarda, D., Puglisi, M.: With or Without? Comparative Study of Preparing Participatory Scenarios Using Computer-Aided and Traditional Brainstorming. Journal of Future Research, Vol.6 (2002) 45-64
14. Maciocco, G. (ed.): Le Dimensioni Ambientali della Pianificazione Urbana. FrancoAngeli, Milano (1991).
15. Shanahan, M.: Solving the Frame Problem. MIT Press, Cambridge (1997)
16. Sillince, J.A.A., Saeedi, M.H.: Computer-Mediated Communication; Problems and Potentials of Argumentation Structures. Decision Support Systems, Vol.26 (1999) 287-306

Visible Display of Automated Observation of Collaborative Workspaces

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Abstract. Through the Facilities Innovation Research Programme, (www. facilitiesinnovation.co.uk) staff at the University of the West of England, Bristol and at Johnson Controls have been investigating systems that have the potential to track collaborative activities in the workplace, capture them, and in real time respond to them. The longer term goal is to develop embedded technologies that provide intelligent feedback in predictable office environments but also address the unpredictable working environments of nomadic knowledge workers and of remote workers engaged in virtual collaboration with those physically present. Some of these systems are relatively close to market and others are less immediately applicable. It is suggested that a heterogeneous mix of such systems is likely to be necessary for some time to come. A prototype real time location system for workers has been developed and is being tested to determine the extent to which it assists in better management of space and support of collaborative activity.

1 Introduction

Because of increased mobility in their day-to-day work, collaborative workers today interact in a wide variety of working environments, yet there is no basis yet for a fully effective working environment which responds to demands and needs in a proactive manner. Through the Facilities Innovation Research Programme (FI) Johnson Controls and their research partners have launched an investigation into such ‘smart space management’[1]. Within this initiative the ‘Visible’ project has the overall goal of mapping and utilising users’ behaviour while collaborating, to monitor, record and store contextual knowledge in order to automatically provide a working environment adapted to the needs of each user or group of users. This paper examines the scope for that first stage of mapping user behaviour, in order to understand better how space affords or disables collaborative knowledge work, and how that environment can be optimised. Some of the systems to enable this mapping are relatively close to market and others are less immediately applicable. It is suggested that a heterogeneous mix of such systems is likely to be necessary for some time to come. A prototype real time location system for workers has been developed and is being tested to determine the

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 192 – 199, 2006.

extent to which it assists in the better management of space and in support of collaborative activity.

"The concept of Ambient Intelligence (AmI) provides a vision of the Information Society where the emphasis is on greater user-friendliness, more efficient services support, user-empowerment including respect for privacy, and support for human interactions. People are surrounded by intelligent intuitive interfaces that are embedded in all kinds of objects and an environment that is capable of recognising and responding to the presence of different individuals in a seamless, unobtrusive and often invisible way"[2]. For this it is held that there will need to be substantial integration of three converging technologies: (1) Personal Digital Assistants (Palm or Windows CE); (2) Wearables / objects and people (includes RFID); and (3) microelectronic controlled equipment. "Most of these systems are currently stand-alone. Integrating these devices in an integrated communication environment using existing or easy-to-install networks (e.g. powerlined, wireless systems) will allow major enhancements to existing and the creation of completely new applications and services"[3].

Furthermore it has been suggested that employees need different types of ambient intelligence applications than citizens in general, because work organisation, business process redesign, change management, motivation, reward systems, etc. are involved [4]. "The discipline of work design faces a fundamental dilemma: Increased productivity involves specialisation, standardisation and an increased degree of routine, i.e. a reduction of complexity. On the other hand, the innovative ability of knowledge-intensive enterprises and the competence development of knowledge workers require an increased complexity of tasks. It is necessary to consider the complete working system (competence, staff, work, technology, organisation)"[5]. More research is needed into the inter-relations between knowledge workers and their organisations with regard to the constraints and affordances of their working environments. This paper examines the scope for currently equipping the working environment with sensors that 'perceive users', suggesting this is a prerequisite before such research leading to forms of context based communication can become effective.

2 Longer Term Research Goals

Ambient Intelligence is the now increasingly widely used term that embraces: ubiquitous computing; pervasive computing; 'smart' technologies; and the convergence of devices, communications and networks. It is in use by the EC and most major mobile phone companies. Its development is in theory based on continuous user evaluation and feedback, not waiting to discover customer demand, and so based on forward gazing scenarios and 'living labs'. The WWRF 'book of visions' in 2001 [3] stated that "In the mobility and location-related category sensory input will play a major role in providing the information. Sensor technologies are embedded in the mobile equipment and networks and services will sense who the user is, where he is, what he is doing, what the environmental conditions are, etc. The environment itself will also be equipped with sensors that perceive users and communicate with their devices." However it is not clear that much has changed since 1999, when it was stated that "Understanding human activity is held to be one of the most difficult open problems in the area of automated video surveillance"[6].

In studying mobility in the workplace Kakihara and Sørensen stated that “a workplace is a particular subject area of CSCW [Computer Supported Cooperative Work] in general and the study on mobility in particular, since increasing mobilities in various dimensions have further mobilised people’s collaborative work and sharing knowledge in workplaces…We then could argue that contextuality plays a critical role in constituting human interaction just as spatiality and temporality do. Contexts in which people reside continuously frame their interaction with others, including people’s cultural backgrounds, particular situations or moods, degrees of mutual recognition, and so on”[7]. They went on to identify the relevance of and to categorise location as: ‘in space – where? in time - when? and particularly in context: in what way; towards which actor(s); in what circumstances?’[8]. Hornecker defines CSCW embodied facilitation as follows: “tangible interaction systems provide procedural as well as physical and spatial structure, which shapes the ways we act. It can induce collaboration, foster it or make us refrain from it. Thus, tangible interaction systems embody styles, methods and means of facilitation”[9]. Bradley argues that “a coherent evaluation and feedback system should be an integral part of any workplace change program…Without such a learning loop, we will fail to convince business leaders of how changes in corporate workplaces contribute to business success”[10].

Other Needs for Better Observation of the Workplace

Static, physically co-located organisations are insufficiently understood, yet ‘Corporate Real Estate 2010’ forecast that the biggest challenge for the FM industry is the transformation of the business environment towards ‘networked enterprises’, one dispersed but connected working environment, where IT/ICT support and communication are essential [11]. Workplaces are a major cost burden for organisations and organisations therefore require a better understanding of how this space is used by employees. On average 60% of workstations are unused during normal working hours, (for example it has been estimated that there are 48 million sq. m of unused or underused space in the UK against a possible 561m sq. m across the EU15). The average cost of each workstation is around €15,000/yr [12]. Heerwagen et al argue that there is a central conflict in designing collaborative working environments (CWE): “how to design effectively to provide a balance between the need to interact and the need to work effectively by oneself. The body of literature shows that features and attributes of space can be manipulated to increase awareness, interaction and collaboration. However, doing so frequently has negative impacts on individual work as a result of increases in noise distractions and interruptions to on-going work”[13]. This paper argues that space and facilities can either constrain or support collaborative work and that, while there is not enough research to be able to accurately predict the impact of changes to the workplace, changes must still be made. As Marmot states “because investment in the workplace is relatively long term, with buildings typically lasting thirty years or more and fit outs typically ten years, future trends must be anticipated within the limits of current knowledge”[14]. There is a need for more research into: how people use their workspaces; which uses are more effective for interaction / team and knowledge work; which uses can be enhanced through digital means; when people have just-in-time or ad-hoc working needs and whether these can be automatically detected to trigger a system response.

3 RTLS in the 'Visible' Project Programme of Research

In Facilities Management the state of the art for research into space usage and employee behaviour is at best to observe and retrospectively analyse playback from CCTV cameras, undertake work-studies or audit space use as largely a clipboard and observation process. Gilbreth, who over 100 years ago first commenced the process of 'time-study' observer based analysis and notation of activity in the workplace, is still being cited today [15]. Such observer based notation methods continue to be developed [16]. While the process of 'Experience and Application Research' defined by ISTAG [17] uses the concept of the 'Living Lab'. The 'Living Lab' has been defined as a user-centric research methodology for sensing, prototyping, validating and refining complex situations in multiple and evolving real life contexts. Such field trials have been shown to provide contradictory results to those from focus group research, leading to more valid results about the attractiveness of new applications from more fully engaged users.

In offices there are already various systems: Asset Management; Building Management Systems (BMS); Access Control (video, security, etc.); that could in principle act together as ad-hoc 'living labs', and thus better support and partially react to staff needs. However these are not sufficiently integrated for information gathering, analysis, or for automating interventional changes in response to detected user need. Even sophisticated BMS are not able to detect and therefore automatically respond to actual occupancy levels, yet user surveys reveal that worker productivity and contentedness are inter-related with their environmental conditions [18]. Although technically these systems could be used for observation, in practice they remain static and unable to self-interact with the user to meet changing individual and group needs within CWE's. This static state is an impediment to enhancement of collaborative interaction via ambient intelligence. While ISTAG 2004 generally defines 'Field Trials' as quasi-realistic, the FI team is seeking to apply these technologies in mobile trials within real working environments, initially to automate and speed up the previous clipboard observational process, and later to apply cognition, ethnographic and psychology based user-centric research into: interaction technologies for collaborative interaction in an ambient intelligence context; appropriate design processes; methods for usability testing; and test and validate prototypes. It is argued that current observational sensor tools need to be robustly relocatable, since sensor costs are still high, and there are issues of privacy to address, that are eased if the installation is usually temporary.

3.1 Real Time Location Systems

Many aspects of Ambient Intelligence are state of the art, not requiring radical technological innovation to support simple identification and tracking or cover industrialisation and socialisation. The challenge is to determine a user's actual location with sufficient precision to explore user mobility, context and interaction. Hence these systems need to comprise a Real Time Location System (RTLS) that for specific tasks will require being in advance of the state of the art in positional accuracy. Mobile phone or GPS location tracking is not accurate enough or effective indoors.

RTLS accuracy depends on enhancement techniques that go beyond the mobile phone identification of presence within a cell, location fixes are based on either the time difference between signals reaching different access points, or the strength of the signal from the device as measured by the access points, or multiples of these known as RF fingerprinting. Time difference tends to be used more outside, and signal strength more inside buildings. Further refinement is achievable using triangulation from several receivers (beacons / access points) or trilateration. High levels of accuracy have been achieved in lab tests, e.g. the Cricket ultrasound system claims centimetre accuracy in mobile situations under lab conditions with line of sight [19]. Accuracy is lower in workplace applications using current commercial systems. The 'Ekahau Position Engine 3.1 using proprietary location technology (calibrated positioning model based) claims an accuracy of up to 1m (indoors with 3 or more overlapping access point signals) "as compared to the Cisco location engine, which may have a variance of 20 feet. Therefore, it finds increased application in item-level tracking as compared to zone-level tracking"[20].

The Current Facilities Innovation Real Time Location System

Following research and development the FI team has newly installed a showcase building using RFID (Radio Frequency ID) tags worn as security passes by personnel to form an RTLS. This system has been developed to be visually unobtrusive in highly polished corporate settings. The tags have antenna and batteries (hence high cost) and broadcast their position once a minute (battery life is approximately 2 years depending on frequency of broadcasts). These broadcasts are received by specialist (potentially battery operated) wi-fi based readers (collated back to a wireless access point) that can be adjusted to receive only within a limited globe of space, and can overlap. Hence close up readers can be adjusted to receive within a zone of a few centimetres close to a desk or appliance, while other over-lapping readers are adjusted to detect the complete zone or room. The skill is in configuring the arrangement and sensitivity of the readers. The tests have shown that approximately 0.7m accuracy is achieved. In conjunction with effective mapping of furniture and facilities this level of accuracy allows e.g. the frequency of use of space to be monitored, occupancy rates to be assessed, and void space to be identified. Collaborative contacts between workers can be inferred, but not precisely known. It needs further enhancement to fully support an AMi environment. (Early results of use of the system will be reported at the conference.)

The currently implemented Space Management Tool in the context of the Facilities Innovation Real-time-location-system delivers a host of tangible benefits including:

- Increased Accuracy: it records activities using RF technology to assess location with real-time user information to capture mobile workers to within centimeters;
- Redeployable / Reconfigurable: due to the costs of devices currently the system has been designed to be fully redeployable. A snapshot can be taken of a to-be-changed environment prior to that change, and the outcome re-measured at selected times following implementation of the changes;
- Scalability: hundreds of mobile workers and users wearing smart cards can be tracked simultaneously, helping ensure that location services can be applied to an entire working environment;

- Transparency: it is the only solution to integrate location tracking with industry standard FM software such as Archibus. A single networked interface point suffices to exchange data with the FM system;

Space typology	Real time occupancy grid	Space utilisation grid	Reporting

Fig. 1. Screenshots from live system

- Flexibility: it offers an integrated system which allows accurate monitoring of mobile workers and/or devices equipped with RFID Smart Cards. It helps FM to appropriately manage the space, instantly knowing which space is vacant or in-use;
- Integrated into Business Systems: It is fully integrated into broader business systems, and a complete bespoke Space Management Tool is in use with state-of-the-art technologies and graphical user interface;
- Integration: It can deliver asset tracking, inventory management, location-based security together with other new business applications that can be easily integrated to the solution (e.g. links to Finance or HR systems via ORACLE or SAP).

Future Development

Many issues remain that need to be resolved, if automated observation is to become more effective. One issue is how much needs to be detected automatically to be effective? Is it enough to record the time and duration of tasks, or is it necessary to break down tasks into sequences of actions? If it is enough to record the time and duration of tasks can this be done by the declaration of the user, or the use of an RFID smart card to identify that the task is being started and ended? If it needs to be broken down into sequences of actions then there are a number of existing approaches to notation of actions (deriving from time-study etc), that are worth investigating to determine which may be most useful.

There is an argument that no single current technology can yet operate sufficiently effectively to reliably capture and record or analyse actions, but that hybrid systems or fusions of systems may. However these systems would then also require software that could arbitrate and best guess when the results of different sets of sensors are not in accord. Most of the systems available are most fully effective with line of sight, and the wireless ones that can operate out of sight are prone to variable occlusion (from columns, furniture and people) and false readings from reflections. One way in which accuracy can be further improved is by techniques that map and calibrate the space for reflections and occlusions, such as using a known reference grid of ‘passive tags’ to provide accurate location specific information about local signal loss or reflection, or combining with inertial navigation systems that estimate positions using accelerometers or digital gyroscopes. However in the WiFi field currently the best accuracies achieved through use of calibration are approximately 0.5m, although ultra-wideband is being suggested as less prone to such interference. It would appear likely that the most immediate contribution to be made by the emergence of coherent embedded devices in the equipment in use in the workplace may thus be to assist in providing a larger if ad-hoc grid of APs and therefore greater triangulation as well as a more highly calibrated environment.

The FI team have also explored the use of digital means to record and capture synchronised real-time sensor, video and audio data for observation. The current major disadvantage of such approaches is the enormously time consuming retrospective analysis of the results, that reduces the number of experiments that can be run. The Valhalla IST project led by UWE, Bristol [21] showed that calibrating real-time video against objects in a previously mapped space made it possible to associate and later search and retrieve a video 'shot' from automatically added metadata about objects in the field of view. Similarly inferred collaborative activity recorded in real-time from RFID tagging could be used to identify and to retrieve specific video shots for observational analysis, and so enhance and speed an otherwise conventional analytical observational process, to determine the accuracy of the inferences. Fully automated observation may emerge from a combination of RFID and other wireless technologies to capture out of sight or obscured activity in conjunction with automated real-time analysis of video - face tracking technologies are already in use, and gait or posture analysis is emerging, although clothing creates difficulties by changing the expected human profile. While these are issues that need to be addressed and overcome, solutions such as the use of infrared technologies have also been investigated that are not so readily obscured by clothing, and that may serve to better preserve the privacy of those observed. Consideration has been given to the real issues of awareness of surveillance and how to gain informed consent. On the one hand reality TV tends to indicate that users get used to being 'surveilled' after an initial period, so maybe the observer does not alter the experiment as much as might be expected. On the other hand privacy of location is not guaranteed in any UK privacy-related legislation [22].

4 Conclusion

Within the limits of current technologies it would appear that practical ambient collaborative workplace environments are still some way from achievement. There is a need for much more research, for example to enable distinctions to be made between the various needs and modes of work of different workers as individuals and in collaboration. There is a need for better data more effectively using new technologies for automated observation and detection. If actions are able to be recorded adequately there still remains the issue of how to recognise adequate or effective performance, followed by how to enhance performance by identifying and removing constraints and positively facilitating the actors. When an automated system emerges to detect sets of actions and compare them to an optimal standard, it would appear to follow that that system should both appropriately enhance the environment and provide persuasive feedback to encourage operation at that level of performance.

Acknowledgements

Dr. KJ Kristensen, Dr. C Aguilera, for discussion via various bid writing exercises.

References

1. www.facilitiesinnovation.co.uk
2. From ftp.cordis.lu/pub/ist/docs/istagscenarios2010.pdf
3. WWRF Book of visions (2001) www.wireless-world-research.org
4. Kristensen, KJ. in discussion 2005.
5. Nejdl, W, Wolpers, M. (2004) 'European E-Learning: Important Research Issues and Application Scenarios' ED-Media 2004, Lugano, Switzerland.
6. Collins, RT Lipton, AJ Kanade, T (1999) 'A System for Video Surveillance and Monitoring' esil.univ-mrs.fr
7. Kakihara, M. Sørensen, C. (2001) 'Mobility Reconsidered: Topological Aspects of Interaction' IRIS 24, Ulvik, Norway, Bergen Uni.
8. Kakihara, M. and C. Sørensen (2002). "Mobility: An Extended Perspective." 35th Hawaii International Conference on System Sciences, Hawaii, USA.
9. Hornecker, E (2005) A Design Theme for Tangible Interaction: Embodied Facilitation Proceedings of the 9th European Conference on Computer Supported Cooperative Work, September 18-22, Paris, France. Springer
10. Bradley, SJ (2001) 'What's Working? Briefing And Evaluating Workplace Performance Improvement' Occupier.org
11. Review of Corporate Real Estate 2010 report www.nreionline.com
12. The Flexible Working Survey, sponsored by Johnson Controls, undertaken through the FI programme. www.mosaic-network.org
13. 13. Heerwagen, JH. Kampschroer, K. Powell, KM, Loftness, V. (2004) 'Collaborative knowledge work environments' in Building Research & Information Issue: Volume 32:6 Routledge
14. Marmot,A. (2003) 'Future Proofing: Key trends influencing the future of the workplace' www.occupier.org
15. eg Reeves, TC. Duncan, W. Ginter, PM. (2001) 'Motion Study in Management and the Arts: A Historical Example' Journal of Management Inquiry 10: 137-149.
16. eg Computer-aided Time Study Work Sampling Industrial Engineering and simplification methods www.c-four.com and e.g. http://www.worksimp.com/
17. ISTAG Report on Experience and Application Research "Involving Users in the Development of Ambient Intelligence" http://www.cordis.lu/ist/istag.htm
18. Zagreus, L. Huizenga, C. Arens, A. Lehrer, D. (2004) 'Listening to the occupants: a Web-based indoor environmental quality survey' Indoor Air 2004; 14 (Suppl 8): 65–74
19. Smith, A. Balakrishnan, H. Goraczko, M. Priyantha, N. (2003) 'Tracking Moving Devices with the Cricket Location System'
20. Quoted in the RFID Gazette online at www.rfidgazette.org/asset_tracking/index.html
21. The Valhalla Project EC - IST-2000-28541. http://environment.uwe.ac.uk/valhalla
22. From 'Visualization and multimedia: Wireless GIS and Location Based Services' conference March 2004 ESRC Transdisciplinary Research Seminars Programme. Coordinated by University College London's Centre for Advanced Spatial Analysis.

A System to Support Collaborative Mobile Electronic Meetings

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Abstract. In this article we focus on the meetings that according to different aims are held in organizations. In these work meetings the participants share information, discuss ideas, make decisions and produce documents. Specifically, we approach a type of meeting in which the participants are at distance and make use of mobile devices on wireless networks. Along this line, we have developed a system to support these new kinds of electronic meeting settings. The system design was informed with our observations of real meetings, the analysis of some EMSs and other information collection techniques. The system, called REMO, follows a three-stage model (pre-meeting, meeting and post-meeting) and includes a wide set of collaborative tools. REMO can be used both from a central meeting place, with video-projectors and interactive whiteboards, and from remote locations.

1 Introduction

The areas of CSCW and Ubiquitous Computing are being developed with growing speed in the last years, attracting the interest of many researchers. In the future, software systems will incorporate ubiquitous and collaborative facilities in a more natural and transparent way for the user. But at the moment, it is necessary to investigate how traditional work settings can be supported and enhanced using these technologies.

In this article we focus on the meetings that, with different aims, are held in organizations. In these work meetings the participants share information, communicate, make decisions, and produce documents. A technology-supported meeting seeks for increasing participation, innovation and problem solving capability [16]. The systems used in these meetings are called Electronic Meeting Systems (EMSs). But society demands more flexible organizations. These trends result in teams whose members are scattered over large geographic areas [15]. We approach a meeting in which the participants do not have to be necessarily present in the same physical space nor be static but they will be able to move and therefore they will use mobile devices.

From this perspective, we aim at developing a software system to support users to hold mobile electronic meetings (MEMs). We call such a system Mobile EMS. A

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 200 – 210, 2006.

Mobile EMS gives response to the demands of society and organizations in terms of mobility and productivity in meetings. The devices that people will use to participate in these meetings will be very different, ranging from desktop PCs, laptops and Tablet PCs to more mobile devices such as PDAs (Personal Desktop Assistants) and mobile phones. Wireless technologies for their inter-connection will be used. Other interaction devices such as video-projectors or interactive whiteboards complete the MEM configuration.

The design of this kind of systems requires not only technical considerations but also social and psychological ones, since it is necessary to study the people's behaviour and how they collaborate during a meeting held by means of a technological environment supporting work at distance. Along this line, a series of interviews and questionnaires have been carried out to collect user requirements of the meetings that take place in different organizations. This has allowed us to outline the system functionalities. Some tools for preparing the meeting (objectives, participants, documents, agenda, etc) must be offered. These are pre-meeting tools. Also other tools for holding the meeting from any location are required. Among them we can mention communication, voting and edition tools. In a post-meeting stage the participants need access to the artefacts produced and the decisions made.

After describing the results of a questionnaire presented to potential users of these MEM settings (Section 2), this article continues with the study of some related systems (Section 3). Then, in Section 4, the system developed to support MEMs, called REMO, is described. Finally, we draw some conclusions and outline the future work in Section 5.

2 Analyzing Electronic Meetings

In the design of the REMO system we first considered the study of organizations and the meetings they hold. Although there are many types of organizations and meetings, our objective was to design a generic and flexible system able to give support to the greatest possible number of meeting types.

In order to collect user requirements we elaborated a questionnaire that was filled out by two different collectives: workers from organizations who participate in meetings using or not using computer technologies, and Computer Science (CS) engineers. The former answered the questionnaire in the context of the meetings they hold more frequently, expressing necessities and contributing their professional experience. The latter, by means of the same questionnaire, contributed solutions to model a MEM.

The workers (N=33) were from enterprises such as banks, software factories, business companies, insurance companies, etc., and from research and academic organizations. They were general managers (9.1%) as well as department directors (18.2%) and operative employees (69.7%). In relation to the computer-supported cooperative work tools they used, they considered the electronic mail as the most useful groupware tool in their work. This was followed by the instant messaging (chat) and by the audio conference. Tools such as shared whiteboards, video conference and group document editors are also used but with less frequency.

These workers from organizations participated in meetings to organize or plan their activities, and to make demonstrations. When they were asked about whether they thought that it would be useful that some of them could be in other location or in mobility situations (e.g., travelling) in these meetings, 75.8% answered affirmatively, 15.1% answered negatively, 3% indicated that they did not find it useful, and 6.1% thought that there were not enough resources in their organization to support this. Additionally, although 63.6% of the workers polled viewed using a PDA to attend an electronic meeting at distance and to participate actively as beneficial, only 15% admitted using a PDA in their work, and 12.1% indicated that they used it at a personal level. This is an indicator that PDAs are not yet very much in use in Spanish organizations.

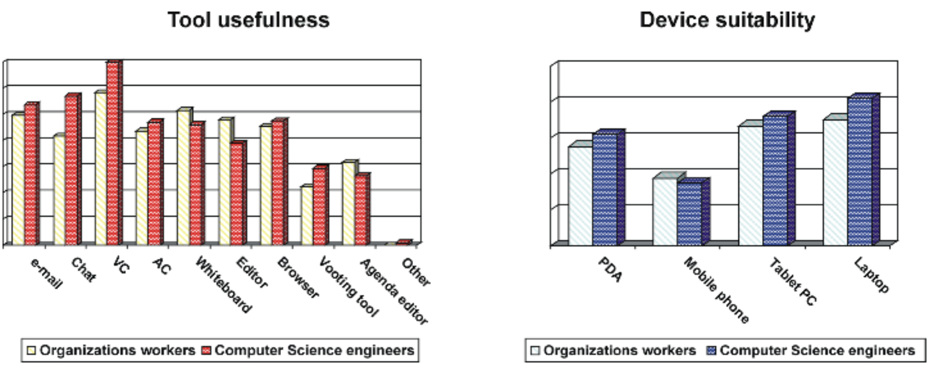

Fig. 1. Tool usefulness (left) and device suitability (right) in a mobile electronic meeting

The workers polled were requested to score the usefulness of some collaborative tools in a MEM with a number ranging from 1 (low usefulness) to 9 (high usefulness). The average score per user is graphically shown in Fig. 1 (left). The tools proposed to be scored were: electronic mail, chat (instant messaging), video conference (VC), audio conference (AC), shared whiteboard, group document editor, group document browser, voting tool, and agenda editor. Both workers from organizations and CS engineers (N=20) agreed that a video conference tool would be the most useful tool. Other very useful tools for CS engineers were chat and e-mail. The workers from organizations agreed with CS engineers with respect to e-mail, but not to the chat usefulness. These workers would prefer a whiteboard, a shared editor or even a document browser. One of the most significant results of this graphic is the different chat scores from the two collectives. The organizations' workers did not see the potential of instant messaging and preferred other more socially-interactive tools such as VC. Moreover, they liked the whiteboard, probably because they were familiar with the use of this tool in their meetings.

With respect to the device suitability to a MEM, the average scores (from 1-low to 5-high) assigned to PDAs, mobile phones, Tablet PCs and laptops were similar in both collectives. Laptops are the most suitable device in these meetings, while mobile phones are the least suitable. Undoubtedly, the workers and engineers polled have taken into account the size of the device user interface in their scores.

3 Related Work

Many systems support electronic meetings in one way or another. Some representative systems are shown in Table 1. For each system the table shows whether it can be used in mobile devices, whether audio and video support are available on it, whether it offers tools to support structured decision-making, which other collaborative tools are offered to the users, and whether it supports the use of interactive electronic white-boards. Two types of systems are distinguished: PC-based EMS, as Sametime, Team-Rooms, TeamWave and Habanero, and EMS that can be used in mobile devices, as Shared Notes, MSN Messenger and Pocket Skype.

Table 1. Some systems that support electronic meetings

System	Mobile devices	Audio support	Video support	Decision-making tools	Collaborative tools	Support for interactive whiteboards
Sametime	No	Yes	Yes	No	Chat, Whiteboard, Turn request tool, Slide presentation	No
TeamRooms	No	No	No	No	Concept map tool, Outliner, Post-it tool, …	No
TeamWave	No	No	No	Voting tools	Brainstormer, Concept map tool, File viewer, Post-it tool, Slide presentation, Web browser, …	No
Habanero	No	Yes	No	Voting tools	Chat, Whiteboard	No
Shared Notes	Yes	No	No	No	Structured drawing editor	Yes
MSN Messenger	Yes	No	No	No	Chat	No
Pocket Skype	Yes	Yes	No	No	Chat	No

IBM Lotus Sametime [14] is a real-time collaboration software that provides instant messaging and introduces creative methods for connecting people, forming groups and sharing information. This system is used by millions of users to support business meetings. TeamRooms [15] is a groupware system that supports team rooms for groups whose members can work both face-to-face and at distance. TeamRooms follows the metaphor of a workplace, which contains persistent artefacts. TeamWave [7] is an evolution of TeamRooms. TeamWave also supports teams that work in virtual meeting rooms, and offers a richer set of collaborative tools to support these meetings. Habanero [12] is a framework to develop collaborative applications as well as a collaborative environment offering a series of tools. Some of the tools make it possible to use this environment to hold distributed meetings.

Some systems allow users to share notes using PDAs. Shared Notes [8] is an example of such systems. Shared Notes aims at investigating how people move from individual to group work using PDAs and shared public displays. Its protocol of use is as follows: firstly, the users create notes on their PDAs; secondly, they meet and make their notes public by publishing them on a shared display; lastly, the group manipulates both public and personal notes. Some systems supporting instant messaging can be used to hold meetings with mobile devices. This is the case of MSN

Messenger [11] and Skype for Pocket PC [13]. The popular Messenger for PC allows two users to carry out an audio-video conference. However, MSN Messenger, which is the mobile version of this system, does not support these types of conferences. On the contrary, Skype for Pocket PC supports audio conferences among the users.

4 The REMO System

The REMO system aims at improving the meetings in organizations by providing electronic shared workspaces and advanced collaboration tools, allowing work at distance by making use of mobile devices. In the design of the system the challenge was to mimic a classical meeting into a distributed electronic meeting with mobile participants. To do so, we took into account the information collected in some interviews and the questionnaires about the requirements of the potential users of such systems (see Section 2), and the review of related systems (see Section 3). Next we discuss the context of use, functionality and architecture of REMO.

4.1 Scenario of Use

The REMO system is based on a three-stage life cycle meeting:

- Pre-meeting: In this stage the meeting administrators must define the agenda. In a classical meeting this requires only to define the items on the agenda and who the participants are. In a MEM the tools that will be available during the meeting in general and in specific items on the agenda must also be specified.
- Meeting: This stage consists of the course of the meeting itself. The participants will communicate, discuss, coordinate and produce results using the available tools and following the agenda. At this stage the system acts as moderating factor of the session and also directs its development.
- Post-meeting: Lastly, the system must provide the meeting results (artefacts built, documents produced and decisions made) by means of automatically generated minutes.

According to Borghoff & Schlichter [1], EMSs are characterized in general by a strong process orientation. From the three-stage setting described above a concrete structuring is inferred. Moreover, the meeting stage, is structured in a sequence of items to approach. REMO allows the specification of these items and of the tools that will be available to develop them. However, our objective has been to make the system flexible and able to, for instance, support more open and less structured meetings. A REMO meeting could therefore consist of an only item on the agenda with all the collaborative tools available. This is in harmony with the opinion of the workers polled (see Section 2). 42.4% of them prefer a more spontaneous meeting, while 30.3% prefer a more structured meeting; 27.3% are indecisive. In contrast to Shared Notes [8] the structuring of a REMO meeting is not always the same thanks to the meeting specification.

In the pre-meeting and post-meeting stages the collaboration is asynchronous. On the contrary, in the meeting stage the collaboration is synchronous since it is required that all the users participate at the same time. The MEM takes place in two types of locations: a main meeting room that contains an interactive whiteboard and in which there are a number of participants, and remote locations from which other users participate at distance. In both cases the users will be able to use any type of device, from desktop computers to mobile devices.

4.2 Tools and Functionality

REMO contains a wide set of tools, including (among others) the ones shown to the users polled in the questionnaire described in Section 2. It is important to highlight that nobody identified any other useful tool for a MEM. We have also incorporated other interesting tools as a result of the related system analysis (e.g., the brainstormer and the turn request tool). The aim has been to satisfy all the possible necessities of the users and to support a broad spectrum of meeting types. These tools are flexible and adaptable to different purposes. Their design is inspired by our previous research in the CSCL and CSCW areas. This is the case, for example, of the chat and the voting tool [5] and of the turn control tool and the collaborative editor [4]. The collaborative whiteboard is an evolution of the one integrated in the Space-Design system [2].

The tools available in the system life cycle are classified in three categories: meeting management tools, communication and coordination tools, and meeting-specific collaborative tools. The meetings in REMO are accessed from a web page. The meeting management tools, used during the pre-meeting and post-meeting stages, are tools with web interface, while the communication, coordination and meeting-specific tools, which are collaborative, are Java applications that are launched from this web page. The tools are the following:

- Meeting management tools:
  - Manager of participants and meetings: This allows the meeting administrator to define the meeting timetable and the users that will attend it.
  - Meeting agenda editor (Ag): With this tool the administrator defines the meeting and its agenda (structure) in an XML file. Very structured or more open meeting can be specified. This tool can also be used by the participants to consult the agenda before the meeting.
  - Meeting minutes browser: This tool visualizes the results of the meeting.
- Communication and coordination tools:
  - Session panel: This panel shows a list of the participants, including their photos.
  - Audio conference (Ac): This tool allows the communication among the participants using audio support.
  - Video conference (Vc): This facility offers video support so that all the users can see their colleges during the meeting.
  - Turn control tool (Tc): This tool supports the assignment of the working turn to a specific user. Three assignment models are possible: *first come first served*, assignment by voting, and rotation turn.
  - Structured decision-making tool (Dm): This tool allows a user to propose a voting. After having defined the voting, the users have to vote. Finally, the system counts the votes and distributes the results to the users.

  - Structured chat (Ch): This is a chat with sentence openers. The set of sentence openers is defined in an XML file, so that the communication language can be defined for each meeting. In the PDA version, the sentence openers are selected from a list. The last sent messages are inserted in other list in the user interface so that they can be reused. Bravo et al [3] have shown that this structured communication facility is effective for communication on a PDA.
- Meeting-specific tools:
  - Brainstorming tool (Bs): This tool allows the users to throw ideas freely, which are shown in a panel.
  - Document sharing tool (Ds): With this tool the users can share their documents before the meeting or during it on the fly.
  - Collaborative editor (Ed): This is a document editor with which the users can create documents collaboratively.
  - Collaborative whiteboard (Wb): This whiteboard supports the collaborative building of models and drawings.
  - Browser (Br): This tool allows the shared browsing of documents and web pages. Therefore, a user can make the presentation of a document (in HTML format) to the group.

The meeting course goes through a set of items on the agenda. An item can consist of having a voting session, producing a diagram, visualizing a document, etc. The agenda specification indicates the tools that will be available for each item. This way, there are item-oriented tools, e.g., the structured decision-making tool, and meeting-oriented tools, e.g., the structured chat or the audio conference. The tools can be used by all the users at the same time or only by a user. This is specified in the agenda as well. In the case that only a user can interact with a specific tool, the turn control tool is used to define who can make use of the tool, depending on the assignment mode.

Taking the characteristics presented in Table 1 (see Section 2) as a basis we can state that the REMO system is a complete and innovative proposal to support MEMs. REMO integrates support for audio and video conference, operates in mobile devices, includes voting tools to make decisions, and offers a wide set of collaborative tools. The meeting users can be remote or in the same meeting room, with an interactive whiteboard. The agenda structure and the tools available in a meeting are specified by the administrator in an XML file. None of the systems analyzed in Section 2 allows the definition of the agenda in such a way.

Fig. 2 shows two REMO screenshots of the PDA version. In this interface version a maximum number of two tools can be shown at the same time, apart from the session panel. The PC version consists of a frame that contains windows that correspond to tools, so that all the tools that fit in the frame can be shown and used at the same time. In the top part of the interface the meeting toolbar can be found (A). Each tool is represented by two letters (they are indicated in the list of tools above). In Fig. 2 (left) an example in which the meeting agenda editor (B) and the structured decision-making tool (C) are active can be seen; in the example on the right a whiteboard with a design (D) and the structured chat (E) are active.

According to Wiberg [17], a problem that arises when using computers to support meetings is that the technology draws too much attention from the participants. In the case of the PDAs this problem becomes worse. In addition, the use of a device as

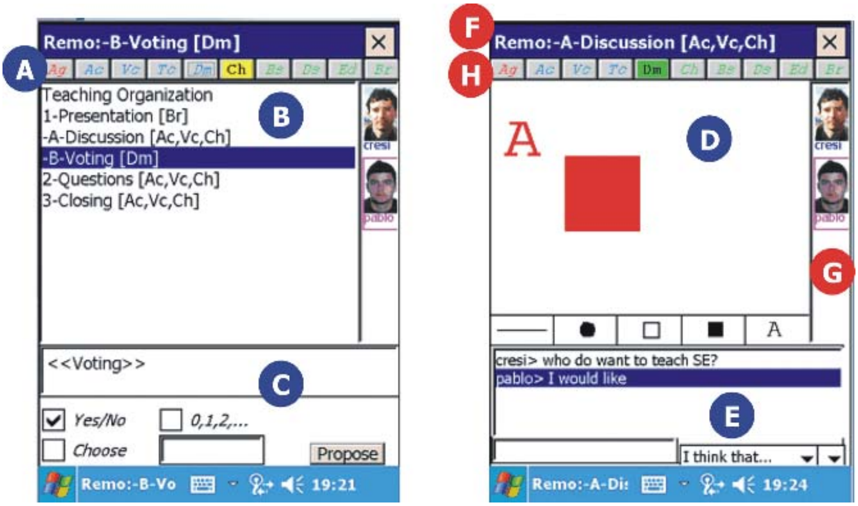

Fig. 2. The REMO user interface in the PDA version

small as a PDA in a meeting is an important challenge. Awareness, then, acquires special importance. Dourish & Belloti [6] define awareness as the "understanding of the activities of others, which provides a context for your own activity". Thus, awareness can, on the one hand, improve the social feeling of group work and make the user focus on the task instead of on the technology, and on the other hand, the awareness techniques contribute to better give much information in little space. Fig. 2 shows how the awareness problems have been approached in REMO. A user can see the current item on the agenda during all the meeting (F). The session panel (G) shows the session participants (photos and identifications). The state bar (H), in the top part of the user interface –it is the meeting toolbar itself–, shows by means of visual signs which tools are being used by a user. The yellow color is for tools in which an activity has taken place (e.g., the drawing of a model on the whiteboard), while the green color indicates that the user's participation is required (e.g., to cast a vote) in the corresponding tool. In the example on the left (see Fig. 2) the chat button background is yellow, and on the right the decision-making tool button background is green. Moreover, each tool has its specific awareness mechanisms. For example, the structured chat includes the user's identification at the beginning of each message text.

4.3 Architecture and Implementation Details

Due to the necessity to have the REMO system operating on diverse devices (PCs, PDAs, etc.) we have chosen the Java technology for its implementation. The system follows a client/server architecture in which the data and synchronization services are centralized. In a REMO typical configuration there are two main servers. One is a data and document server that contains a MySQL database. We use the SICS

(Synchronization Infrastructure for Collaborative Systems) infrastructure [4], built with the JSDT toolkit [10], for the synchronization services. The second server executes the SICS server.

The system detects the type of device (a desktop computer or a PDA) in which it is being executed and adapts its user interface to the device characteristics. Since the participants can use mobile devices in the meeting room as well as in any other location, wireless networks and UMTS connections supporting TCP/IP should be available.

According to the questionnaire described in Section 2, an interactive whiteboard is a promising device to be integrated within a MEM. 89.9% of the workers from organizations and 80% of the CS engineers polled saw this interaction device as useful. A special application of the meeting system is executed in a computer dedicated to the control of an interactive whiteboard that is on the main meeting place. We are using a SMART Board 660 whiteboard. Any participant in this meeting place can interact on the interactive whiteboard, by means of the special application, using digital pens and erasers, or even his/her hands. The interaction on this whiteboard, distributed to all the participants (present or remote), makes the users in the meeting room also aware in a face-to-face way, which adds the benefits of face-to-face interaction to the electronic virtual environment recreated by the REMO approach. With respect to the related systems analyzed, only Shared Notes [8] includes an interaction whiteboard in its configuration.

In order to implement the conference tools for the PC version, for the audio-video transmission we have used a Java implementation of the Java Media Framework (JMF) [9] that does not use cross-platform native methods. With regards to the PDA version, the video conference is not available. For the audio conference we are using the third party software Skype for Pocket PC [13]. In the development and tests we have utilized the PDA HP iPAQ hx4700 running the Microsoft Windows Mobile 2003 operating system, and the Java virtual machines J9 of IBM and Jeode of Insignia Solutions. In a short future we aim at implementing these conference tools for PDA extending the JMF. Thanks to the use of Java we are also implementing the mobile phone version to be executed on J2ME (Java 2 Micro Edition) with a CLDC (Connected Limited Device Configuration) 1.1 configuration and MIDP (Mobile Information Device Profile) 2.0 profile. We are using toolkits from some mobile vendors.

5 Conclusion and Next Steps

Present organizations demand more flexibility and mobility in their meetings, seeking to improve their competitiveness. The potential benefits of Mobile EMSs are substantial in terms of increased motivation and participation, productivity and cost savings. We have developed the REMO system as a response to these necessities. This system supports these new kinds of electronic meeting settings in which the participants are at distance and use mobile devices on wireless networks. The system design was informed with our observations of real meetings, the analysis of some

EMSs and other information collection techniques. The meeting model underlying can be applied to different types of meetings aiming at different purposes (problem solving, planning, presentation, etc.). This is achieved thanks to a rich set of collaborative tools.

REMO is currently under usability studies. This way, refinements in its user interface and functionality will be made. When the system is tested in real contexts it will be transferred to companies and organizations.

The system is also a means to investigate different issues of the people's behaviour and collaboration in a MEM from a technological point of view. We are planning to study the system impact on different organizations. In addition, we are currently developing the audio and video conference tools to be incorporated on the PDA version of REMO.

Acknowledgements

This research is supported by the Comunidad Autónoma de Castilla-La Mancha (Spain) in the PCI-05-006 project. The authors would like to thank the workers from organizations and the Computer Science engineers who participated in the questionnaire for collecting user requirements.

References

1. Borghoff, U.M., Schlichter, J.H.: Computer-Supported Cooperative Work: Introduction to Distributed Applications. Springer (2000) 373–414
2. Bravo, C., Gallardo, J., García-Minguillan, B., Redondo, M.A.: Using specifications to build domain-independent collaborative design environments. In: Luo, Y. (ed.): Cooperative Design, Visualization and Engineering. Lecture Notes in Computer Science, Vol. 3190. Springer-Verlag (2004) 104–114
3. Bravo, C., García, J., Gallardo, J.: Juegos de Tablero Colaborativos para PDA: Especificación, Generación Automática y Experiencias. Proceedings of VI Congreso de Interacción Persona-Ordenador. Thomson (2005) 119–126
4. Bravo, C., Redondo, M.A., Mendes, A.J., Ortega, M.: Group Learning of Programming by means of Real Time Distributed Collaboration Techniques. In: Lorés, J., Navarro, R. (eds.): HCI related papers of Interacción 2004. Springer (2006) 289–302
5. Bravo, C., Redondo, M.A., Ortega, M., Verdejo, M.F.: Collaborative environments for the learning of design: A model and a case study in Domotics. Computers and Education 46 (2) (2006) 152–173
6. Dourish, P., Belloti, V.: Awareness and coordination in shared workspaces. Proceedings of ACM Conference on Computer Supported Cooperative Work. ACM Press (1992) 107–114
7. Greenberg, S., Roseman, M.: Using a Room Metaphor to Ease Transitions in Groupware. In: Ackerman, M., Pipek, V., Wulf, V. (eds.): Sharing Expertise: Beyond Knowledge Management. MIT Press (2003) 203–256
8. Greenberg, S., Boyle, M., Laberge, J.: PDAs and Shared Public Displays: Making Personal Information Public, and Public Information Personal. Personal Technologies 3 (1) (1999) 54–64
9. http://java.sun.com/products/java-media/jmf/

10. http://java.sun.com/products/java-media/jsdt/
11. http://mobile.msn.com/
12. http://www.isrl.uiuc.edu/isaac/Habanero/
13. http://www.skype.com/download/skype/mobile/
14. http://www-142.ibm.com/software/sw-lotus/products/product3.nsf/wdocs/st75home
15. Roseman, M., Greenberg, S.: TeamRooms: Network Places for Collaboration. Proceedings of ACM Conference on Computer Supported Cooperative Work. ACM Press (1996) 325–333
16. Szerdy, J., McCall, M.R.: How To Facilitate Distributed Meetings Using EMS Tools. In: Coleman, D. (ed.): Groupware: Collaborative Strategies for Corporate LANs and Intranets. Prentice-Hall (1997) 207–230
17. Wiberg, M.: RoamWare: An integrated architecture for seamless interaction in between mobile meetings. Proceedings of the International ACM SIGGROUP Conference on Supporting Group Work. ACM Press (2001) 288–297

Efficient Technique for Fast IP Traceback

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Abstract. This paper suggests techniques to restrain the convergence time and the combinatorial explosion. IP traceback technique allows a victim to trace the routing path that an attacker has followed to reach his system. It has an effect of deterring future attackers as well as capturing the current one. FMS (Fragment Marking Scheme) is an efficient implementation of IP traceback. Every router participating in FMS leaves its IP information on the passing-through packets, partially and with some probability. The victim, then, can collect the packets and analyze them to reconstruct the attacking path. FMS and similar schemes, however, suffer a long convergence time to build the path when the attack path is lengthy. Also they suffer a combinatorial explosion problem when there are multiple attack paths. The convergence time is reduced considerably by insuring all routers have close-to-equal chance of sending their IP fragments through a distance-weighted sampling technique. The combinatorial explosion is avoided by tagging each IP fragment with the corresponding router's hashed identifier.

1 Introduction

DOS (Denial Of Service) attack typically is performed by sending a large number of packets to the victim system[4,10]. To hide the attacker's location, it often uses a spoofed IP address[3,11]. There are several IP traceback techniques that can trace the attack path in spite of IP spoofing[1,2,9,14]. Most of them, however, requires a heavy traffic or log analysis in the intermediate routers and are impractical without the management support at the routers.

Recently, efficient IP traceback techniques based on IP marking have been suggested[16,19]. In these schemes, the routes in the packet-traveling path mark their IP on the passing-through packets. If all routers write their IP's on all packets, the packet length will be increased out of control. To avoid that, the routers mark their IP's only probabilistically; that is, they mark only if a randomly generated number (between 0 and 1) is less than a certain sampling probability. Since a full IP address is still too large, they split it into a number of fragments (e.g. 8 fragments) and write only one of them. To let the victim know which fragment it is, they include the offset of that particular fragment in the packet. Also, since there could be several routers on the attack path, the routers need to convey information about the distance or hop counts from the victim. For this purpose, a distance field is included in the packet, too. Finally, to facilitate error-checking process, a hashed value of the original IP is included (in fragmented form).

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 211 – 218, 2006.

These solutions are based on an observation that a DOS attack typically involves a large number of packets, and even though the intermediate routers mark their IP's occasionally, the victim can construct the full attack path by collecting all the IP-marked packets. Since the attack path can be constructed automatically without further helps from routers, these solutions are superior to previous IP traceback techniques. However, they still have a number of drawbacks. First the constant sampling probability chosen by FMS, one of the prominent IP marking techniques, tends to penalize distant routers from the victim. The further is the router from the victim, the harder for it to deliver its IP fragments to the victim. Because of this, the time to collect all necessary IP fragments to reconstruct the full attack path (the convergence time, in short) becomes unnecessarily longer. Secondly, they are weak to multiple attack paths[5,7,8]. With multiple attack paths, the victim receives multiple IP fragments with the same offset and distance. Since there are multiple routers at the same distance, the victim has no way of knowing which IP fragment belongs to which router. In FMS, the victim has to try all possible combinations of IP fragments to recover the original IP's.[19] suggests a technique to avoid this, but it requires the victim to maintain a map of upstream routers.

In this paper, we suggest techniques to solve above two problems. The convergence time can be minimized by insuring all routers have equal chance of sending their IP fragments. Since all routers have an equal chance, there are no particular routers that are unduly penalized, and the victim wouldn't have to wait for the slowest router sitting idle. Giving a fair chance is possible through a distance-weighted sampling technique. Each router samples packets based on the values of the distance the packet has traveled so far. Our algorithm encourages the routers to choose short-traveled IP fragments over long-traveled ones for IP marking. This strategy tends to equalize the arrival rates of IP fragments from different routers. We analyze what would be the optimal sampling function that would make all routers have the same chance of IP marking.

The combinatorial explosion is avoided by tagging each IP fragment with the corresponding router's hashed identifier. Since IP fragments are tagged with a particular router's identifier, the victim can easily extract IP fragments belonging to the same router. However, this hashed identifier could collide, and we give an explanation about how often this collision could happen and what can be done when that happens. The rest of the paper is structured as follows. Section 2 surveys related researches. Section 3 explains the distance-weighted sampling technique. Section 4 explains the Tagged Fragment Marking Scheme. Section 5 gives the experimental results. And finally, Section 6 draws a conclusion.

2 Related Researches

Reconstructing an attack path during or after an attack is not an easy problem[6,14]. There are several techniques that are varied in cost and performance. Input Debugging technique[18] utilizes the input debugging feature provided in most routers. Using this feature, a router operator can associate a packet's egress port to the corresponding ingress port. Starting from the closest router, the victim can construct an attack path by identifying the upstream link at each router. This technique, however, requires the router operator's manual searching of the right upstream link. Controlled Flooding technique[2] is proposed as a solution for the above problem. The victim somehow coerces the upstream routers to flood each of their egress ports. By monitoring the change in attack packet volume, the victim can tell which upstream link the attack packet is coming from. This technique does not require help from the operators, but it assumes the victim knows the upstream router map and is weak for multiple attack paths. Logging technique[15] suggests a way of keeping efficient logs at key routers. Only the minimum information is logged to avoid data explosion, however it still calls for massive accumulation of data.

ICMP technique[1] takes a different approach. Rather than relying on the victim's blind search for the attack path, it requires the routers to sample their packets with a very low probability, copy them into special ICMP packets with information on adjacent routers, and forward them. The victim, then, can construct an attack path based on this information. However, since the sampling probability is very low (e.g. 1/20000), the victim needs a huge number of packets to complete the attack path.

FMS (Fragment Marking Scheme)[16] is based on a similar idea as ICMP technique: the router sends information about its location to the victim. However, in this case the router writes its partial IP address directly in the passing packets. Since it does not need to generate additional ICMP packets, it can write the IP address more frequently without worrying about traffic increase. In order to write the router's IP address without increasing the original packet size, it uses the 16-bit IP "identification" field that is rarely used these days (less than 0.25% in typical packets [12,17]). Since multiple routers compete for this field, and 16-bit is not enough for even a single IP address, FMS requires each router to run some probability function and write its partial IP (e.g. one eighth of it) only when the result is below some threshold value. The offset of the chosen IP fragment and the distance of the router from the victim along the attack path are also written in the "identification" field as shown in Fig.1. FMS is efficient and allows an automatic attack path discovery. However it still has a number of problems such as a weakness against multiple attach paths or a long convergence time for computing attack path. Advanced Marking Scheme[19] provides a solution that is robust under multiple attack paths. However, it requires each victim has a map for upstream routers beforehand, which is not a trivial problem.

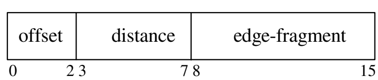

Fig. 1. The structure of an IP fragment in FMS

3 Distance-Weighted Sampling

In this section, we deal with the long convergence time. In Section 4, we address the problem of combinatorial explosion. A convergence time is the time to construct the attack path. In FMS, each router sends its IP by fragments, and the victim should wait until the last router sends its last IP fragment. Therefore, the convergence time is determined by the slowest router. For a constant sampling probability, as adopted by FMS, the furthest router from the victim is the slowest because its IP fragments are most of time overwritten by other routs in the downstream path. In [16], sampling probability $p = \frac{1}{n}$, n being the number of hops in the attack path, is suggested as one that can optimize the convergence time. However, the routers in the middle of the attack path do not know what would be the total number of hops of the attack path, and as explained later a constant sampling probability penalizes the furthest router and fails to optimize the convergence time.

We propose a distance-weighted sampling technique in which the sampling probability depends on the distance the target packet has traveled so far such that the probability is inversely proportional to it.

$$p = \frac{1}{f(d)} \text{ (where } d \text{ is the distance)}$$

Since the convergence time will be minimized when the IP fragments of different routers arrive at the victim with equal rates, our question is what *f(d)* will make the arrival rate equal. To find the right *f(d)*, we need to look at the sampling process more closely as shown in Fig. 2.

Fig. 2 shows how an attack packet gets a new IP fragment and a distance value at each router. All packets leaving R1 has an IP fragment of R1 and distance d=0. These packets are denoted by d0 box in R1. Upon receiving these packets, R2 samples them with $p = \frac{1}{f(0)}$ since all packets have distance zero. For those sampled, it overwrites the existing IP fragment with its own and set d = 0 again. For those not sampled, R2 XORs its corresponding IP fragment and increases the distance by 1. The d0 and d1 box in R2 denotes these two kinds of packets. The arrow in the figure shows a possible transition from one state to another.

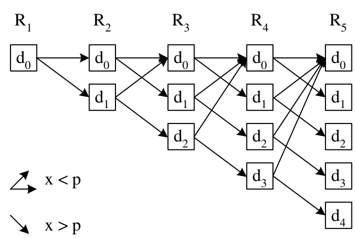

Fig. 2. Sampling process at each router

Now R3 receives two kinds of packets: packets with d = 0 that are marked by R2 and packets with d = 1 that represent the edge between R1 and R2. For packets with d = 0, R3 uses sampling probability $p = \frac{1}{f(0)}$ to transform them into two different kinds of packets as shown by the arrows in the figure. For packets with d = 1, R3 uses $p = \frac{1}{f(1)}$ to produce again two kinds of packets. As shown in the figure, d0 box collects packets from all kinds of packets in the previous router while other boxes receives packets from only one kind (the one-level lower box in the previous router). This regularity can be exploited to construct a recursive formula on arrival rates of various kinds of packets at various routers as follows.

First, let's define X(n,i) as the number of IP fragments with distance i arrived at router n. Then, the recursion below holds.

$$X(n+1, 0) = X(n,0)^* \frac{1}{f(0)} + X(n,1)^* \frac{1}{f(1)} + ... + X(n,n)^* \frac{1}{f(n)}$$

$$X(n+1, d) = X(n,d-1)^* (1 - \frac{1}{f(d-1)}) \text{ for } d = 1, \dots, n+1$$

That is, packets with d=0 at router R(n+1) has been collected from all kinds of packets at router Rn. The contribution factor of each box in Rn is $\frac{1}{f(d)}$, where d is the distance value, meaning that packets belonging to a particular box in Rn moves to d0 box in R(n+1) with the probability of $\frac{1}{f(d)}$. Other boxes in R(n+1) collects members from the one-level lower box in Rn with factor of $(1 - \frac{1}{f(d-1)})$.

In order to minimize the convergence time we have to choose *f(0), f(1), .., f(n)* in such a way that the minimum of X(n+1, i) for i =0, ..., n+1 would be maximized. It turns out to be equivalent to minimize the standard deviation of X(n+1, i) for i =0, ..., n+1. Based on the above recursion formula, it is obvious that *f(0)* would be 2. The next value *f(1)* would be greater than or equal to 2 to sustain the minimum value 1/4. The theoretical optimal value would be 1/3 but in our case 1/4 would be the maximal minimum value. But in the sense of minimizing standard deviation and maximal minimal value in the next step, *f(1)* would be 4. Continuing our argument about selecting *f(d)* values, we can reach the general formula by a mathematical induction. The optimal value of *f(d)* would be *2(d+1)*. This choice of *f(d)* value guarantees that we will have the minimum standard deviation. At each router the distribution of packets of different distances is symmetric, that is, we have the smallest or two smallest packets (depending on whether we have an even or odd number of different distance packets) of the middle distance. The shape of packet distribution is a symmetric V shape in optimal case. We can find two largest packets of the nearest and the farthest distance.

4 Tagged Fragment Marking Scheme

In FMS, each router makes a decision for each input packet whether it is going to mark its IP or not. If marking is decided, it computes a 32-bit hash out of its own IP, interleaves them with its IP, and splits the 64-bit result into k fragments. One of these fragments will be written on the packet. As explained in previous sections, an offset and a distance value are also included to facilitate the path reconstruction process. If the router decides not to mark, the distance field will be merely increased. The victim then can differentiate IP fragments by the distance field. Fragments with the same distance would have come from the same router at that distance, and the victim can recover its IP address. The problem with this scheme is when there are multiple attack paths. If there are m routers at distance d participating in the attack, the victim will receive m IP fragments for each offset value. To calculate the original m IP addresses, the victim needs to try all possible combinations of these IP fragments. With k=8 and m=10, the number of possible combination is 10^8.

To cope with the combinatorial explosion, we propose to tag each IP fragment with a 4-bit hash value of the original full IP. Since we don't have additional space in the IP identification field, we reuse the 4-bit hash field as in FMS. Instead of sending 1/8 hash fragment, we tag each IP fragment with the same 4-bit hash value as in Fig. 3.

offset	distance	IP frag	tag
0 2	3 7	8	15

Fig. 3. Tagged Fragment Marking Scheme

The victim can collect IP fragments with the same tag and recover the original IP. The problem with this scheme is collision. Since 32-bit IP address space is hashed into 4-bit space, there can be collisions between routers. Collisions between routers at different distances do not cause a problem because the victim can differentiate them. Collisions between routers at the same distance, however, do cause a problem. In this case, the victim should try all possible combinations to recover the original IP's as in FMS. However, the number of collided routers at the same distance should be much less than the total number of routers.

The more serious problem is when the recovered IP's all hashed into the same tag value we are looking for, but not the right IP's. This could happen because we validate the correctness of the selected combination of IP fragments by hashing them and comparing the value with the attached hash value. A wrong combination still could produce a correct hash value through collision. This kind of nested collision should occur to all selected combinations; otherwise we wouldn't have accepted them as the recovered IP's. We first argue that this nested collision happens quite rarely, and that even though it happens, we still can recover the true IP's through backtracking.

Suppose there were m routers that collided, and the hash value is H. The probability of m routers to collide is $\left(\frac{1}{16}\right)^{m-1}$. Furthermore, assume the victim has selected wrong IP combinations, and all of these wrong combinations still produce the same hash value, H. The probability that this would happen is $\left(\frac{1}{16}\right)^{m} m^{7}$ (assuming k=8). Therefore the probability that m routers at the same distance collide, and the victim computes wrong IP's without knowing the incorrectness is $\frac{m^7}{16^{2m-1}}$.

For m=2,3,4,…, the probability decreases rapidly as 1/32, 1/479, 1/16384, … Even though the probability becomes very small especially as m increases, we still need a systematic way of dealing with this collision. The basic observation is that since the IP fragments except ones with distance=0 come in edge-id forms, to recover the original IP we need to XOR the candidate edge-ids with a known IP address. This XORing should be applied to all combinations of IP fragments. If our selection of IP's at distance 0 was wrong, the extracted IP's through XORing with them at the next distance level in most cases have a rare chance of being correct. They could again produce the right hash value even though they are not the correct IP's, but the probability of this is quite low. The probability would be the multiple of wrong selection probability at distance 0 and the probability of producing the same hash value. And even though we pass the second level, the probability of not detecting faulty IP's at the next higher levels becomes extremely small as the level goes up because we have to multiply the probability of not detecting at every stage in addition to the chance of producing the same hash value for wrong IPs. If we detect a problem at level x, we should backtrack to level x-1 to try another IP's.

5 Conclusion

IP tracing is an important technique to defend a computing system from attackers. FMS (Fragment Marking Scheme) is one of the promising IP tracing techniques that is simple and efficient. However, FMS has a number of drawbacks: the convergence time to reconstruct the attack path gets considerably long when the path is lengthy, and there is a combinatorial explosion problem under multiple attack paths. In this paper, we have proposed Distance-Weighted Sampling technique to reduce the convergence time and Tagged FMS to avoid the combinatorial explosion. We have proved that the Distance-Weighted Sampling technique gives the optimal convergence time and showed that the Tagged FMS technique reduces the number of combinations considerably.

References

1. S. M. Bellovin, "The ICMP Traceback Messages," Internet Draft: draft-bellovin-itrace-00.txt, *http://www.research.att.com/~smb*, Mar. 2000.
2. Hal Burch and Bill Cheswick, "Tracing anonymous packets to their approximate source," Unpublished paper, December 1999.
3. Computer Emergency Response Team (CERT), "CERT Advisory CA-1995-01 IP Spoofing Attacks and Hijacked Terminal Connections," *http://www.cert.org/ advisories/CA-1995-01.html*, Jan. 1995.
4. Computer Emergency Response Team (CERT), "CERT Advisory CA-2000-01 Denial-of-service developments," *http://www.cert.org/advisories/CA-2000-01.html*, Jan. 2000.
5. David A. Curry, "UNIX System Security," Addison Wesley, pp.36-80, 1992.
6. Drew Dean, Matt Franklin, and Adam Stubblefield, "An algebraic approach to ip traceback," in Network and Distributed System Security Symposium, NDSS '01, February 2001.
7. Dave Dittrich, "Distributed Denial of Service (DDoS) attacks/tools resource page," http://staff.washington.edu/dittrich/misc/ddos/, 2000.
8. Sven Diettrich, Neil Long, and David Dittrich, "Analyzing distributed denial of service attack tools: The shaft case," in 14th systems Administration Conference, LISA 2000, 2000.
9. P. Ferguson and D. Senie, "Network Ingress Filtering: Defeating Denial of Service Attacks Which Employ IP Source Address Spoofing," RFC 2267, Jan. 1998.
10. J.D. Howard, "An analysis of security incidents on the internet," Phd thesis, Carnegie Mellon University, Aug. 1998.
11. L.T. Heberlein and M. Bishop, "Attack Class: Address Spoofing," In 1996 National Information Systems Security Conference," pages 371-378, Baltimore, MD, Oct. 1996.
12. S. Kent and J. Mogul, "Fragmentation Considered Harmful," In Proceedings of the 1987 ACM SIGCOMM Conference, Pages 390-401, Stowe, VT, Aug. 1987

13. Jon Postel, “Internet Protocol-Darpa Internet Program-Protocol Specification,” RFC 791, *http://www.faqs.org/rfcs/rfc791.html*, Sept. 1981.
14. “Project IDS - Intrusion Detection System,” *http://www.cs.columbia.edu/ids/index. html*, 2002.
15. G. Sager. Security Fun with Ocxmon and Cflowd. Presentation at the Internet 2 Working Group, Nov. 1998.
16. Stefan Savage, David Wetherall, Anna Karlin, and Tom Anderson, “Practical network support for IP traceback,” in *Proc. of ACM SIGCOMM*, pp. 295-306, Aug. 2000.
17. Ion Stoica and Hui Zhang, “Providing guaranteed services without per flow management,” in *SIGCOMM' 99*, pp. 81-94, 1999.
18. R. Stone, “CenterTrack: An IP Overlay Network for Tracking DoS Floods,” In to appear in *Proceedings of thje 2000 USENIX Security Symposium*, Denver, CO, July. 2000.
19. Dawn Xiaodong Song and Adrian Perrig, “Advanced and Authenticated Marking Schemes for IP Traceback,” in *Proc. IEEE INFOCOM*, April. 2001.

Research on Fuzzy Kohonen Neural Network for Fuzzy Clustering

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Abstract. A model of fuzzy Kohonen neural network for fuzzy clustering is presented. It uses fuzzy membership degree to describe approximate degree for input patterns and clusters' centers, which is represented by learning rate. In addition, in order to extract more useful information from input patterns, a supervised learning, called post-learning phase, is added to adaptive learning. Then the model is applied for a specific clustering's problem, the result shows it can greatly improve performances of recognition and classification.

1 Introduction

1.1 Fuzzy Clustering

Clustering is a process, where data sets are partitioned into several groups or categories. It makes data objects in the same groups are closer to each other, and ones in different groups are not approximate. Using the approach of fuzzy set to solve the problem of clustering is called as fuzzy clustering[1]. Clustering method can be actively bringing together cooperatives to work together in every way possible by both type and parameters. Cooperatives are expected to cluster together to derive the highest return on what they consider to be their competitive advantage[8].

1.2 Fuzzy Kohonen Network

Traditional Kohonen network is a kind of adaptive neural network, which is applied to make rough classifications for data sets. The network has such advantages that the learning rate can decrease with the time and the weights can be ultimately convergent, while it still exists such disadvantages that the learning rate does not make approximate degree for input patterns and clusters' centers under consideration and the network is imperfect for classifications. While fuzzy Kohonen network[2][3], on the basis of the traditional Kohonen network, can heuristically decrease learning rate and correct mistakes by the means of introducing fuzzy membership degree and supervised learning phase. So the learning time and the mistake for clustering are greatly decreased, that is, the clustering's efficiency is greatly increased.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 219 – 224, 2006.

2 Fuzzy Kohonen Neural Network

Artificial Neural Network is composed of a large number of neuron which simulate the way of brain nerve disposing information with information parallel processing and converse-nonlinear. Training neural network by the information of samples endows it with similar capability of memorizing and recognizing to brain.

2.1 TStructure of Fuzzy Kohonen Newtwok

The topological structure of fuzzy Kohonen neural network is displayed by Fig.1, where La is the input layer, and Lb is the output layer. The upper layer of the network is represented by output nodes, which form a matrix in a two-dimensional pattern, and the lower one is composed of input nodes, these nodes are all connected by weights. After competitive learning, neighborhoods of one certain node in the matrix must have bigger outputs for closer patterns, through which neighbors of winning nodes are created during the course of training[4][5].

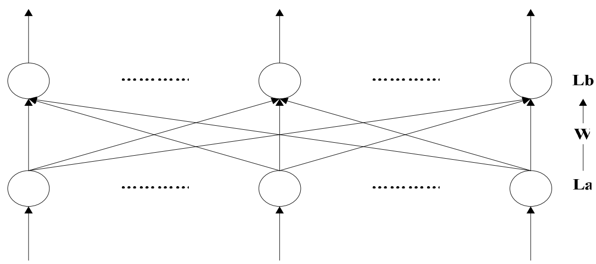

Fig. 1. Structural diagram of fuzzy Kohonen network

2.2 Algorithm Description

The learning algorithm of fuzzy Kohonen network actually combines fuzzy c-means algorithm and traditional Kohonen rules, so it is self-organizing and self-adaptive [6][7].

2.2.1 Basic Concept

$X=\{x_j | j=1, 2, \ldots, p\}$, and $x_j=[x_{j1}, x_{j2}, \ldots, x_{jn}]^T$ is defined to describe input patterns in a R^n space. $W=[w_1, w_2, \ldots, w_c]$ is defined to describe c centers of clusters. u_{ij} is applied to describe fuzzy membership degree for x_j to w_i. The fuzzy c-means algorithm is to make the value of target function minimum:

$$J(W,U,X) = \sum_{i=1}^{c}\sum_{j=1}^{p}(u_{ij})^m d^2(x_j, w_i) \tag{1}$$

Where $m \in [1,\infty]$ is called as fuzzy index, $d^2(x_j, w_i)$ is the distance from input pattern x_j to center w_i.

Fuzzy Kohonen network uses fuzzy membership degree to represent learning rate, that is, input patterns' contribution to centers of clusters is inversely proportional to the distance to those ones. The distribution of learning rate and the scale of neighborhood vary with the time, which are under automatic control of fuzzy index m. And m can change with the time by:

$$m_t = m_0 - \Delta m = m_0 - t*(m_0 - 1)/t_{mzx}. \qquad (2)$$

Where m_0 is the initial value of m_t, and $m_0>1$, t_{max} is the upper limit of iterating number.

$u_{ik,t}$ is defined to describe the fuzzy membership degree of input pattern x_k to cluster i, so learning rate can be fuzzified by:

$$a_{ik,t} = (u_{ik,t})^{m_t} \quad (1 \le i \le c) \qquad (3)$$

Where is the number of clusters.

2.2.2 Learning Algorithm

A Self-learning phase

<1> Determine c, and assign the value of ending condition ε (ε>0)

<2> Assign the values of m_0 and t_{max}, and initial centers of clusters.

<3> For t=1, 2, …, t_{max}

<3.1>Calculate $m_t = m_0 - \Delta m = m_0 - t*(m_0 - 1)/t_{mzx}$ (4)

<3.2> For k=1, 2, …, p, calculate

$$u_{ik,t} = \left\{ \sum_{j=1}^{c} \left[\frac{\| x_k - w_{i,t-1} \|}{\| x_k - w_{j,t-1} \|} \right]^{\frac{1}{m_{t-1}}} \right\}^{-1} \quad I_k = \Phi \quad \begin{matrix} u_{ik} = 0 & i \notin I_k \\ u_{ik} = 1 & i \in I_k \end{matrix}$$

$$I_k \ne \Phi \qquad I_k = \{ i \mid 1 \le i \le c, d^2(x_k, w_i) = 0 \} \qquad (5)\ (6)$$

<3.3> For k=1, 2, …, p, calculate

$$a_{ik,t} = (u_{ik,t})^{m_t} \quad 1 \leqslant i \leqslant c) \qquad (7)$$

<3.4> Update weights.

$$w_{ik} = w_{i,t-1} + \frac{\sum_{k=1}^{p} a_{ik,t}(x_k - w_{i,t-1})}{\sum_{k=1}^{p} a_{ik,t}} \qquad (8)$$

<3.5> Calculate $E_t = \| w_t - w_{t-1} \|^2$ (9)

<3.6> End if $E_t \leqslant \varepsilon$ then goto <3>else to get next t.

B Supervised learning phase

<1> Find the output cell whose fuzzy membership degree is biggest for an input pattern x.

<2> Suppose x is belonged to r, while the corresponding category for the output cell is s, therefore

$$\begin{cases} w_{s,t} = w_{s,t-1} + [\sum_{k=1}^{p} a_{ik,t}(x - w_{s,t-1})] / \sum_{k=1}^{p} a_{ik,t} & r = s \\ w_{s,t} = w_{s,t-1} - [\sum_{k=1}^{p} a_{ik,t}(x - w_{s,t-1})] / \sum_{k=1}^{p} a_{ik,t} & r \neq s \\ w_{i,t} = w_{i,t-1} & i \neq s \end{cases} \tag{10}$$

3 Experimental Result

The model is applied into a specific fuzzy clustering, and the fuzzy Kohonen neural network is trained by 36 samples which are belonged to 6 classes.

3.1 Experiment Data

These 6 classes are respectively represented by 6 mathematical functions, and each class provides 6 samples. Six classes are defined by Table 1, while 36 samples are given by Table 2.

Let t_{max}=9000, m_0=1, ε=1.00e-6, and supervised learning begins after 5000 times of adaptive learning.

Table 1. Samples' class

Class	Mathematical function
C_1	$y=x$
C_2	$y=4x+6$
C_3	$y=x^2$
C_4	$y=3x^2+4x+8$
C_5	$y=x^3$
C_6	$y=5x^3+7x^2+9x+11$

Table 2. Training samples

Class	1	2	3	4	5	6
C_1	(0.05, 0.05)	(0.12, 0.12)	(0.33, 0.33)	(0.75, 0.75)	(0.82, 0.82)	(0.97, 0.97)
C_2	(0.05, 6.20)	(0.12, 6.48)	(0.33, 7.32)	(0.75, 9.00)	(0.82, 9.28)	(0.97, 9.88)
C_3	(0.05, 0.0025)	(0.12, 0.0144)	(0.33, 0.1089)	(0.75, 0.5625)	(0.82, 0.6724)	(0.97, 0.9409)
C_4	(0.05, 8.2075)	(0.12, 8.5232)	(0.33, 9.6467)	(0.75, 12.6875)	(0.82, 13.2972)	(0.97, 14.7027)
C_5	(0.05, 0.0001)	(0.12, 0.0017)	(0.33, 0.0359)	(0.75, 0.4219)	(0.82, 0.5514)	(0.97, 0.9127)
C_6	(0.05,11.4681)	(0.12, 12.1894)	(0.33, 14.9120)	(0.75, 23.7969)	(0.82, 25.8436)	(0.97, 30.8797)

3.2 Result

After the use of learning algorithm, experiment results can be gained as shown in Table 3. The recognition rate=35/36=97.2%. Comparing with the native BP and the fuzzy BP[9], this method has obvious advantage in the correction rate as shown in Table 4.

Table 3. Experimental result

Class	Sample
C_1	(0.05, 0.05) (0.12, 0.12) (0.33, 0.33) (0.75, 0.75) (0.82, 0.82) (0.97, 0.97)
C_2	(0.05, 6.20) (0.12, 6.48) (0.33, 7.32) (0.75, 9.00) (0.82, 9.28) (0.97, 9.88)
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Table 4. The Comparition of Correction for Recognition Rate

Method	Correction Rate
Native BP	80.1%
Fuzzy BP	86.9%
Fuzzy Kohonen	97.2%

4 Conclusions

The paper presents a model of fuzzy Kohonen neural network for fuzzy clustering. The model uses fuzzy membership degree to describe approximate degree for input patterns and clusters' centers, which is represented by learning rate. In addition, in order to extract more useful information from input patterns, a supervised learning, called post-learning phase, is added to adaptive learning. The experiment shows it can greatly improve performances of recognition and classification. In the future , it is need to decrease the computing time.

Acknowledgements

This work is supported by the Natural Science Foundation of Jiangxi Province (0511072) ,the funds of Education Bureau(DB200406011) and Test and Control Center (ZX200328002), Jiangxi Province.

References

1. Bir bhanu, Anlei Fong, Concept Learning with Fuzzy Clustering and Relevenve Feedback, Lecture Notes in Computer Science, Vol.2121/2001, 102-107
2. Bock, H. H.: Clustering and Neural Networks. In: A. Rizzi et al. (Eds.): Advances in Data Science and Classification. Springer, Heidelberg (1998), 265-278.
3. Henning B., Heinrich H.,Artificial Neural Network and Fuzzy Clustering - New Tools for Evaluation of Depth Profile Data?, Mikrochimica Acta 133,2000,95-103
4. Kulkarni, U.V. General Fuzzy Hypersphere Neural Network. Proceedings of the International Joint Conference on Neural Networks. V3, 2002, 2369-2374.
5. Liu Puyin. Regular Fuzzy Neural Network as Universal Approximator of Fuzzy Valued Function. Konzhi yu Juece/Control and Decision, v18, n1, January, 2003, 19-23+28.
6. Yanchang, Xie Fan, Song Junde. D ILC, A Clustering Algorithm Based on Density-isoline, Journal of Beijing U niversity of Po sts and Telecommunicat ions, Vol.25No.2,2002, 8-13.
7. Junkuo Cao, Suisheng Ye, Xiangqian Ding, Application of Fuzzy Kohonen Network in Tobacco Clustering, Computer Engineering, Vol.31 No.2,2005,P222-224
8. Dana Petcu, Marcin Paprzycki and Maria Ganzha, Clustering Multiple and Cooperative Instances of Computational Intensive Software Tools, Parallel Computing Technologies: 8th International Conference, 2005.P452-458
9. Cai Hong, Ye Shuisheng, Zhang Yong, An Algorithm of Combined BP Network Mining Based on Fuzzy Clustering, Computer Engineering and Application, 2005,No 36

Applying Pattern-Based Techniques to Design Groupware Applications

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Abstract. In the last years the production of systems supporting learning and work in group has been high. However, the design and development of this kind of systems is difficult, especially due to the multidisciplinarity involved. We propose a design and development process based on the use of several conceptual models. In this process several techniques are used. In this paper we present our proposal of using pattern-based techniques to design groupware systems. We define collaboration patterns for modeling collaborative tasks and protocols of cooperation. These techniques are part of a methodological framework which outlines several stages and notations to describe other aspects of a groupware system.

Keyworks: Modeling, patterns, methodological approach, CSCW, groupware design, interaction design.

1 Introduction

Computer Supported Collaborative Work systems development is not a trivial task due to the multidisciplinarity of such systems. Problems generated in this kind of applications come from mainly three areas: the social nature of these systems, problems in the field of distributed systems and problems in relationship with Software Engineering. Cooperative behaviors modeling support or shared information workspaces are becoming requirements to take into account when developing these systems. Studying the existing alternatives [1-7] in this field we have noted certain deficiencies in modeling the collaborative aspects, particularly, proposals that combine group work applications aspects and interactive aspects. These problems confirm and justify the lack of a methodological framework supported by a coherent set of notations for designing interactive and collaborative tools. We have defined a notation called CIAN (*Collaborative Interactive Applications Notation*), which allow expressing collaborative and cooperative tasks differently. Their differences, pointed out by Dillenbourg [8] affect the division of tasks, the roles participation in the tasks and the obtained product as a result in a joint activity. This notation might be used in a methodological framework for designing groupwork systems. This methodological approach can benefit from the identification and the reuse of the analysis and modeling that appear in a recurrent way

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 225 – 233, 2006.

in several CSCW systems. We propose using patterns [9] in several stages of our methodological proposal with the aim of facilitating the design of this kind of systems.

In this paper we present the application of patterns to our methodological approach for designing collaborative interactive groupwork applications. In section 2, a brief presentation of its stages is shown, as well as aspects that can be specified in each. Section 3 explains which stages might benefit from using patterns, and section 4 shows some of them in detail. Finally, the conclusions obtained are explained.

2 Methodological Framework

In this section we present the stages in our methodological approach, named *CIAM* (*Collaborative Interactive Applications Methodology*). Our proposal implies adopting different viewpoints for creating conceptual models of this kind of systems. The first stages undertake a group-centered modeling, going on in subsequent stages to a process-centered modeling (cooperative, collaborative or coordination process), approaching, as we go deeper into the abstraction level, a more user-centered modeling, in which interactive tasks are modeled, that is, dialog between an individual user and the application. Two first modeling approaches describe the context [10] in which the interactive model is created, and serve as starting point for the last one. In this way, collaborative aspects (groups, process) and interactive (individual) modeling problems are tackled jointly. These framework acts as a guide for designers to create conceptual specifications of the main aspects that CSCW systems define. Specified information in each stage serve as a basis for modeling in the following stage. This information is extended, related or specified in a more detailed way in the next stage in the process.

Stages in this proposal (see figure 1), and the objective of each are enumerated as follows:

1) *Sociogram Development*. In this phase, the organization structure is modeled, as well as the relationship between its members. Organization Members are in one of those categories: *roles, actors, software agents*; or in aforementioned associations, forming *groups*, that is, groups of persons with homogeneous responsibilities or *work teams*, consisting of several roles. Elements in those diagrams might be interconnected by means of three kinds of basic relationships (*inheritance, performance* and *association*)
2) *Inter-Action Modeling*. In this phase, the main tasks (or processes), which define group work in the organization previously defined, are described. For each process, the roles involved, the data manipulated and the products generated are specified. Each task must be classified in one of the following categories: *cooperative tasks, collaborative tasks* and *individual tasks*. Processes will be interconnected by means of several kinds of relationships that, in several cases, can be interpreted as dependences.
3) *Responsibilities Modeling*. In this phase, attention is payed to the individual perspective of each organization member (role), adding to their shared responsibilities, the ones which are exclusive for them. We can see that the specified information in this phase is supplemented with the previous one. It is necessary that both models be consistent to each other.

4) *Multiuser Tasks Modeling*. In this stage the group tasks identified in the previous stage are described in a more detailed way. There are two different kinds of tasks, which must be modeled in a differentiated way: (a) *Cooperative Tasks* are specified by means of the so-called *responsibilities decomposition graph*, in which subtasks make up the group task, so that, in a lower abstraction level only an *individual task* must appear. (b) *Collaborative Tasks* modeling includes specification of the roles involved, as well as the data model objects manipulated by the work team (that is, the *shared context* specification). Shared context is defined as the set of *objects* that are visible to the users set, as well as the *actions* that can be executed on them. Once the objects that make up the *shared context* have been decided, it is necessary to fragment this information in three different parts: objects and/or attributes manipulated in the *collaborative visualization area*, the ones which appear in the *individual visualization area* and the ones that make up the *exclusive edition segment* (a subset in the data model that is accessed in an exclusive way for only one application user at the same time).
5) *Interaction Modeling*. In the last phase interactive aspects of the application are modeled. An *interaction model* for each individual task detected in the diverse phases of the gradual refinement process is created. A *interactive tasks decomposition tree* in CTT [11] is developed. As for the collaborative tasks, the interactive model is directly derived from the shared context definition. Our methodological approach includes the way of obtaining this model from the shared context modeling. However, its explication exceeds the limits of the present paper.

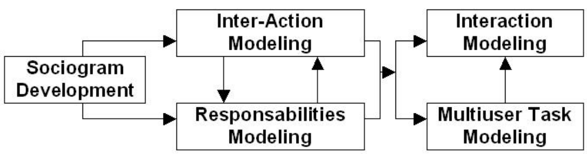


Fig. 1. CIAM methodological proposal stages

In the next section, the phases that can benefit from using patterns are pointed out.

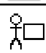
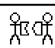
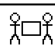
3 Patterns Application

In the methodological approach previously described, we consider of interest the application of patterns mainly in two phases: in *inter-action modeling* and in *interaction modeling*. In this paper, we are going to center on patterns that can be applied in the first of those phases. For presenting the patterns we are going to use the CIAN notation (*Collaborative Interactive Apllications Notation*). This notation is a simplification of another notation for *workflow* modeling, called APM (*Action Port Model*), proposed by Carlsen [13]. This notation has been enriched for supporting a differentiated modeling of cooperative and collaborative tasks, and simplified in some aspects (for characterizing a task just a task identification, the roles involved and the objects manipulated are included). Graphical models are complemented by means of a tabular and textual representation of another concepts of interest for designing the CSCW application.

A pattern describes a contrasted solution to a recurrent problem in a specific context [9]. Patterns have been applied in several fields. There are design patterns, hypermedia patterns [14], in the area of automatic code generation and User Interfaces design [15], organizational patterns in the analysis of requirements [17, 18], or patterns used as a guide in modeling and design processes [19, 20].

The models generated in the *inter-action modeling* phase specify the main tasks or processes in which the organizational roles that the CSCW system to be designed will use are involved. In this model not only the workflow between tasks is included, but also the context in which the group works are carry out is shown graphically, by means of the roles and the objects of the domain model involved. The tasks, which can be of individual, cooperative or collaborative nature (see table 1), are related to each other by different kinds of relationships: *time relationships* (order relationships; for these, we use the CTT operators set, derived from LOTOS [11]), *data dependence* (when several processes need data manipulated by previous processes), *notification* (when it is necessary to generate a certain notification event so that the work flow can continue). Apart from those kinds of relationships between processes, there are dependences of an individual nature, related to the iteration of a certain task, or the maintenance of a condition so that the execution can continue. In this case different kinds of conditions are identified: *termination* condition (conditions of ending an iterative execution), *period* condition (indicates time-related events of ending a task) or *execution* condition (optional execution conditions).

Table 1. Meaning of some graphical symbols of CIAN notation

Graphical Symbol	Meaning
	Role
	Individual Task
	Cooperative Task
	Collaborative Task
	Abstract Task

Detecting patterns in this context implies generalizing repetitive behaviors related to work organization and action protocols taking place in the organization.

4 Some Patterns for Task Modeling in Groupwork

There are certain ways of working, of labour division and of interaction between members in group work that are repetitive in several application contexts. As far as interaction between work team members is concerned (what we call *inter-action*) we can identify significant ways of behaving. So, for example, in cooperative work between the team members, two different situations are possible: (a) those in which various team members handle the same objects, producing various versions of the same object, which makes it necessary to come to a final decision-making process to decide the version to be the group solution, or (b), those in which various team members handle different parts of a same shared context. In this situation it is necessary to assemble individual contributions (partial solutions) to form the group solution. This task of assembling can be carried out by a specific role of the team. Each of those situations is modeled by inter-action patterns, shown in figure 2 (Multiple Versions in Cooperative Tasks Pattern) and 3 (*Múltiple Work Pieces in Cooperative Tasks* Pattern). Figure 2 shows the situation in which there is a work division in concurrent tasks (related by the operator |||), which are carried out by actors playing the same role in this context (all those tasks tackle the complete performance of the same *individual elaboration task*). Once individual work has been completed (different instances of the object *Object* has been created), we go on to decide in a collaborative way, with all the members, the final result (the object *Result* is created). The pattern shown in figure 3 differs from the previous one in several aspects. In this case, the responsibilities of each member (tasks to realize) are not only independent from the others', but also different, since these affect different sections of the information shared by the group. Again those tasks are followed by a decision-making process, which can be developed in a collaborative way (as in the previous case), or it can be carried out by a specific role.

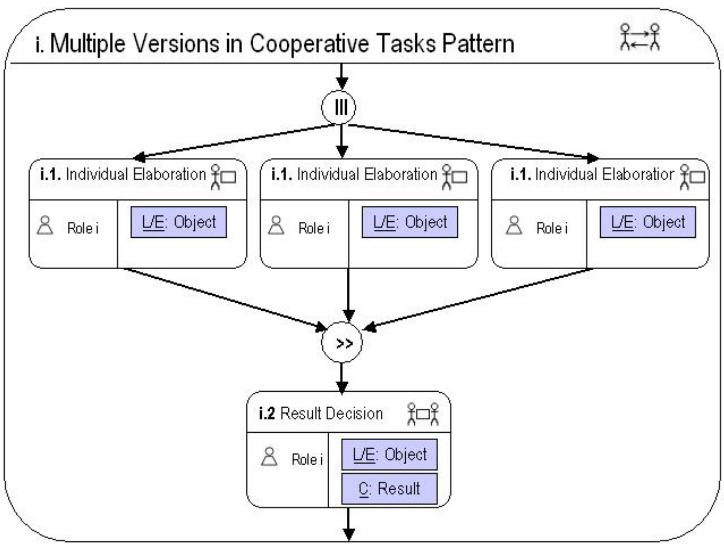


Fig. 2. *Multiple Versions in Cooperative Tasks* Pattern

As well as detecting inter-action patterns, related with *labour division* and creating their corresponding results, it is possible to detect patterns related with the interaction between team members, while they are carrying out their individual work. In this sense, it is possible to structure communication between different *roles* in their *social relationships*. There are contexts (we mean, domains), in which the communicative

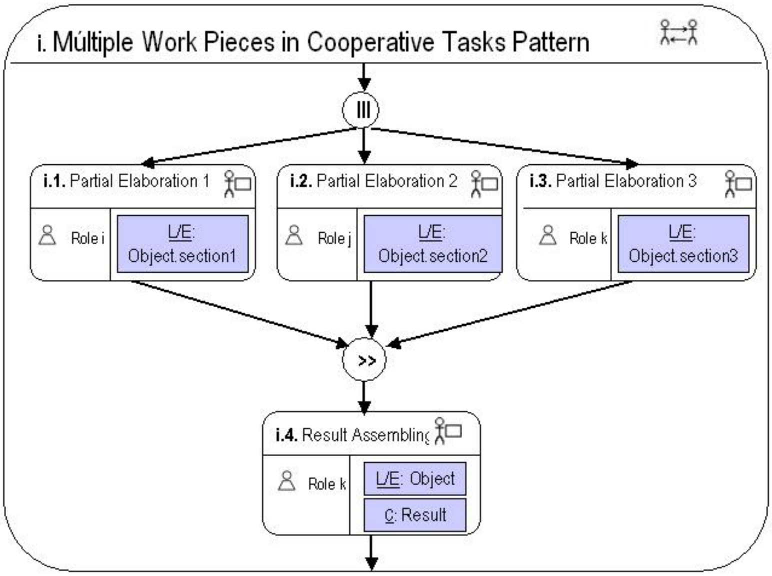


Fig. 3. Múltiple Work Pieces in Cooperative Tasks Pattern

behavior of the members depends on their respective roles. So, for example, in systems of collaborative edition of documents, the behavior depends on each role (author, reviewer, etc). Communicative Processes are described according to: roles, role dependencies, objective messages, rules and operations. In this case, specification depends to a large extent on the specific domain in which we are working. However, proposed notation allows modeling all these aspects. In the same way, a set of *conversation oriented coordination patterns* can be specified [21]. These of pattern models interactions between the team members, in which the group work is supported by a speech acts exchange (conversation). Speech acts, in general, are mapping on messages between conversation partners. In order to specify this kind of inter-action patterns, it is necessary to consider the kinds of specified messages (for example, explanations, suggestions, questions, proposals, etc.), which are generated depending on the inter-action *state*.

Another set of patterns is related with the *decision-making processes*. Figure 4 shows the *Unstructured Decision-Making* Pattern, also called *Brainstorming*. There are some situations, in which, whatever the application domain is, the following pattern of interactions and activities is detected. As regards to the previous diagrams, it is necessary to point out that the CIAN notation allows representing abstract tasks, that is, group work tasks that can be decomposed into others in a lower level of abstraction and of different kinds. It also supports the specification of optional tasks (their names appear in brackets, [ ]).

At the same time the "*Build Consensus"* and "*Evaluate Proposals"* tasks, shown in figure 4, can fit into several inter-action patterns between members who carry them out, but in a lower abstraction level.

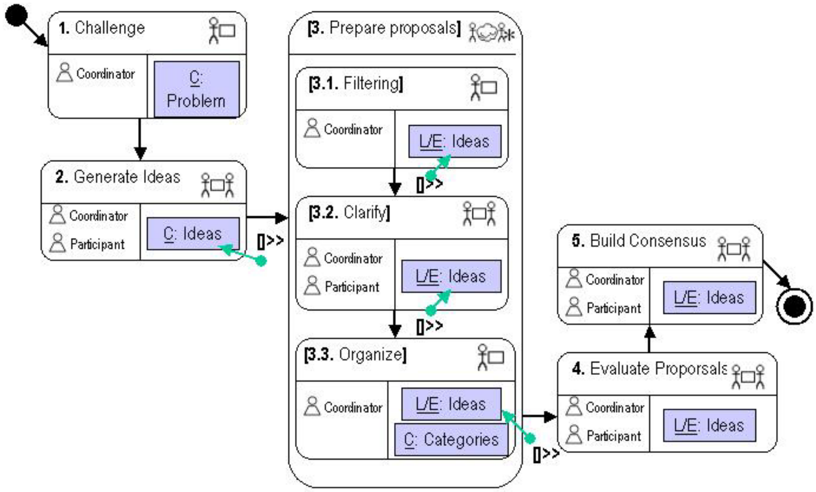


Fig. 4. *Unstructured Decision-Making* Pattern (*Brainstorming*)

There are other patterns that, due to the lack of space, are not included in this paper. Some of them are quite trivial. We will quote just a few: *An Object Transformation Oriented Coordination* Pattern, *Procedure Oriented Coordination* Pattern, *Token Passing Coordination* Pattern, etc.

The aforementioned patterns are of use for conceptual modeling of groupware applications for supporting collaborative and cooperative design in various contexts. So, for example, an application for supporting collaborative elaboration of documents can include a first more creative and unstructured phase in which an outline of the document structure is conceived. Once an initial structure is considered, a division of labour can be made. This work division can be of one of the aforementioned kinds (divided it into independent segments of text, or different versions of the resulting document). The first option can be of interest in work teams, in which there are more specialized roles in certain tasks than in others, while the second case refers to members who are able to tackle with the whole work.

5 Conclusions and Future Works

In the last years there has been a high production of applications that support work developed by several persons, playing various roles. Besides, since the user interface of the applications is attracting more and more attention, it will be taken into account when accepting or rejecting an application. Studying approaches that deal with these topics, we can detect that there is not a proposal that links both aspects; those of proposing notations and specific conceptual models that allow modeling distinctive features in this kind of systems. In this paper, a methodological approach for solving this lack has been introduced. This proposal consists of a set of phases, in each of which models are created in a specific notation. Besides, patterns mean a very useful tool for reusing solutions. Their benefits have been proved in various contexts. In this paper we have indicated in which stages in our proposal it is useful to use patterns. In particular, we consider applying them in the *inter-action* phase (that tackles with modeling of interaction between work team members). We have presented some examples of patterns. Also, a first categorization of inter-action patterns has been pointed. We identify three categories: *work division* patterns, *conversation oriented coordination* patterns and *decision-making* patterns. Using these patterns we obtain an improvement of the development process in CSCW systems. As for the implementation, each pattern can correspond with a developed component for supporting these complex tasks. Therefore, time and effort of CSCW systems development can be reduced considerably. Future works will enrich this set of patterns, as well as those that can be applied to interaction modeling, and to its evaluation. For this, we are going to develop a CASE tool to support our methodological proposal that will include the possibility of incorporating the detected pattern in the CSCW systems development process.

Acknowledgements

This work has been partially supported by the Junta de Comunidades de Castilla – La Mancha in the project GAMTest (PCI-05-005).

References

1. D. England and M. D., "Modelling Multiple and Collaborative Tasks in XUAN," presented at Whorshop in HCI2003, England, 2003.
2. J. L. Garrido, "AMENITIES: Una metodología para el desarrollo de sistemas cooperativos basada en modelos de comportamiento y tareas," in *Departamento de Lenguajes y Sistemas Informáticos*. Granada: Universidad de Granada, 2003.
3. R. Hourizi, P. Johnson, A. Bruseberg, and I. Solodilova, "Modelling Collaborative Work in UML," presented at 21th European Conference on Human Decision Making and Control, Glasgow, 2002.
4. F. Paternò, C. Santoro, and S. Tahmassebi, "Formal model for cooperative tasks: Concepts and an application for en-route air traffic control.," presented at 5th Int. Workshop on Design, Specification, and Verification of Intractive Systems DSV-IS '98, Abingdon, 1998.
5. M. van Welie and G. C. van der Veer, "Groupware Task Analysis," in *Handbook Of Cognitive Task Design*, E. Hollnagel, Ed. LEA., NJ, 2003, pp. 447-476.
6. P. Dillenbourg, M. Baker, A. Blaye, and C. O'Malley, *The Evolution of Research on Collaborative Learning*, vol. Learning in humans and machines. Towards an interdisciplinary learning science. London, 1995.
7. E. Gamma, R. Helm, R. Johnson, and J. Vlissides, *Design Patterns: Elements of Reusable Object-Oriented Software*: Addison Wesley, 1995.
8. H. Beyer and K. Holtzblatt, *Contextual Design: Defining Customer-Centered Systems*. San Francisco: Morgan Kaufmann Publishers, 1998.
9. F. Paternò, "ConcurTaskTrees: An Engineered Notation for Task Models.," in *The Handbook Of Task Analysis For HCI*, D. Diaper and N. A. Stanton, Eds. LEA, Mahwah, NJ.,, 2004, pp. 483-501.
10. S. Carlsen, "Action Port Model: A Mixed Paradigm Conceptual Workflow Modeling Language," presented at 3rd IFCIS International Conference on Cooperative Information Systems, 1998.

11. S. Montero, "Integración de Patrones en el Proceso de Diseño de Sistemas Hipermedia mediante el uso de Ontologías," in *Departamento de Informática*. Leganés: Universidad Carlos III de Madrid, 2005, pp. 304.
12. P. J. Molina, "Especificación de Interfaz de Usuario: De los requisitos a la generación automática," in *Departamento de Sistemas Informáticos y Computación*. Valencia: Universidad Politécnica de Valencia, 2003.
13. A. Gaffar, D. Sinnig, A. Seffah, and P. Forbrig, "Modeling Patterns for Task Models," presented at Task Models and Diagrams for User Interface Design (TAMODIA 2004), Prague, Czech Republic, 2004.
14. J. L. Isla, F. L. Gutiérrez, and M. Gea, "Patrones de organización. Integración en un proceso de desarrollo centrado en el grupo," presented at INTERACCION 2005, Lleida, 2004.
15. M. Kolp, P. Giorgini, and J. Mylopoulos, "Organizational Patterns for Early Requeriments Analysis," presented at 15th International Conference on Advanced Information Sustems Engineering, Velden, Austria, 2003.
16. A. Martínez, O. Pastor, and H. Estrada, "A pattern language to join early and late requirements," *Journal of Computer Science & Technology*, vol. 5, 2005.
17. C. Bravo, "Protocolos de Coordinación y Comunicación Estructurada en Entornos CSCL Síncronos," presented at VII Simposio Internacional de Informática Educativa, Leiria (Portugal), 2005.

Metrics for Evaluating Design of Reconfigurable Machine Tools

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Abstract. This paper shows the development of metrics for evaluate the design of reconfigurable machine tools to process bamboo, which allows the numerical comparison of reconfigurability parameters in the design process, based on a concurrent design methodology to Reconfigurable Machine Tool development. In response, metrics for evaluate the development of this type of machine tools is outlined.

Keywords: Metric, Reconfigurability, Design, Machine Tools.

1 Introduction

The manufacturing tendencies reflect the changes on the customer demands over the years. Nowadays the market is constantly requiring more customized products, moving from mass production, through mass customization in less time with lower production costs. These conditions demand the development and application of approaching which allows to convert the production to new models capable of integrating new technologies and of increasing the variety of products.

The reconfigurable manufacturing system, will allow flexibility not only in producing a variety of parts, but also in changing the system itself. Such a system will be created using basic process modules –hardware and software– that will be rearranged quickly and reliably. The art and science of RMT (Reconfigurable Machine Tools) development are still at their developmental stage.

A goal of the work presented in this paper is to provide metrics for evaluate the design of reconfigurable machine tools to process bamboo, which allows the numerical comparison of reconfigurability parameters in the design process, based on a concurrent design methodology to reconfigurable machine tool development. On section 2 a literature review of research in studies about the metrics in engineering design is presented. A reference methodology for metrics development is described in

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 234 – 241, 2006.

Section 3. Section 4 presents the metrics for evaluating design of reconfigurable machine tools. Finally, Section 5 deal with the metrics applied on reconfigurable bamboo processing machine design.

2 Related Previous Studies

There are several studies related to developing metrics to evaluate different aspects in design process, these metrics are a great aid to designer's decision making in engineering. Table 1 summarizes the major studies about the metrics in engineering design.

Table 1. Summary of studies about the metrics in engineering design

	Fields of research	Authors
–	Design for variety: developing standardized and modularized product platform architectures (based on QFD analysis)	Martin, M. V.; Ishii, K. [6]
–	Methodology for understanding the costs of product proliferation	Martin, M. V.; Ishii, K. [4]
–	Assessing value in plat formed product family design	González, J. P.; Otto, K. N.; Baker, J. D. [2]
–	A metric for evaluating design commonality in product families	Kota, S.; Sethuraman, K.; Miller, R. [3]
–	Design for variety: development of complexity index and design charts	Martin, M. V.; Ishii, K. [5]
–	Setting target product requirements: decision analytic approach	Takai, S.; Ishii, K. [9]
–	Platform-driven development of product families: linking theory with practice	Vuuren, W. V.; Halman, J. I. M. [10]
–	Optimal selection of module instances for modular products in reconfigurable manufacturing systems	Yigit, A. S.; Allahverdi, A. [11]

Research related to the developing of indexes and charts which allow studying the different factors involving machine tools reconfigurability are directed in focusing in the search of coefficient which can connect several aspects for developing products family and variety.

Concerning machine's reconfigurability there are few studies reflecting the analysis of features that permit a comparison between many concepts in a machine tools.

3 Reference Methodology for Metrics Development

The general characteristics of a methodology based on modularity are proposed by Pérez *et al.* [7]. The proposed methodology for the modular development of RMT's establishes four domains which go from the requirements of the machine tool builder to the definition of the reconfigurable modularity. Each layer established by the

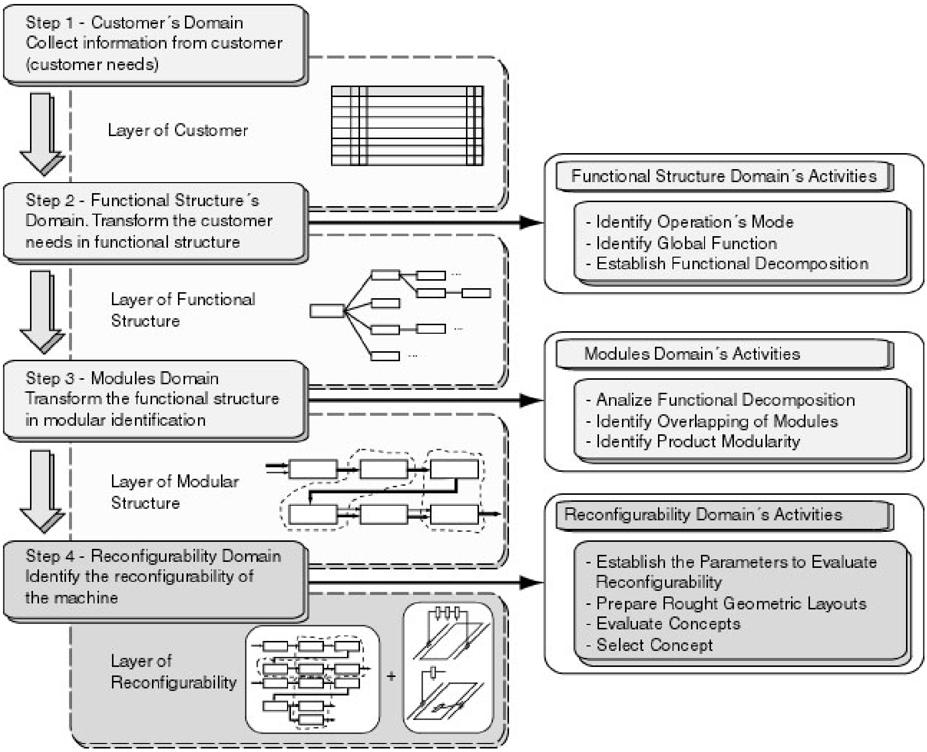

Fig. 1. Overview of the modular reconfigurability design methodology [7]

methodology and shown in Figure 1 constitutes a formalization of the knowledge that is obtained in any given step.

Four activities are recommended within the step four, related to reconfigurability domain (see Figure 1). The first one consists of identifying which are the parameters that characterize the reconfigurability of the machine, or family of machines. The second activity consists of generating preliminary geometric schematics. Once the different machine concepts have been defined, it is necessary to evaluate them. To evaluate these concepts in terms of their reconfigurability, a Reconfigurability Concept Matrix (RCM) is proposed [7].

To improve the methodology, it's necessary to develop metrics for evaluating design of reconfigurable machine tools that allows the numerical comparison of reconfigurability parameters. Based on the methodology proposed in Figure 1, the details of the metrics and the experiences obtained from her application are presented in the following sections.

4 Metrics for Evaluating Design of Reconfigurable Machine Tools

Key metrics are defined as quantitative measurements that give useful information related to measurable facts through aggregation and relativization. They are generally used in operational controlling and their application serves for control and steering of success potentials. Key metrics have different functions and can be either used as information or steering instruments [1].

Our approach defines the machines and cutting tool's reconfigurability rate, as metrics which permit the comparative evaluation of solutions in RMT´s designing process.

a) Machine's reconfigurability rate

To evaluate a specific machine tool's degree of reconfigurability, and to use that number as a reference in a comparative research, a reconfigurability rate was developed; it characterizes the most relevant aspects involving the reconfigurability of that machine.

Machine's reconfigurability rate (R_{MT}) is a number which shows a machine degree of reconfigurability starting by the possible configuration, the numbers of structural components, the secondary operations and the possible numbers of motion of the cutting tools. It's stated by the following equation (1).

$$R_{MT} = \ln(Cfg) \bullet \ln\left(\frac{Aop \bullet Mct}{\ln(Stc)}\right) \bullet 0.368 \tag{1}$$

where:

Cfg: Possible configurations number.

Indicates the quantity of possible configurations that a machine tool can undergo to perform generic technological operations in a determined time (e.g. a conventional lathe will only have a possible configuration, because it can only execute the technological operation of turning).

Stc: Number of structural components.

Indicates the number of the fundamental structural components of the machine tools. In the case of the conventional lathe, there would be five components: frame, gear box, cutting tool support, tailstock and spindle.

Mct: Number of the possible motions of the cutting tools.

It allows to characterize numerically, the number of possible movements that can execute the organ or the organs of court of a certain machine tool. In the case of a conventional lathe, he would have three possible movements: rotation of the spindle and movement of the cutting tool in the cutting tool support in two planes.

Aop: Auxiliary operations. It characterizes the number of auxiliaries operations that can develop the machine tool.

The metric R_{MT} takes values from cero to one, due to the configuration of the equation in terms of logarithm and the use of the coefficient 0.386.

Obviously, it is wanted that the machine tool possesses the highest value in RIMT, for this way to increase its versatility and reconfigurability possibilities. Therefore, it's to find the most appropriate values in the different variables that it depends, so that on the whole you guarantee a harmonic value that reflects the reconfigurability of the machine.

Because the equation (1) it is expressed in terms of the logarithm, the minimum value of RI_{MT} will be zero when the machine is not a reconfigurable machine tool. The value of RI_{MT} will be bigger than zero, when the machine is reconfigurable.

b) Cutting Tool's reconfigurability rate

As a form of evaluate the reconfigurability with respect to the useful of cutting tool of the machines and that this evaluation allows a comparative study, a cutting tool's reconfigurability rate was developed to characterize the most important aspects that influence in the cutting organs.

Cutting tool's reconfigurability rate (R_{CT}) is a number which shows a machine degree of reconfigurability of the cutting tools in function of the types of cutting profiles, the cutting edges and the cutting areas. This index is expressed through the equation (2).

$$R_{CT} = \ln\left(\left((Cpf + Ca) \bullet 0.8\right)^{(Ced \bullet 0.2)}\right) \quad (2)$$

where:

Cpf: Number of cutting profile.

Indicates the quantity possible of different cutting tool's profiles that can develop the organ of cutting of the machine tool. For this type of machines, the validity of the equation is expressed for intervals of Cpf from one to four cutting profile.

Ca: Number of cutting areas.

Indicates the possible number of different cutting's areas that can execute the cutting's organ of the machine tool. For this type of machines, the validity of the equation is expressed for intervals of Ca from one to five cutting areas.

Ced: Number of cutting edges.

Indicate the maximum number possible of cutting edges of the cutting tools of the machine tool. For this type of machines, the validity of the equation is expressed for intervals of Ced from one to four cutting edges.

When it's analyzed in a certain machine tool their cutting tools, it's wanted that the same one possesses the highest value in R_{CT}. The contribution of the variables in the equation (2) indicates the importance that has the number of cutting profiles and the number of cutting edges. To adjust the ranges of values of the equation, the coefficients 0.8 and the exponent 0.2 are used.

5 Metrics Applied on Reconfigurable Bamboo Processing Machine Design

The partner of the investigation, the technical department of KARIME workshop, needed of qualitative tools that help the designer of machines in the comparison and selection of concepts of reconfigurable machine tools, in this case for machines dedicated to the processing of bamboo. The requested indicators should be intuitive and easy of obtaining, still in the primary stages of the design process. These numeric indicators also act as packages of information about design and manufacturing among the different stages of the life cycle of the product in an environment of Concurrent Engineering.

The metrics analyzed in the previous section fill the gaps that were found in the test case. It will be used as example a real case developed in KARIME, specifically the design of a machine tool to process bamboo. The functional requirements and the steps (1, 2 and 3) were analyzed in [8]. Subsequently, we will analyze the application of the metrics described in the section 4 to the design of this type of machine tool, following that expressed in the step 4 (see Figure 1).

For this case, four constructive solutions of a planning machine tool to process bamboo that the design department should study are analyzed (see Figure 2). The case allows illustrate the potential use of the metrics obtained. The key aspect for the qualitative evaluation of the solutions for the designer consists on the use of the reconfigurability rates R_{MT} and R_{CT} exposed in the section 4 (see Table 2).

Table 2. Reconfigurability rates for the solution's design of the machine tool to process mamboo

Solution	Cfg	Aop	Stc	Mct	Cpf	Ca	Ced	R_{MT}	R_{CT}
A	1	1	9	1	1	1	3	0.000	0.282
B	2	2	7	1	1	2	3	0.007	0.525
C	3	3	6	2	4	5	4	0.489	1.579
D	4	2	7	2	5	3	4	0.368	1.485

Starting from the evaluation of the reconfigurability rates, the designer appreciates intuitively that the solution C is more appropriate from the point of view of the reconfigurability of the machine to process mambo. In the case of the enterprise KARIME, decided to use the concept expressed by the solution C, where the rates R_{MT} and R_{CT} contributed to the making of decisions regarding the solution of this project. The concerning details related to the different indicators of the equations (1) and (2) are exposed in Table 3.

Table 3. Details of the indicator for solution C

Indicator	Details
Cfg	Configuration 1: planning of mambo; configuration 2: polishing of mambo; configuration 3: press of mambo
Stc	Structural elements: frame; support of the transmissions 1, 2 and 3; support of the organ of work 1 and 2
Mct	motions of the cutting tools: rotation of the rollers, axial displacement
Aop	Auxiliaries operation: court of nodes; court of fins; unify profiles
Cpf	Cutting profiles: plane, grooved, curved, irregular.
Ca	Cutting areas: five different types
Ced	Cutting edges: cutting tool with four cutting edges

In the Figure 2 the geometric model developed for the selected solution C of the Table 2 is shown. The Figure 3 show the prototype of machine tool to process bamboo obtained in KARIME enterprise with some one of the characteristics exposed in the Table 3.

The reconfigurability rates obtained for the case of the necessities of KARIME, show the benefits that it reports for a designer of machines, to have features for the making decisions in the design process.

The work presented can facilitate the integration of the system to the methodology of reference and can facilitate the concurrent design of machine tools to process bamboo.

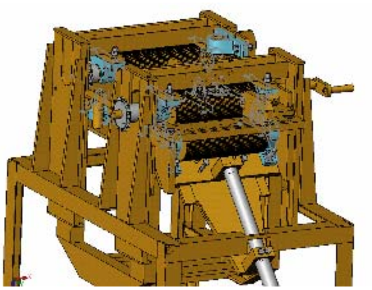

Fig. 2. Geometric model of the adopted solution

Fig. 3. Prototype of the machine starting from the adopted solution

6 Conclusions

This article has presented metrics for evaluating design of reconfigurable machine tools to process bamboo, which allows the numerical comparison of reconfigurability parameters in the design process. The developed metrics provides an aid in the identification of the machine tool solution, starting from the knowledge of the characteristic of the machine tool concept. This metrics was integrated to the methodology of the reference model.

Acknowledgement

This research is part of the Research Chair in Concurrent Engineering at Mechanical Engineering Department at the University of Holguín (Cuba), the Technical Department of KARIME workshop (Cuba), the Industrial Equipments Design Centre at Polytechnical University of Catalonia (Spain) and the Research Chair in Mechatronics at ITESM Campus Monterrey (México) titled “Design, Manufacturing and Integration of Reconfigurable and Intelligent Machines”. The authors want to acknowledge the support of these grants in the preparation of the manuscript.

References

1. Blecker, T.; Abdelkafi, N.; Kaluza, B.; Friedrich, G., Variety steering concept for mass customization, Paper of the College of Business Administration, No. 2003/04, University of Klagenfurt, Austria, 2003, 56 p.
2. González, J. P.; Otto, K. N.; Baker, J. D., Assessing value in platformed product family design. Research in Engineering Design, (13) 2001, 30-41
3. Kota, S.; Sethuraman, K.; Miller, R., A metric for evaluating design commonality in product families, Journal of Mechanical Design, December, (122) 2000, 403-410
4. Martin, M. V.; Ishii, K., Design for variety: a methodology for understanding the costs of product proliferation. Proceedings of DETC´ 1996, ASME Design Engineering Technical Conference, August, 1996, Irvine, California.

5. Martin, M. V.; Ishii, K., Design for variety: development of complexity indices and design charts. Proceedings of DETC´ 1997, ASME Design Engineering Technical Conferences, September, 1997, Sacramento, CA.
6. Martin, M. V.; Ishii, K., Design for variety: developing standardized and modularized product platform architectures. Research in Engineering Design, (13) 2002, 213–235
7. Pérez R., R.; Aca, J.; Valverde, A.; Ahuett G., H.; Molina G., A.; Riba R., C., A modularity framework for concurrent design of reconfigurable machine tools, Lecture Notes in Computer Science, (3190) 2004, 87-95
8. Riba R., C.; Pérez R., R.; Sánchez A., J. L.; Domínguez, M. D.; Aca S., J.; Molina G., A., A Concurrent Approach to Design of Reconfigurable Machine Tools to Process Bamboo, Lecture Notes in Computer Science, (3675) 2005, 210-217
9. Takai, S.; Ishii, K., Setting target product requirements: decision analytic approach. Proceedings of ASME 2002 Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Montreal, Canada, September, 2002
10. Vuuren, W. V.; Halman, J. I. M., Platform-driven development of product families: linking theory with practice. Proceedings of the conference “The Future of Innovation Studies”. Eindhoven University of Technology, the Netherlands, September, 2001. 16 p.
11. Yigit, A. S.; Allahverdi, A., Optimal selection of module instances for modular products in reconfigurable manufacturing systems, International Journal of Production Research, (41) 2003, No. 17, 4063–4074

Computer-Aided Modelling, Evaluation and Management of Construction Projects According to PLM Concept

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Abstract. The major problem for investors in construction area is to choose the financially effective construction alternative, most often associated with underestimated actual demand for resources. The lack of information feedback among all participants of the project and the uncertainty treats at the design and construction stages are presented in this paper. Solution is the theoretical 3D building information model, combined with resource demand calculations, comparison of alternatives and determination the duration of all construction project life stages. The software based on this aggregate 4D PLM model can be the mean of effective management of the construction project, embracing planning, design, economic calculations, construction, management, usage and maintenance of the completed building. The paper also describes multiple criteria evaluation software used to identify the most effective construction alternative with presented suggestions of implementation in practice.

Keywords: Project life cycle management, 3D and 4D modelling, computer-aided evaluation and management in construction.

1 Introduction

Investors such as governmental organizations, financial-insurance companies, banks, industrial companies and active owners at the local and foreign real-estate markets face the same problem – the rapid grow of prices for real-estate and qualified human working power. The same big and more smaller problems influence the construction industry. The construction process is affected by many factors, influencing all the parameters (such as development, infrastructure, duration, resource demand, financial stability). At the beginning of the construction project implementation, efforts are made to predict the influence of these factors with the help of various calculation means and data bases, relying on both statistical and expert-provided data. It is assumed that parts of the project under consideration or even the entire project are similar to accomplished earlier construction projects. However, these assumptions are not always correct and their bias degree is quite high in comparison to actual obtained parameters after the construction project implementation.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 242 – 250, 2006.

In order to determine theoretical values of the parameters as precisely as possible [1] and to reduce errors in the field of construction, the use of Product Lifecycle Management (PLM) [2], [3] or the so-called four-dimensional (4D) concept [4] is recommended. To achieve the effective management, fulfil the correct Enterprise Resource Planning (ERP) conditions with proper Supply Chain Management (SCM) and automated Material Requirements Planning (MRP), it is recommended first to create a 3D model of the construction project and to perform the simulation of its implementation. The fourth dimension – time, is employed for the analysis of simulation [5], [6], i.e. the project can be evaluated in terms of time (resistance to long-term effects, uniform durability of the project parts, saving power and other resources in implementing the project, analysis of the environmental pollution, etc.).

2 Objectives of the Research

The works devoted to the analysis of various aspects of construction projects' management [7], scheduling-planning and safety [8], design-planning-estimating procedure integration [9] analyze both structure and models used to evaluate the available alternatives [10], as well as major principles of their implementation [9]. Researchers offered possibilities of cost and time reduction for project documentation [11], schedule information, visualisation, communication [12], construction projects management and analysis using 4D project both with IT power. Most of them identified advantages [8], [9], [12] such as the same design interpretation among project members, understanding of construction sequences, certified amounts of construction works, design quality analysis and possibility of alternative evaluation.

However, the researchers tend to underestimate the influence of suitability and precision of the evaluation data as well as the reliability of methods and means of their application [13]. The present paper analyses the indicators of project efficiency as well as the methods of determining their values and precision of the technique used which will help to avoid further comparative analysis of inefficient project alternatives. The application of 4D concept model for the construction project management will also can be considered as the computer-aided financial and organizational means for company management and resource planning.

A traditional construction project can be described as a model covering all stages of its implementation [4], [9]: development and planning, design and economic assessment, tender and negotiations, construction and handover, maintenance and utilization. In these stages certain participants (Customer, costomer's representative, department, designer, contractor, investor or owner) perform the appropriate actions. The information collected through earlier stages [6] is transferred to the next stages. However, the data collected in this way often are not suitable and should be changed in order to implement the most effective construction alternative.

The main problem is the lack of information exchange between the construction project developed-assessed by designers (architectural, technical and work design of the project, 3D models) [2] and the construction works performed by a contractor. For example, at the design stage, technical decisions are made without consulting with construction specialists, and, at the construction stage, the contractor often attempts to implement the vision of designers in the simplest way. The lack of information exchange among the project participants negatively affects its implementation of the construction project: increasing the execution times, being the reason for the demand of non-scheduled resources, including ruined human resource management (HRM) and planned resource supply chain.

Therefore, to keep the schedule of the construction project implementation, based on the calculated resources, the effective management system of data distribution among the participants of project, control system throughout the whole construction project life [4], ensuring a full cycle of engineering support (The Building Continuum) [14] is needed.

3 Modeling and Calculation Analysis

Construction consulting and contracting company can fill the information lack ensuring coordination works and information feedback in development, design and construction stages. The feedback from the participants is ensured by using a 4D concept for the management of construction projects combined information flows inside enterprise. Therefore, a theoretical three-dimensional information model of the building (3D BIM) [14] consisting of intellectual volume elements [15] is developed, which is combined with resource demand calculations, comparison of the alternatives [16] and determination of the project lifetime at all stages of its implementation [17]. Expression of the 3D model in time embracing whole life of the project is 4D concept. Practically project manger can have whole information related with project before the construction process and can better prepare for project implementation.

A complete cycle of operations is being executed within the stages of the 4D concept model (Fig. 1) in order to make the best solution. A constant exchange of information between the stages [18] encouraging the selection of the most effective alternative is maintained. The structure of 4D concept model is divided into levels: at the first level (cells in bold), all stages and their interrelations are presented; at the second level (cells marked with dotted line), the initial data (and means) are presented; the third level (cells with arrows) is intended for the actions and processes to be carried out; the fourth level (big cells) presents the obtained result and benefits.

We can see that primary elements of the model structure have the greatest influence on the efficiency indicators, with the selection of the best solution mostly depending on precise determination of the demand for resources and Supply Chain Management (SCM). The errors made at this stage will prevent from determining the most effective alternative. Therefore, in order to establish the exact demand for project resources, a thorough calculation of the project-related quantities should be made. In most cases this manual work is time-consuming. To reduce the time needed for this the calculation of the required quantities and to avoid mistakes and inaccuracies caused by manual calculation, the 4D concept model can be used [4].

The main principle of the 4D model application is as follows: the quantities of modelled, described and parameterized elements are obtained automatically from the developed building information model (3D BIM) together with the determined demand for project resources. Basing ourselves on the specified technical capacities, we can obtain the timescale of the project operations and according their technological sequence the timescale of the entire construction project is derived.

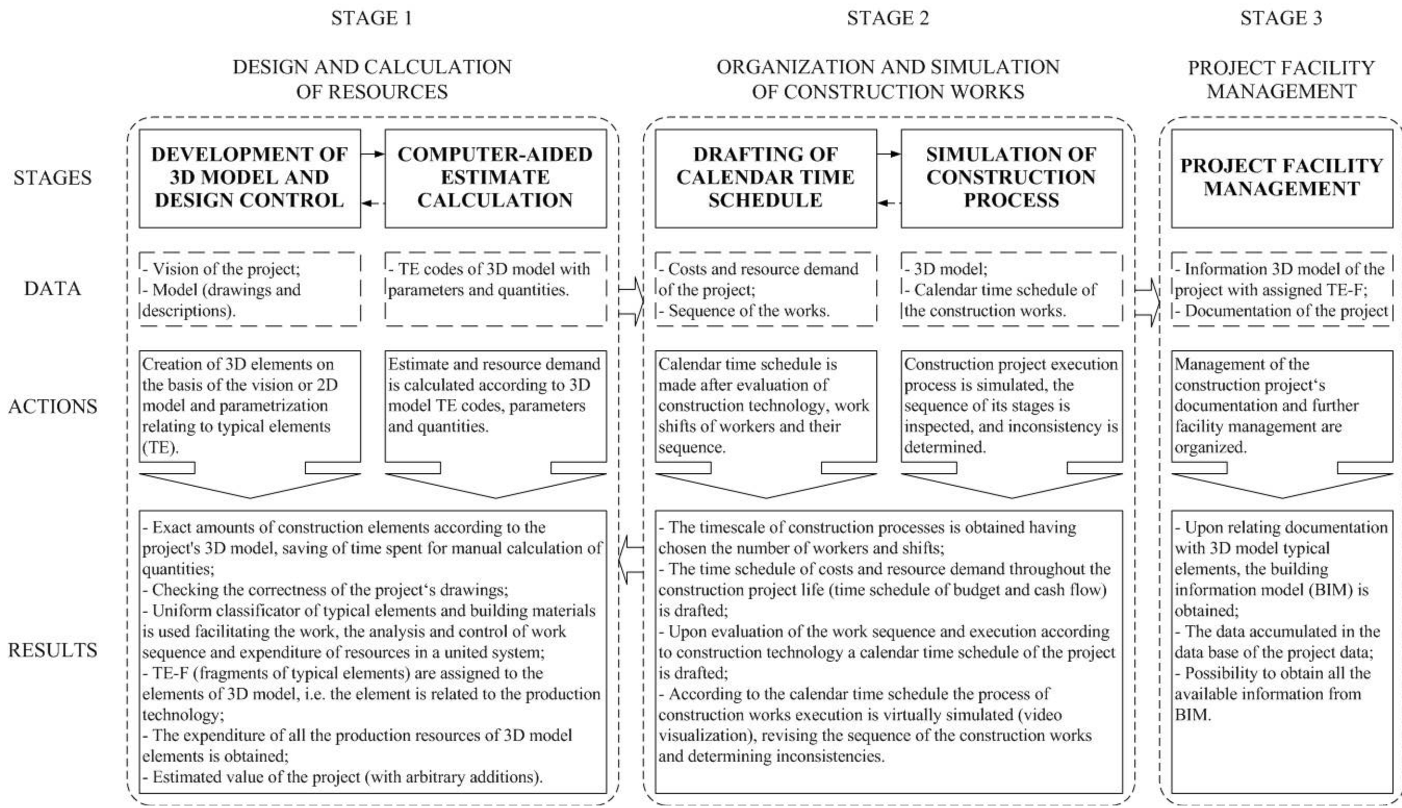

Fig. 1. The main stages of the 4D concept implementation and its elements

In the 4D concept model being used, the stages of every phase have inner cyclical relations needed for constant phase correction, while stages 1 and 2 share the data used for specifying the calculations and reducing the bias. Stage 3 receives the information from stage 2 saving it in the database (for further Facility Management).

To describe the 4D concept implementation (Fig. 1) a model of 4D concept implementation in the construction project management (Fig. 2) is made. This model has similar structure as his anterior but in addition it shows the management of calculated and collected data flow using special software packages such as SAS (System of the Automated eStimates – for composition estimates), Bentley Navigator and Microsoft Project. Included uniform classificators of typical elements (TE) and construction materials are used for control and analyze the course of construction and the expenditure of resources. Particular programs are connected with interrelationships and also the relations between stages are presented.

The effectiveness indicators of the stages are obtained, which are later used for multiple criteria comparative assessment of the construction project alternatives. When the whole cycle of the 4D concept is completed, the precise data of the analysis of the alternatives are obtained and used for choosing the final alternative of the construction project. If some major adjustments for 3D BIM must be made to ensure smooth Enterprise Resource Planning (ERP) with adequate Supply Chain Management (SCM) for several construction projects [19], its advisable to use full 4D concept implementation cycle.

The research made by scientists [4] has already compared duration of construction stages to determine the demand for resources, to calculate the estimates and to compare the construction alternatives. Main conclusion of this research is – the time saved to complete tendering procedures using 4D concept, compared to tendering procedures made in ordinary way, can be used for managing a larger amount of construction project tenders with a possibility to perform a more thorough analysis and a comparison of more alternative solutions for each construction project.

4 Determining the Effective Construction Project Alternative

When 3D BIM model is completed, the main characteristics of the construction project are analyzed and the 4D concept is applied, a model suitable for determining the most effective alternative in each project implementation stage is developed (Fig. 3). The generalized model of computer-aided construction project management throughout its life consists of initial stage and four project life cycle stages (lower row) individually combined with comparison of alternatives (upper row).

Initial stage. Every construction element from developed 3D BIM model must be assigned to typical element (TE) by describing and parameterizing according construction technology and exceptional implementation conditions. Assignment gives possibility to ensure the storage of all information related to the certain element of 3D model in single data base and can be used for any assessment.

3D model and TE stage. The estimate of the construction project is generated automatically according to quantities of each TE and general quantities of the project. Collected data can be used to establish tendering procedures for contractor selection.

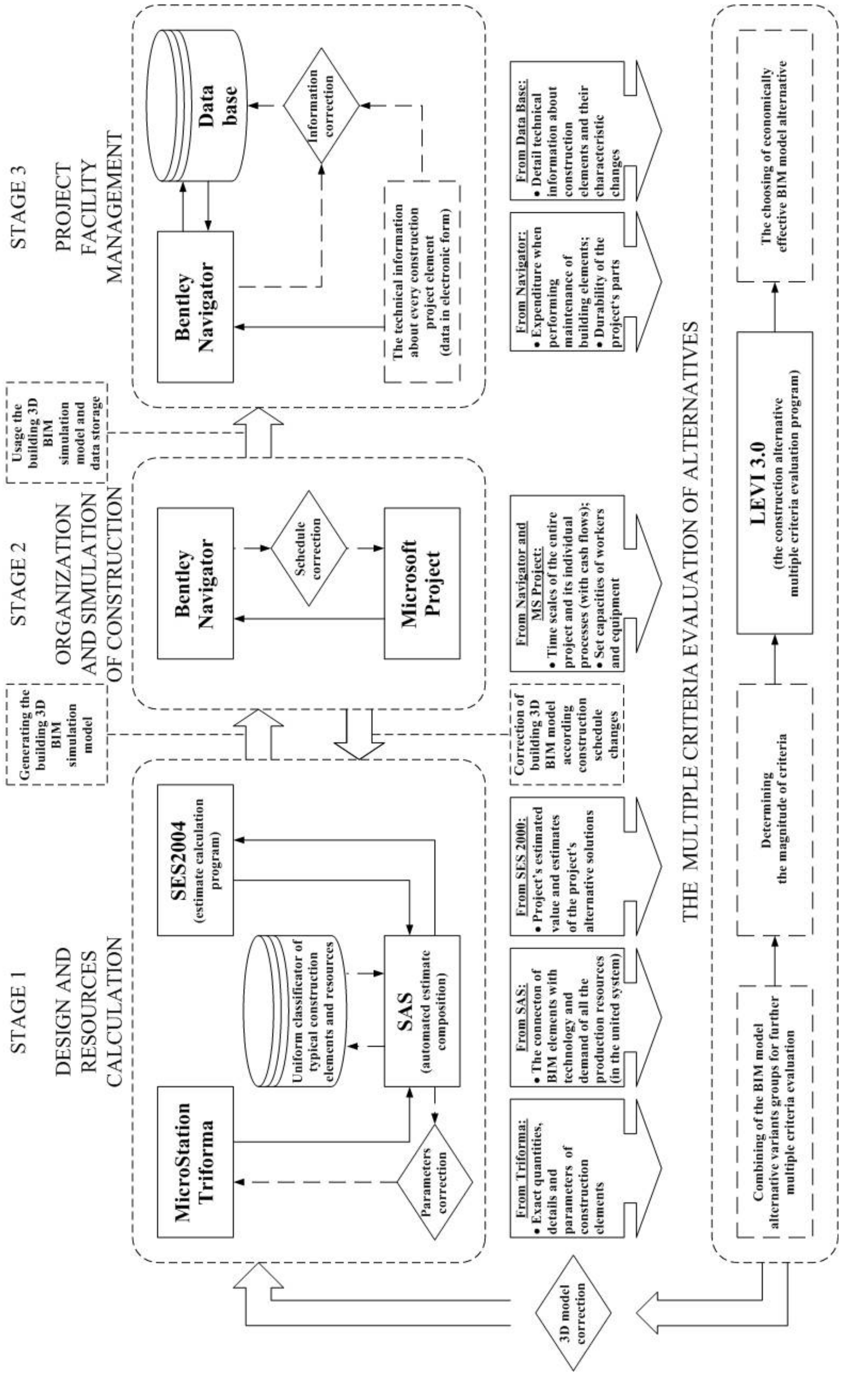

Fig. 2. A model of 4D concept implementation in the construction project management

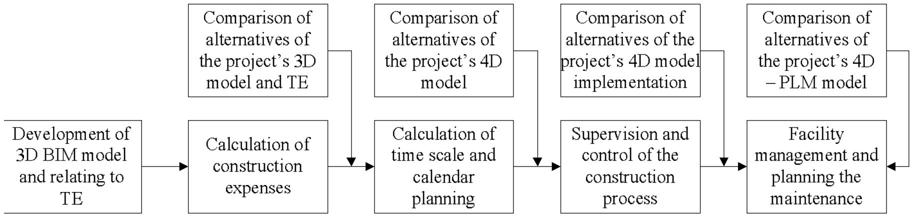

Fig. 3. A model of computer-aided management of the construction project throughout its life

4D model stage. Using the data from the 3D model and TE stage (resource demand) and having entered the technological sequence it is obtained working time schedule of the construction project, project implementation timescale, duration of processes and the demand of resource. In this stage it is available the simulation of the construction project implementation (visualising the future construction process) and analysis of possible alternative scenarios to foresee-reduce risk and uncertainty.

4D model's implementation stage. A virtual model of the project expressed in time (4D) is used for the supervision, control and management of the construction process with effective correction of the inconsistencies, i.e. there is a possibility to determine the difference between the actual and theoretical demand for resources and to follow the scope and course of the construction process in the visualisation. Information about actual demand of resources helps to control costs and dynamically react to volatile situation in construction site.

4D PLM model stage. All the available information related to facility management and maintenance is accumulated in the virtual model of the project (database), i.e. the data on the producer of the element, element's characteristics, peculiarities of maintenance, warranty servicing period, etc. are accumulated there.

Practical benefits of presented models can be described as: better management, communication and visualization of implemented projects with more consistent project documentation. Therefore project team was supported with: early information about missed design solutions and possible arising problems before production-installation, generated quantities for tendering procedures and analysis comparing to actual amount of the works. The 3D model connected with construction and supply schedule were used as a tool for operative planning and management of construction process. That is why detailed solutions enable manager to stay a step ahead, anticipate and solve everyday problems even before the client is confronted with them.

The best solution for construction company must be based on effective management of construction projects with analysis of the resource demand change. The possibility of comparison the alternatives in each stage (Fig. 3) can be applied using multiple criteria evaluation methods. In construction, the indicators of the implemented designs often differ from those calculated according to the design and drafts. The lack of information results in uncertainties or unreliable or incomplete data. When these uncertainties are caused by random effects defined by evaluations according to the distribution laws set by various statistical methods, then we have the problems of stochastic indefiniteness [10]. In decision-making under these uncertainty conditions, the game theory methods may be applied [20].

5 Multiple Criteria Evaluation of Alternatives

In this paper, the research is focused on the integration of multiple criteria decisions into computer-aided modelling-management-evaluation systems as well as using the algorithm of the synthesis methods [21], for combining several construction projects or a few phases of design stages into a joint system [6]. The researchers Peldschus, Zavadskas, Ustinovichius developed decision support software LEVI 3.0 [10]. Using this software, it is possible to find solutions to problems by different methods, to compare the construction projects and to select the most economically effective project implementation alternative in construction industry [22].

LEVI 3.0 can evaluate the effects of the application of different methods of transformation on the numerical results and improve the quality of transformation as well as ensuring precise solving of technological and organizational problems (tasks). This application with usage of the appropriate transformation methods allows to avoid inaccuracies in assessing the alternatives of construction projects.

6 Conclusions

The interconnection of the construction process participants and exchange of information are ensured by introducing the 4D concept for managing the construction projects. The main advantage of the 4D concept as a whole is a feasibility to simulate the management of the project, to calculate precisely the demand of financial and corporeal resources on the basis of 3D model, to determine the timescale of the project implementation and to assess the alternatives effectively.

Therefore, all the information should be accumulated in the building databases for further construction and facility management. It is advisable to use the multiple criteria decision support software LEVI 3.0 as a powerful tool for choosing the effective construction project alternatives.

The software based on the 4D PLM model should be in further developed as a powerful means for analyzing and effective management of the construction projects with analysis of the resource demand change and Supply Chain Management (SCM) throughout the construction project implementation and service life.

References

1. Ford, S., Aouad, G., Brandon, P., Brown, F., Child, T., Cooper, G., Kirkham, J., Oxman, R., Young, B.: The object oriented modeling of building design concepts. Building and Environment, Vol. 29(4), (1994) 411-419
2. Donath, D., Loemker, T., M., Richter, K.: Plausibility in the planning process – reason and confidence in the computer-aided design and planning of buildings. Automation in Construction, Vol. 13(2), (2004) 159-166
3. Sacks, R., Eastmanand, C.M., Lee, G.: Parametric 3D modeling in building construction with examples from precast concrete. Automation in Construction, Vol. 13(3), (2004) 291-312
4. Ustinovičius, L., Popov, V., Migilinskas, D.; Automated management, modeling and choosing of economically effective variant in construction. Transport and Telecommunication, Vol. 6(1), (2005) 183-189

5. Ekholm, A., Fridqvist, S.: A concept of space for building classification, product modelling, and design. Automation in Construction, Vol. 9(3), (2000) 315-328
6. Leinonen, J.; Kähkönen, K.: New construction management practice based on the virtual reality technology. In: 4D CAD and Visualization in Construction. Issa, R.R.A., Flood, I., O'Brien, W.J., A.A. Balkema Publishers, Lisse, (2003) 75-100
7. Chantawit, D., Hadikusumo, B.H.W., Charoenngam C., 4DCAD-Safety: visualizing project scheduling and safety planning. Construction Innovation Vol. 5(2), (2005) 99-114
8. Aouad, G., Marir, F., Child, T., Brandon, P., Kawooya, A., Construction Integrated Databases - Linking design, planning and estimating, The OSCON approach. In: International Conference on the Rehabilitation and Development of Civil Engineering Infrastructures. American University of Beirut, (1997) 52-60
9. de Vries, B., Broekmaat, M. Implementation Scenarios for 4D CAD in Practice. In: Maas, G. and van Gassel, F. (eds.): Proceedings of the 20th International Symposium on Automation and Robotics in Construction. (Eindhoven University of Technology. Eindhoven, NL), (2003) 393-398
10. Zavadskas, E.K., Ustinovichius, L., Turskis, Z., Peldschus, F., Messing, D.: LEVI-3.0 – multiple criteria evaluation program for construction solutions. Journal of Civil Engineering and Management, Vol. 8(2), (2002) 184-191
11. Nowak, M.: Investment projects evaluation by simulation and multiple criteria decision aiding procedure. Journal of Civil Engineering and Management, Vol. 11(3) (2005) 193-202
12. Leeuwen, van J.P., Zee, van der A.: Distributed Object Models for Collaboration in the Construction Industry. Automation in Construction, Vol. 14(4), (2005) 491-499
13. Migilinskas, D.: The influence of normalization methods selection in construction including game theory adaptation. Technological and economic development of economy, Vol. 9(2), (2003) 73-79
14. Maute, K., Raulli, M.: An interactive method for the selection of design criteria and the formulation of optimization problems in computer aided optimal design. Computers & Structures, Vol. 82(1), (2004) 71-79
15. Garner, B., Raban, R.: Context management in modeling information systems (IS). Information and Software Technology, Vol. 41(14), (1999) 957-961
16. Dijkstra, J., van Leeuwen, J.P., Timmermans, H.J.P., Evaluating Design Alternatives Using Conjoint Experiments in Virtual Reality. Environment and Planning, Vol.30 (2003) 357-367
17. Popov, V., Mikalauskas, S. Migilinskas, D., Vainiunas, P.: Complex usage of 4D information modeling concept for building design, estimation, scheduling and determination of effective variants. Technological and economic development of economy, Vol. 12, (2006)
18. Borg, J., Yan, X.T, Juster, N.P.: Exploring Decisions' Influence on Life-Cycle Metrics to Aid 'Design for Multi-X'. Artificial Intelligence for Engineering Design, Analysis and Manufacture, Vol 14(2), (2000) 91-113
19. Aouad, G., Sun, M., Faraj, I. Computer integrated construction: recent developments and future directions. In: Topping, B.H.V. (ed.), Civil and Structural Engineering Computing: 2001. Saxe-Coburg Publications, UK, (2001) 27-54
20. Migilinskas, D., Ustinovichius, L.: An analysis of inaccuracy effect in solving construction technology and economy problems, applying games theory. In: The 8th International Conference „Modern building materials, structures and techniques"- Selected papers (VGTU, Vilnius, Lithuania), (2004) 229-235
21. Sarka, V.: A Decision Support System Applying Multicriteria Synthesis Methods in Construction. Statyba (Civil Engineering and Management), Vol. 6(6), (2000) 464-468
22. Ustinovichius, L.: Determination of Efficiency Of Investments In Construction. International Journal of Strategic Property Management, Vol. 8(1), (2004) 25-44

Development of an e-Engineering Framework Based on Service-Oriented Architectures

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Abstract. This paper presents an ongoing project on the development of an e-Engineering framework proposed by KIMM (Korea Institute of Machinery and Materials). The framework is based on a number of advanced technologies, such as intelligent software agents, Web Services, and Service-Oriented Architecture. And it aims to provide an integrated design environment to support integrating personnel, design activities and engineering resources during product development process. Especially Service-Oriented Architecture technologies enable to utilize and integrate effectively various engineering resources on the heterogeneous geographically distributed computing environments.

1 Introduction

With the rapid growth of electronic computer, information technology, and related engineering technologies (CAD, CAE, CAM, etc.), e-Engineering is becoming an emerging technology, as a new engineering paradigm, to be able to increase rapidly the productivity of the industries and the quality of the products[1,2].

While with the globalization of manufacturing, there is a considerable need for collaborative design environments over the Web to utilize and integrate effectively various engineering resources on the heterogeneous computing environments and to enable collaboration among geographically distributed design teams[3,4].

Integration of the distributed various engineering resources and orchestration (coordination and cooperation) of engineering services provided by the resources have been recognized as crucial issues to construct such collaborative design environments successfully [3,4].

The combination of intelligent agents and a Web services based SOA (Service-Oriented Architecture) framework can be an excellent candidate for the successful implementation of collaborative design environments. Because Web services technology is very powerful in integrating world widely distributed resources, and intelligent agents support cooperation and coordination mechanisms for a range of distributed problem-solving engineering services.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 251–258, 2006.

KIMM has a plan to develop an e-Engineering framework from 2004 to 2009 under the Korean government financial support[11]. This paper reports KIMM's framework, which is being developed with a number of advanced technologies, such as SOA, intelligent software agents, Web Services, business process modeling, workflow, and optimization. And it includes PDM (Product Data Management) interface and various kinds of virtual prototyping technologies.

There are some engineering frameworks such as Phoenix Integration's ModelCenter [5], Engineous Software's iSIGHT [6], and VR&D's VisualDOC [7] that integrate diverse engineering programs and provide optimization algorithms, approximation scheme, and function of reliability analysis. MSC Software has developed SimManager [8] which manages the CAE data and provides the web based engineering portal and the reporting tool.

However, traditional commercial engineering frameworks have limitations such that those just perform the pre-defined processes and activities. And Web-based technologies only provide basic infrastructures for collaborative design systems by standardizing communications between systems. Thus those have difficulties to change the design process dynamically, to perform the decentralized design, and to support the integration of multidisciplinary design environments.

On the one hand, a number of integrated development platforms such as IBM's WebSphere[9] and Microsoft's BizTalk[10] implement the widely accepted industrial application development frameworks for Web services. They support the SOA paradigm through the use of web services, BPEL, and Web services protocols such as UDDI, SOAP, and WSDL. They have achieved various successes at the application level, especially in e-Business applications.

However, the integrated platforms have no the specialized characteristics for engineering domain. Especially in case of BPEL there are many aspects to be improved when it is applied to modeling the engineering processes. The engineering processes may be changed and/or performed dynamically according to its execution history, its state, and so on [11]. But current versions of BPEL are too static to accommodate the dynamic features needed by engineering processes.

Under these circumstances, intelligent software agents and SOA technologies are all very useful in developing collaborative design engineering environments. The combination of these technologies has a greater potential to bring advantageous characteristics, such as autonomy, cooperative, flexibility, adaptability, interoperability, scalability, and loosely coupled architecture.

2 An e-Engineering Framework

2.1 System Architecture

Figure 1 shows the overall architecture that extends the previous multi-agent version [3] as an integrated design/analysis system by applying SOA concept. The architecture is separated to the three layers; the top is a presentation layer that provides several interfaces for various users, the middle is a business processing layer that performs several engineering jobs, and finally the bottom is an

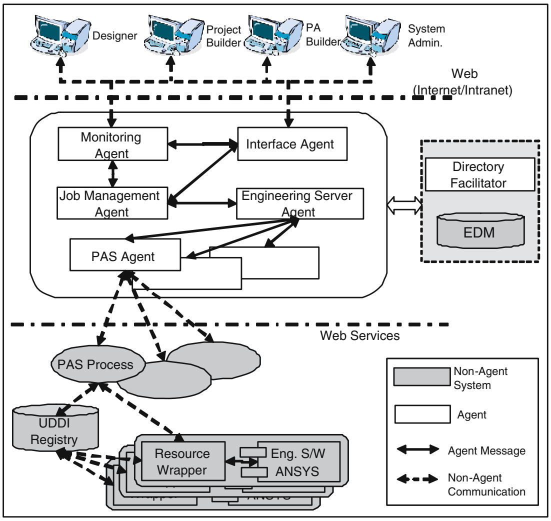


Fig. 1. System Architecture of an e-Engineering Framework

engineering resource layer that enables to utilize the distributed engineering resources via Web Services.

The mid layer is based on the JADE(Java Agent Development)[12] platform. Followings are the agents located in the mid layer.

Interface Agent: Interface agent (IA) is the gateway that enables users (designer, project builder, PAS builder, system administrator and etc.) to access the system to define, manage, monitor and practice the information about the engineering project. Designer can define design parameters; get design results; and monitor the status of engineering process. It provides the Web based designer's interface for multi-user and multiproject. Project or PAS builder can define and manage the engineering project or process through IA. They offer the key information for engineering process.

Monitoring Agent: Monitoring agent (MA) is specially designed to facilitate the monitoring of agents' behavior in the system. Since the information is distributed and controlled by each individual agent in a distributed computing system, it is necessary to have an agent that could accumulate information required from various resources. Through this monitoring agent, dynamic condition of the system environment as well as all individual agents can be conveniently monitored or reviewed. MA can provide independent monitoring interfaces corresponding to each users group.

Engineering Server Agent: Engineering Server agent (ESA) divide its global engineering task into several sub tasks and negotiate the task sharing with several PAS agents based on some task allocation factors such as reliability, cost, and time. It enacts and controls the engineering processes defined to solve the given engineering problem. It manages and files up all kind of the results from PAS agents. In other words, all kinds of the answers from PAS agents are accumulated in its D/B through EDM. The task allocation can be done in view points of engineering analysis fields or sub parts of the product.

Job Management Agent: Job Management agent (JMA) offers the various kinds of optimization scheme to ESA to process the multi jobs efficiently in the multi-users and multi-jobs environment. The multi jobs can be executed independently and concurrently corresponding to the change of design parameters (the configuration change of product, material properties, the change of manufacturing process, all kinds of modeling parameters, and etc).

Process/Analysis Server Agent: Process/Analysis Server (PAS) agent is the actual engineering process solving agent. It not only carries out the communication and negotiation functions but also executes PAS process to do the related analysis, simulation or optimization. It is really autonomous agent because it can determine its own activity by itself through catching the change of world model as the change of external design condition. Of course, it is an intelligent one because it can level up its own ability by updating it own DB, action plan and etc by its own expert algorithm.

2.2 Mapping Relationships Between Components of the Engineering Framework and Elements of SOA

Service-oriented architecture presents an approach for building distributed systems that deliver application functionality as services to either end-user applications or other services [13]. Figure 2 shows the architectural stack and the elements in a service-oriented architecture [14]. The architectural stack is divided into two halves, with the left half addressing the functional aspects of the architecture and the right half addressing the quality of service aspects. Here we describe in detail just functional aspects as follows.

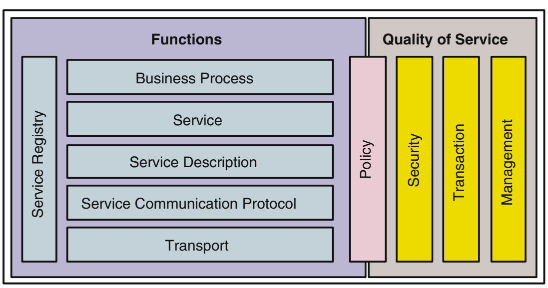


Fig. 2. Elements of a Service-Oriented Architecture

Transport is the mechanism used to move service requests from the service consumer to the service provider, and service responses from the service provider to the service consumer. Service Communication Protocol is an agreed mechanism that the service provider and the service consumer use to communicate what is being requested and what is being returned. Service Description is an agreed schema for describing what the service is, how it should be invoked, and what data is required to invoke the service successfully. Service describes an actual service that is made available for use. Business Process is a collection of services, invoked in a particular sequence with a particular set of rules, to meet a business requirement. Note that a business process could be considered a service in its own right, which leads to the idea that business processes may be composed of services of different granularities. The Service Registry is a repository of service and data descriptions which may be used by service providers to publish their services, and service consumers to discover or find available services. The service registry may provide other functions to services that require a centralized repository.

Table 1. Mapping Relationships between SOA and Engineering Framework

Elements of SOA	Components of the e-Engineering Framework
Transport	HTTP
Service Communication Protocol	SOAP
Service Description	WSDL
Service	Engineering Software
Business Process	Engineering process performed in a multi-agent system
Service Registry	UDDI

Table 1 shows the mapping relationships between elements of SOA and components of the engineering framework. The relationships explain how KIMM's engineering framework realize SOA concept. Followings are the components required to accomplish SOA concepts. Here we omit the descriptions of primitive constituents of Web services such as SOAP, UDDI, and so on.

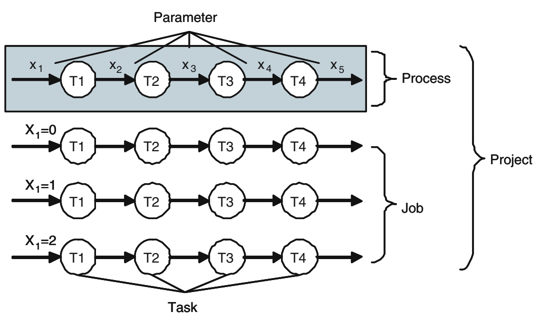


Fig. 3. Structure of an Engineering Process

Engineering Process: One of the key paradigms for SOA development is that the business processes are seamless. Each step in each process should be linked, either as an automatic next step (workflow or flow driven), or as a workflow task on a users' consolidated task list. The business process is represented as an engineering process in KIMM's framework. An engineering process is a sequential or parallel workflow that consists of design/analysis tasks (CAD modeling, structure analysis, kinetics analysis, and etc) needed to solve engineering problems. Each design/analysis task defines an engineering model to be solved and executes the model with parameters using engineering software (CATIA, NASTRAN, ADAMS, and etc). The Figure 3 shows the structures of an engineering process. Here, Task is a unit that performs a design/analysis work using engineering software. Process is a sequential or parallel flow of unit tasks to solve a specific engineering problem. Job is an instance of a process, which executes real works with parameters having a concrete value. Finally, Project is a collection of a process and jobs (the instances of the process). In KIMM's framework, a multi-agents environment in the mid layer of Figure 1 controls the execution of an engineering process with assistances of a number of engineering software in the bottom layer and Web Services.

In the SOA context, PAS process, UDDI registry, and engineering resources are corresponding to a service consumer, a service registry, and a service provider, respectively.

Process/Analysis Server Process: PAS Process created by PAS agent is not an agent but a process, which carries out the tasks delegated by PAS agent. For this, it utilizes the distributed various engineering software resources on the help of Web Services technique. That is, PAS process can access the engineering resources through the protocols, HTTP and SOAP, to use the necessary engineering services registered in the UDDI.

Services: Services, in the SOA context, are defined by explicit, implementation-independent interfaces, are loosely bound and invoked through communication protocols, and encapsulate reusable business function. In KIMM's framework functionalities of various engineering software resources (CATIA, NASTRAN, ADAMS, and etc) are modeled as services.

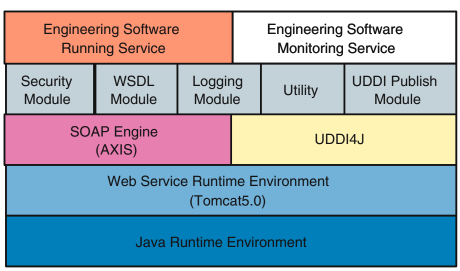


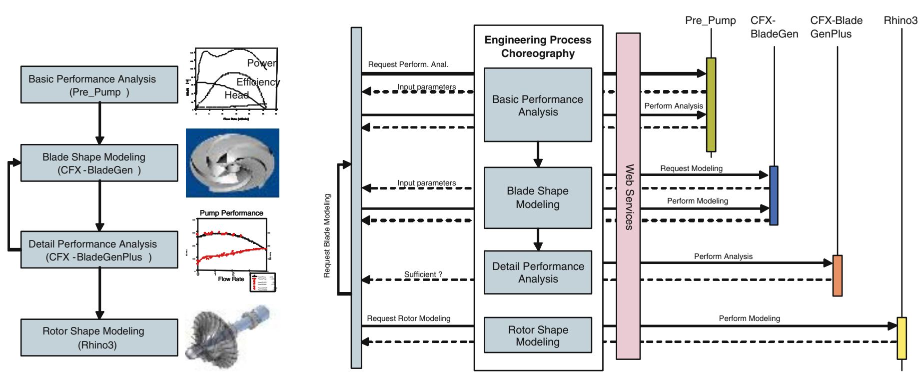
Fig. 4. Architectural Stack of a Resource Wrapper

Resource Wrappers: To solve engineering problems PAS processes may request services of the engineering software resources via Web Services. However the engineering resources may have some troubles to communicate with PAS process directly, because they are legacy systems which have specific interfaces of their own. In order to incorporate them into a SOA context, they should have a unified interfacing mechanism, called a wrapper, which plays a role as a gateway to engineering software. A resource wrapper dictates to execution of engineering software and monitoring of running states of it to respond a request of PAS process. The architectural stack of a resource wrapper is shown in Figure 4.

3 Case Study

Figure 5(a) shows a simple engineering process for the Pump design. It works as follows: The basic performance analysis gets analysis conditions such as a total head, volume flow rates, and rotational speeds as inputs and generates geometrical design data such as the number of blades, the inlet/outlet blade angles, and so on. This task is performed by Pre_Pump, in-house software developed by KIMM. Next the blade shape modeling through CFX-BladeGen works a shape modeling for a three-dimensional blade with the geometrical data generated by the previous task. Thirdly the detail performance analysis, performed by CFX-BladeGenPlus, yields the analysis results such as detail flow fields and (off)design point performances using several inputs like the three-dimensional blade shape generated in the previous task and operating conditions such as rotational speeds, pressures, and temperatures. If the results of the task are unsatisfactory the simulation work goes back to the preceding task and reworks the blade shape modeling. This work will be iterated until the results of the task are satisfactory. Final task generates the shape of rotor as a mechanical system, based on the hydraulic performance evaluations performed in the previous tasks for a pump. Rhino3 is used in the rotor shape modeling.

Currently, a prototype system for the Pump design is built. The system utilizes four engineering software: Pre_Pump, CFX-BladeGen, CFX-BladeGenPlus, and Rhino3. Only Pre_Pump is in-house software, the others are commercial tools.



(a) Engineering Process (b) Interaction Model

Fig. 5. An Engineering Process for a Pump Design and its Interaction Model

Though they are geographically distributed at a few laboratories in KIMM, they are integrated and applied easily through SOA technologies. Figure 5(b) shows an instance of engineering process choreography. In this figure we can find that some actions are initiated by users and other actions are initiated by engineering process automatically. This fact means that the well-defined engineering processes control appropriately the sequences of tasks to solve engineering problems.

4 Conclusions

This paper presents an ongoing project of KIMM for the development of an e-Engineering framework for the design and manufacturing of a mechanical system. SOA framework, agent, Web Services, workflow, and business process modeling are the main technologies used in this project. We are currently working on the implementation of a proof-of-concept software prototype. When the current e-Engineering framework is developed successfully in near future, much saving of man-powers, times and costs in fields of mechanical engineering design/ manufacturing are expected. And it is expected the system will be easily extended for other applications in the design and manufacturing of various industries.

References

1. G. Toye, M.R. Cutkosky, L.J. Leifer, J.M. Tenenbaum, J. Clicksman, "Share: A Methodology and Environment for Collaborative Product Development". *Proc. Second Workshop on Enabling Technologies: Infrastructure for Collaborative Enterprises*, pp.33-47, 1993.
2. W. Shen, D.H. Norrie, and J.P. Barthes, *Multi-Agent Systems for Concurrent Intelligent Design and Manufacturing*, Taylor and Francis, London and New York, 2001.
3. Q. Hao, W. Shen, Z. Zhang, S.W. Park, and J.K. Lee, "Agent-based Collaborative Product Design Engineering: An Industrial Case Study," *Computers in Industry*, No. 57, pp.26-38, 2006.
4. Y. Wang, W. Shen, H. Ghenniwa, "A Web/agent based Multidisciplinary Design Optimization Environment," *Computer in Industry*, Vol.52, No.1, pp.17-28, 2003.
5. http://www.phoenix-int.com/
6. http://www.engineous.com/
7. http://www.vrand.com/visualDOC.html
8. http://www.mscsoftware.com/products/simmanager.cfm
9. http://www-306.ibm.com/software/websphere/
10. http://www.microsoft.com/biztalk/default.mspx
11. S.W. Park, J.K. Lee, J.S. Bang, and B.C. Shin, "Development of an e-Engineering Environment for Automotive Module Design," *Proceedings of the 9th International Conference on Computer Supported Collaborative Work in Design* (LNCS 3865), pp.264-273, 2005.
12. http://jade.tilab.com/
13. M.P. Papazoglou, "Service-Oriented Computing," *Communications of ACM*, Vol. 46, No. 10, pp.25-28, 2003.
14. M. Endrei and et. al., *Patterns: Service-Oriented Architecture and Web Services*, IBM, 2004.

A Real-Time PDA Based Communication Appliance for Multi-users

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Abstract. PDA devices have become an accessory that a large community uses for managing their personal data. With the development of new devices with additional network and video capabilities they gain the potential to be used in more comprehensive communication scenarios too. On the example of usage for image communication we show, how new applications must not be viewed in an isolated way and need innovative approaches for both system hard-and software enhancement as well as for the integration with heterogeneous infrastructure components. The challenging task for creating so called communication appliances is not just to transfer existing desktop mechanisms to smaller and mobile computers but to consider their specifics and establish additional architectures and mechanisms that meet those best. Our paper describes the prototyping of image communication device based on an off-the-shelf PDA, design and usage experiences and potential future enhancements.

1 Introduction

In recent years communication paradigms evolve very fast and we experience a major shift from fixed and stationary systems towards nomadic and mobile communication devices. A realistic future scenario comprises nearly ubiquitous network access in large areas of the world. Moreover the rapid transition towards an open and flexible IP-based heterogeneous network infrastructure will accelerate the definition and deployment of various services spanning the range from audio to multimedia applications. Additionally we also face a change in the type of devices that are used for managing data and accessing services. Whereas computational intensive applications were traditionally bound to host systems or desktop computers, the recent generation of PDAs introduces a shift in this assignment of functions. In addition to having easy means of accessing and storing data, one of the basic motivations for using those portable devices is being able to communicate. With the recent state of technology it gets possible and desirable to use PDAs for not just managing notes, contacts and calendars but for also accessing a huge number of infrastructure based services and for even videophony-like applications. Current innovations in the area of ubiquitous and mobile computing [10],[15] are pushed from research both on the hardware system as well as the protocol and application side. The progress in technology and the availability of powerful hardware and software platforms recently enabled the development and practical deployment of a number of applications that try to use small devices [1] in a collaborative manner [2-3]. For our prototype we benefit from the

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 259 – 266, 2006.

work that is currently done for providing Linux and other Open Source solutions for off-the-shelf PDAs as the iPAQ [4]. In the past we mainly find a number of applications – each packaged in a kind of a ”black box” that are specialized for distinct purposes. You are e.g. using a cellular phone for audio communication whereas the addresses and phone numbers of your communication partners are stored on another device. With the emerging use of these PDAs and other innovative computer end systems the new term ‘communication appliance’ has been introduced. It describes the combination of both hard-and software components as tool for personal use. To fulfil the demand for multimedia communication, everywhere and at anytime, communication appliances have to overcome the apparently contradictory and incompatible requirements of being small and multi-purpose, power-efficient and powerful, autonomous and interacting with heterogeneous infrastructures. We will show how many of these specifics apply to and have to be solved in the area of using PDAs for image communication. Real-time image communication forms a promising technology to provide enhanced and new communication and application scenarios to a number of users.

Basically every networked computer system with appropriate audio capabilities can potentially be used to communicate with other IP-based but via gateways also conventional telephones [5]. In combination with Presence and Instant Messaging applications this holds an enormous potential for the support of seamless ubiquitous communication.

2 System Architecture and Design Considerations

Our intended scenario compromises a set of mobile users with PDAs that are connected to an infrastructure via Wireless LAN and are able to both originate and receive image messages. We use HP iPAQ PocketPC 2210 equipped with PocketPC 2003 OS supporting .NET Compact Framework. This OS is designed for managing the slow CPU and small memory effectively and supporting easy development of user-oriented GUI. In order to implement the communication system synchronized by wireless network, the Socket .NET Compact Framework gives the compatibility between heterogeneous devices, hence the smart devices such as PC, Notebook, PDA, Celuler Phone etc. can communicate each other using TCP/IP on wireless LAN environment as shown in Figure 1. SDIO Type Wireless LAN is used to be expanded through the SD expansion slot. TCP/IP-based system running on Internet infrastructure can support all kind of communication topology. Also unlike the chatting messenger program which is usually centralized server based, this system can be operated independently under various kind of synchronized working environment.

The network is synchronized as the following algorithm as shown in Figure 2.

To activate server, Server Thread is generated. Then TCP Listener is working and waiting for the access from clients

By using TCP Listener and TCP Client Class, Server and Client is set up. TCP Client activates the Server using Server Class, confirms the Client access and the generation of Server.

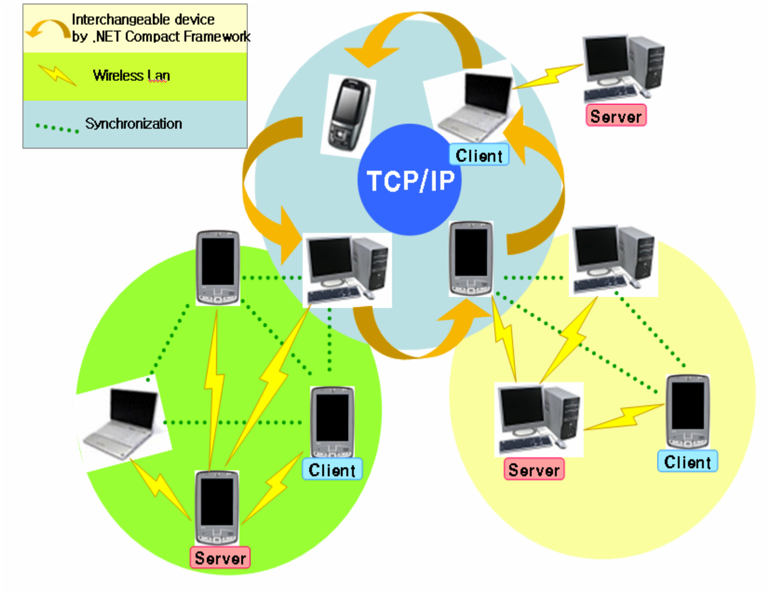

Fig.1. The proposed system environment

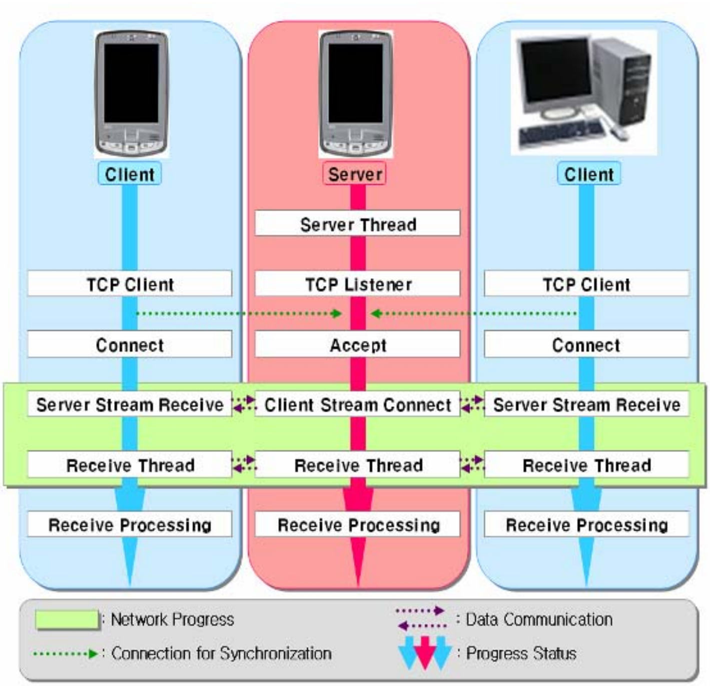

Fig. 2. The flowchart for network synchronization

Client accesses Server and the connection is set up.

When the connection is confirmed, Server connects to Client Stream and Client connects to Server Stream. After setting up the connection, Receive Thread is activated for receiving the transmitted data from the other side.

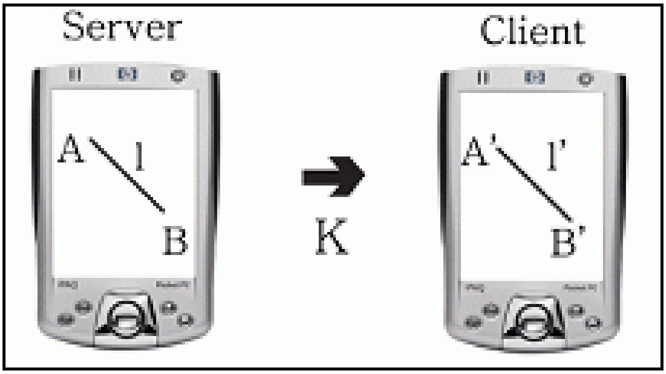

Fig. 3. The line drawing from A to B

When a line is drawn from A to B, stream transmission is synchronized as follows:

The coordinates of all pixels positioned on the line are transmitted sequentially from Server to Client. A line is drawn by computing the coordinates of the first pixel and the last pixel at Client as shown in Figure 3.

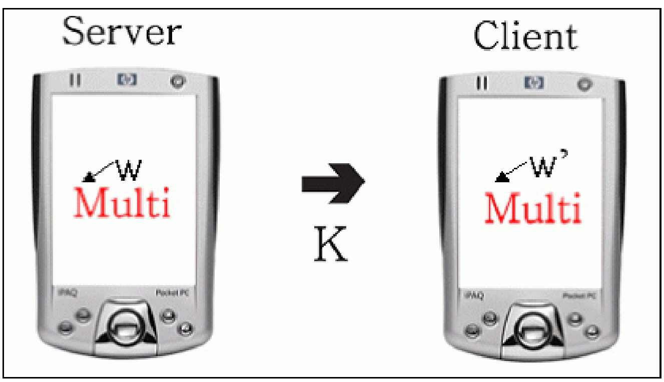

Fig. 4. The transmission of red text

The characters are transmitted as images. The minimum information for the text to be transmitted is described as w(x,y,b,c), where x and y, the coordinate values, b, the width of brush, and c is the pen color as shown in Figure 4.

3 The Prototype System

The HP iPAQ PocketPC 2210 is an off-the-shelf PDA that uses a 400 MHz PXA255 Intel XScale processor. It follows a modular design with a core unit having a color-graphic 320x240 touch-screen interface, an integrated microphone and speaker, an IrDA port for SIR or FIR serial communication and an external connector that provides both the signals of the iPAQs serial port as well as an USB interface. The prototype system allows to place or receive images while moving inside wireless infrastructure. Interoperability has been tested with a number of heterogeneous platforms shown in Figure 5 and 6.

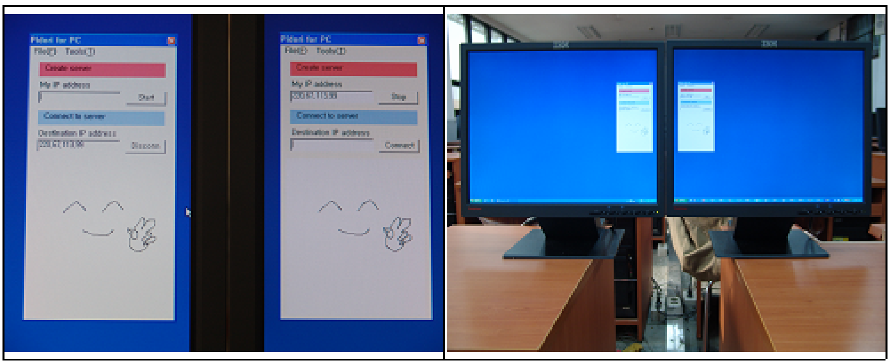

Fig. 5. PC2PC synchronization

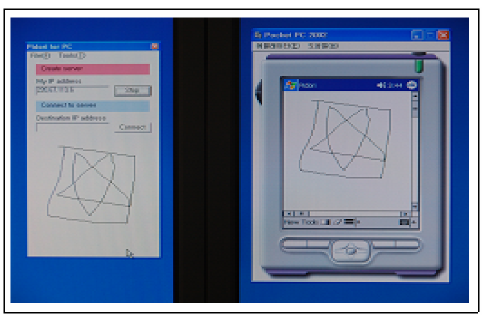

Fig. 6. PC2PDA synchronization

We initially formulated the design and evaluation criteria for our prototype system. Its implementation and test showed a number of both quantitative as well as qualitative results. The memory footprint of the resulting vector graphics is considerably smaller.

Due to the usage of a standard TCP/IP environment and .NET Framework, both for development and runtime, the approach gains a high amount of flexibility, extendability and possible combinations with other standard smart devices.

This must especially considered when comparing against single purpose, specialized embedded systems that are still typically used when building (consumer) communication products. Experimental results are shown in Figure 7 and 8.

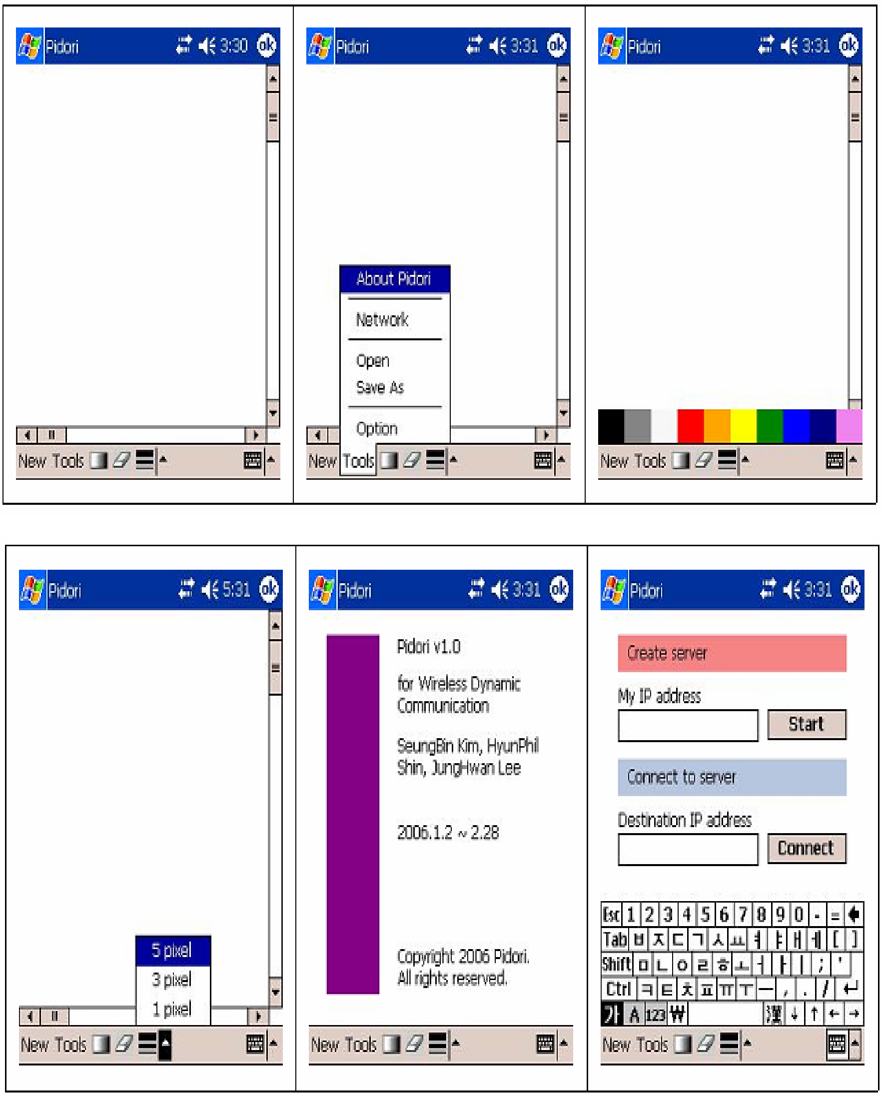

Fig. 7. Appliance Interface

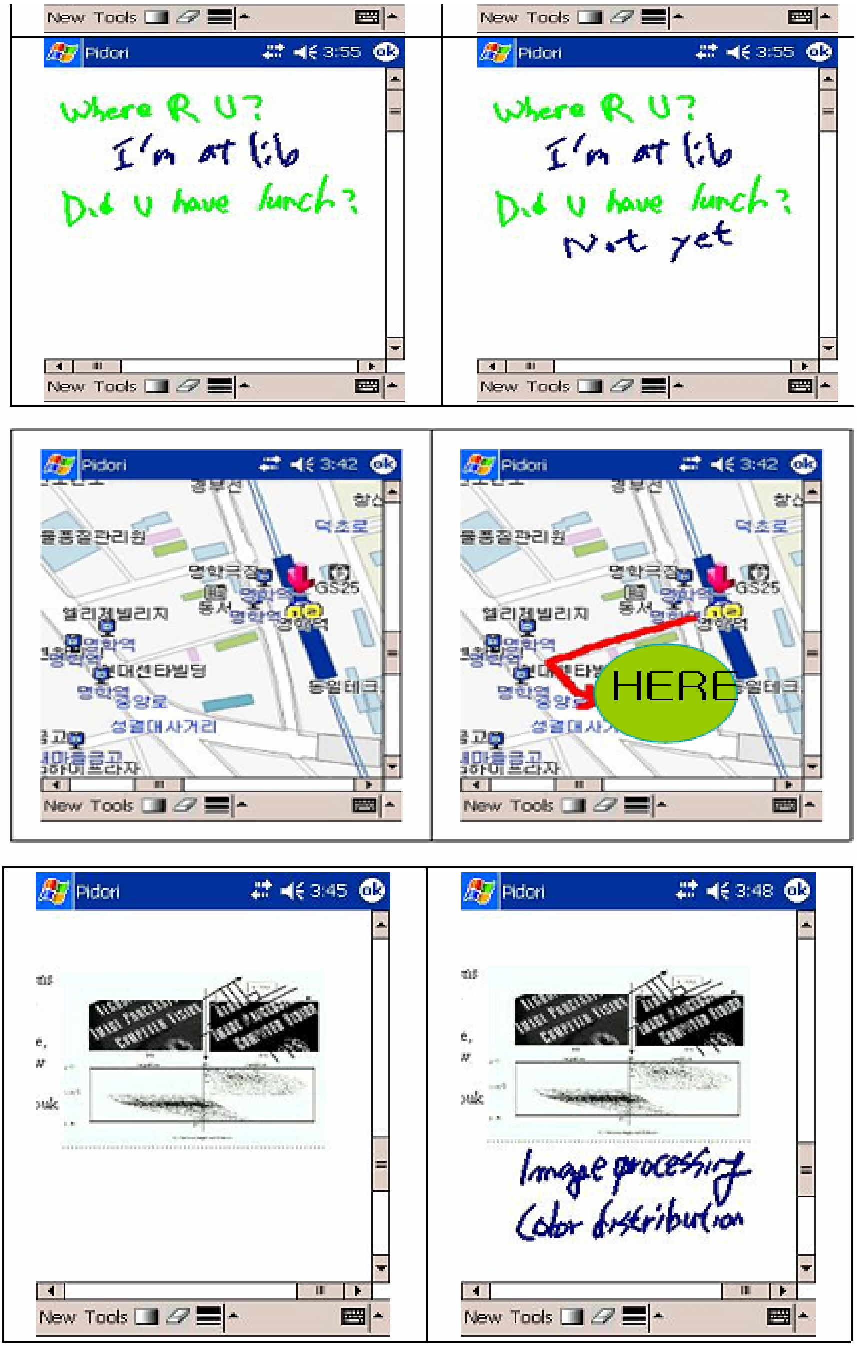

Fig. 8. Experimental Results

4 Conclusion and Future Work

The proposed prototyping environment is a perfect-sized platform for rapid development of new communication services. Using it we could successfully show the feasibility of our decomposition and infrastructure integration approach that forms a general paradigm for enhancing the functionality of small devices, in a working environment.

The paper does not cover the promising area of integrating emotional character based communication yet. We are going to evaluate those that especially benefit from the availability of our image based prototype. We intend to present the systems prototype and future results of our on-going enhancements at the sequel paper.

Acknowledgments

This work has been partially supported by Korea Research Foundation Grant reference KRF-2005-081-D00012.

References

1. M. Weiser. Hot topic: Ubiquitous computing. IEEE Computer, pages 71–72, October 1993.
2. T-L. Pham, G. Schneider, S. Goose, and A. Pizano. Composite Device Computing Envronment: A Framework for Augmenting the PDA using surrounding Resources. Proc. of the ACM CHI 2000 Conference Workshop Situated Interaction in Situated Computing, April 2000.
3. B.A. Myers, H. Stiel, and R. Garggiulo. Collaboration Using Multiple PDAs Connected to a PC. Proc. of the ACM Conference CSCW, pages 285–294, November 1998.
4. Linux on the Compaq iPAQ PDA. http://www.handhelds.org.
5. Ralf Ackermann, Manuel Goertz, Martin Karsten and Ralf Steinmetz," Prototyping a PDA based Communication Appliance," Proceedings of Softcom 2001
6. PS/2 to serial serial converter with Linux input support. http://www.iptel-now.de/HOWTO/PS2SER/ps2ser.html.
7. Tcl/Tk for the iPAQ running Linux. ftp://ftp.handhelds.org/pub/apps/tcltk/.
8. A. Helal et al. Any Time, Anywhere Computing; mobile computing concepts and technology. In Kluwer Academics Publisher, Boston, 1999.
9. R. Hull, P. Neaves, and J. Bedford-Roberts. Towards Situated Computing. Proc. of IEEE First ISWC, pages 146–153, October 1997.

Flexible Collaboration over XML Documents

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Abstract. XML documents are increasingly being used to mark up various kinds of data from web content to scientific data. Often these documents need to be collaboratively created and edited by a group of users. In this paper we present a flexible solution for supporting collaboration over XML documents. Merging of user work is based on the operations performed. A key to achieving flexibility for the definition and resolution of conflicts was to keep the operations distributed throughout the tree model of the document associated with the nodes to which they refer.

1 Introduction

XML is a popular format for marking up various kinds of data, such as application data, metadata, specifications, configurations, templates, web documents and even code. While some XML documents are generated automatically from systems, for example database exports, there are many cases where XML documents are created and edited by users either in raw text format or through special tool support. Our goal was to investigate concurrent editing over XML documents. A key issue in collaboration is merging versions of XML documents produced by different users.

Some state-based approaches for merging XML documents have been proposed in [12,2,9]. As opposed to state-based merging, where only the information about the states of the documents is used, the operation-based approaches keep information about the evolution of one document state into another in a buffer containing a history of the operations performed between the two states of the document. Merging is done by executing the operations performed on one copy of the document on the other copy of the document. Conflicts might exist between concurrent operations and an important issue is how to provide users support for the definition and resolution of conflicts. Merging based on operations offers good support for conflict resolution by having the possibility of tracking user operations.

Operation based approaches for merging XML documents have been proposed in [10] and [4]. These approaches did not deal with issues related to the definition and resolution of conflicts. They maintain a single history buffer where the executed operations are kept and it is difficult to select the operations that refer to a particular node in the document. This fact has limitations for the definition and resolution of conflicts referring to a unit of the document. These approaches adopt an automatic resolution of conflicts by combining the effects of

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 267–274, 2006.

concurrent operations, but do not allow users in the case of conflict to manually select between versions of elements.

In this paper, we propose a flexible merging approach for XML documents where the history buffer containing the performed operations is distributed throughout the tree rather than being linear. We previously applied the distribution of history throughout a tree document model for the case of hierarchical text documents in the real-time [8] and asynchronous [6,7] modes of collaboration. In this paper we show how the association of operations with the structure of the document is used for the asynchronous collaboration over XML documents with a shared repository. The resolution of conflicts is simplified compared to the approaches that use a single history buffer, as conflicting operations that refer to the same subtree of the document are easily detected by the analysis of the histories associated with the nodes belonging to the subtree. Moreover, conflicts can be dynamically defined at different levels of granularity corresponding to the different levels of the document. The policies for merging can be automatically or manually defined by users.

The paper is structured as follows. In section 2 we describe the requirements for merging and editing XML documents. Section 3 presents the model of the document and the set of operations that we adopted. We then go on to describe in section 4 our approach for merging. In section 5 we present the flexibility of our approach for the definition and resolution of conflicts. We present concluding remarks in section 6.

2 Collaboration over XML Documents

In this section we are going to motivate the need for change management over XML documents and give a brief description of the issues to be considered for the editing of XML documents.

Consider the case of a research team in the field of computational chemistry that wants to publish the results of their experiments in XML documents. The XML format offers a number of advantages for computational chemistry, such as clear markup of input data and results, standardised data formats, and easier exchange and archival stability of data.

The results of the simulations may be modified several times by members of the team and various versions may be required at different times. Therefore, a version management system should offer support for the archiving of all versions and for the retrieval of past versions. Members may need to query not only the current value of data, but also past values of some elements of the simulation and process change information.

Concurrent editing of the documents containing the data results should be supported as simulations and the gathering of results can be performed in parallel by the members of the group.

Consider the case that two researchers concurrently edit the following part of an XML document:

```
<substance role="reagent" title="tert-Butyl hydroperoxide">
  <amount>40</amount> <concentration>5</concentration>
</substance>
```

Assume they concurrently modify the values of the `amount` and `concentration` elements, with the values 38 and 6 respectively. The two changes should both be performed and the final version of the document should be:

```
<substance role="reagent" title="tert-Butyl hydroperoxide">
  <amount>38</amount> <concentration>6</concentration>
</substance>
```

A solution for collaborative editing over XML documents is to represent the XML documents as simple text documents and use existing version systems such as Subversion [3] for performing merging. These systems perform merging on a line by line basis with the basic unit of conflict therefore being the line. This means that the changes performed by two users are deemed to be in conflict if they refer to the same line and therefore the concurrent modifications of the `amount` and `concentration` elements are detected as conflict. The user has then to manually choose one of the modifications. If the structure of the document is considered and conflicts are defined at the level of elements both changes could be taken into consideration.

We propose an approach that allows conflicts to be defined using semantic units corresponding to the structure of the document, such as elements, attributes, separators, words and characters. Moreover, in our approach, we offer not only manual resolution for conflicts, but also other automatic resolution policies, such as keeping the changes in the repository or in the local workspace in the case of conflict targeting a given node or to lock some parts of the document.

One possibility for editing XML documents is to edit them as simple text documents and the users have then to take care of maintaining well-formed documents, such as the consistency between the names of a begin and end tag of an element. Another possibility for editing XML documents is to use a graphical interface for performing operations of creation and deletion of elements and attributes and of modification of attributes. However, in this way, the user is not allowed to customise the formatting for the elements, such as the use of separators between the elements, as an implicit formatting of the nodes is used.

In our approach, we offer users the possibility of editing XML documents by using a text interface. We added some logic to the editor to ensure well-formed documents, such as the auto-completion of the elements or the consistency between the begin and close tags of an element, in the same way as support is offered to users in existing single-user XML editors, such as XMLSpy [1]. For instance, consider the case that a user edits an XML document, e.g. by typing the element `<conf>CDVE</conf>` character by character. In this way, the XML document will not be well-formed until the closing tag is completed. The editor should provide support to insert complete elements, so that the operations can be tracked unambiguously at any time in the editing process. Our editor offers auto-completeness of elements. For instance, every time the user inserts a `<` character, the insertion of `<></>` is performed. Of course an empty tag, such as <></> is not a valid XML element, but at least it allows the desired operation of creating a new element to be addressed in a valid way.

3 The Model of the Document and the Set of Operations

We now present our model for XML documents and the particular issues concerning consistency maintenance during the editing of well-formed XML documents.

XML documents are based on a tree model. We classified the nodes of the document into root nodes, processing nodes, element nodes, attribute nodes, word nodes and separator nodes in order that various conflict rules can be defined. The *root node* is a special node representing the virtual root of the document that contains the nodes of the document. *Processing nodes* define processing instructions in the XML document. *Element* and *attribute nodes* define elements and attributes of the XML document. *Word nodes* compose the textual content of an XML element. The *separator nodes* are used to preserve the formatting of the *XML* document and they represent *white spaces* and *quotation marks*. A conflict could then be defined, for example, for the case that two users perform operations on the same word node or for the case that users concurrently modify the same attribute node.

The set of operations contains *insert* and *delete* operations targeting one of the previously mentioned types of nodes. Additionally we defined operations for the *insertion* and *deletion* of *characters* to update *processing* or *element names*, *attributes* and *words*. We also defined operations for the *insertion* and *deletion* of *closing tags* of elements.

Elements of an XML document are ordered and, therefore, each node in the document is identified by a vector of positions representing the path from the root node to the current element. A node contains as children the child element nodes and the attributes associated to that element. For achieving uniformity between the representation of elements and attributes, we considered that the attributes of an element are ordered. However, to distinguish between child elements and attributes, an element in the position vector has associated an index *'c'* or *'a'* showing whether it refers to a child or an attribute element. Each node in the document, except separator nodes, has an associated history buffer containing the list of operations associated to its child nodes. For instance, the history buffer associated with an element contains the insertions and deletions of child elements, that can be other nodes, separators or words, of attributes, of characters that change the name of the element and operations that insert or delete the closing tag of the element.

Consider the following XML document:

```
<?xml version="1.0"?>
<movieDB>
    <movie title="21 Grams">
       <actor>Sean Penn</actor>
    </movie>
</movieDB>
```

The structure of this document is illustrated in Figure 1. We associated different levels to the nodes of the document corresponding to the heights of the nodes in the tree.

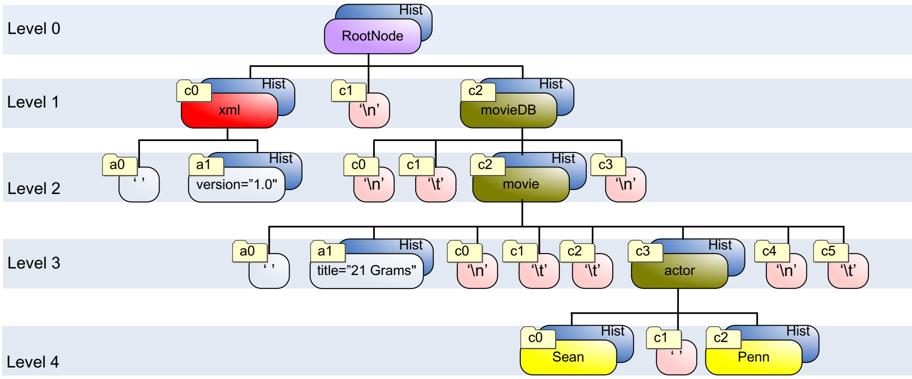

Fig. 1. Structure of an XML document

For instance, the operation of insertion of a second `actor` element `<actor> Naomi Watts</actor>` as child of the `movie` element has the form *InsertElement(*'`<actor> Naomi Watts</actor>`', *c2.c2.c4)* and is kept in the history buffer associated with the `movie` element.

4 Operational Transformation Approach

The basic operations supplied by a configuration management tool are checkout, commit and update. A *checkout* operation creates a local working copy of the document from the repository. A *commit* operation creates in the repository a new version of the document based on the local copy, assuming that the repository does not contain a more recent version of the document than the local copy. An *update* operation performs the merging of the local copy of the document with the last version of that document stored in the repository.

For the merging process we used the operational transformation approach [5]. We first illustrate the basic operation of the operational transformation mechanism, called inclusion transformation, by means of an example. The *Inclusion Transformation* - $IT(O_a, O_b)$ transforms operation O_a against operation O_b such that the effect of O_b is included in O_a. Suppose the repository contains the document whose structure is represented in Figure 1 and two users check-out this version of the document and perform some operations in their workspaces. Further, suppose $User_1$ performs the operation O_{11}=*InsertElement(* '`<actor>Naomi Watts</actor>`', *c2.c2.c4)* to add the `actor` element on the path $/c2/c2$ as the 4th child of the `movie` element. Afterwards, $User_1$ commits the changes to the repository and the repository stores the list of operations performed by $User_1$ consisting of O_{11}. Concurrently, $User_2$ executes operation O_{21}=*InsertElement(*'`<director>`

`Alejandro Gonzalez Inarritu</director>`', *c2.c2.c3)* of inserting the element `director` on the path $/c2/c2$, as the 3rd child of the `movie` element before the existing `actor` element in the document. Before performing a commit, $User_2$ needs to update the local copy of the document. The operation O_{11} stored in the repository needs to be transformed in order to include the effect of operation O_{21}. O_{21} and O_{11} have the same path from the root element to the parent node and they are operations of the same level. As operation O_{21} inserts an element before the insertion position of O_{11}, O_{11} needs to increase its position of insertion by 1. In this way, the transformed operation of O_{11} becomes O_{11}=*InsertElement(* '`<actor>Naomi Watts</actor>`', *c2.c2.c5).*

In the commit phase, the operations executed locally and stored in the local log distributed throughout the tree have to be saved in the repository. The hierarchical representation of the history of the document is linearised using a breadth-first traversal of the tree, first the operations of level 0, then operations of level 1 and so on. In the checkout phase, the operations from the repository are executed in the local workspace.

In the update phase we recursively applied over the different document levels the FORCE [11] operational transformation algorithm for merging linear lists of operations. The *update* procedure achieves the actual update of the local version of the hierarchical document with the changes that have been committed by other users to the repository and kept in linear order in the remote log. It has as its objective the computing of a new delta to be saved in the repository, i.e. the transformation of the local operations associated with each node against the non-conflicting operations from the remote log and the execution of a modified version of the remote log on the local version of the document in order to update it to the version on the repository. The *update* procedure is repeatedly applied to each level of the document starting from the document level. A detailed description of the update procedure applied for text documents represented as a hierarchical structure is presented in [6]. The principles of the update procedure as presented in [6] have been applied also for the XML documents.

5 Conflict Definition and Resolution

Our asynchronous editor for XML documents lets users edit the document from a textual interface, with an overview over the tree structure of the document visualised alongside where the user can define the policies for merging. The client interface presents the user with a log showing the operations performed locally and the operations checked out, committed or updated from the repository.

Two policies were adopted for merging, namely automatic and manual. Automatic policies merge the operations performed locally with the operations from the repository without the intervention of the user. Manual policies for merging involve the intervention of the user for the resolution of conflicts.

In what follows we are going to illustrate the merging policies by means of some examples. Assume the two users start working from the same version of the document illustrated in Figure 1. Suppose that the first user inserts a `director` element as child of the `movie` element, as shown in the left client window in Figure 2 and afterwards commits the changes to the repository.

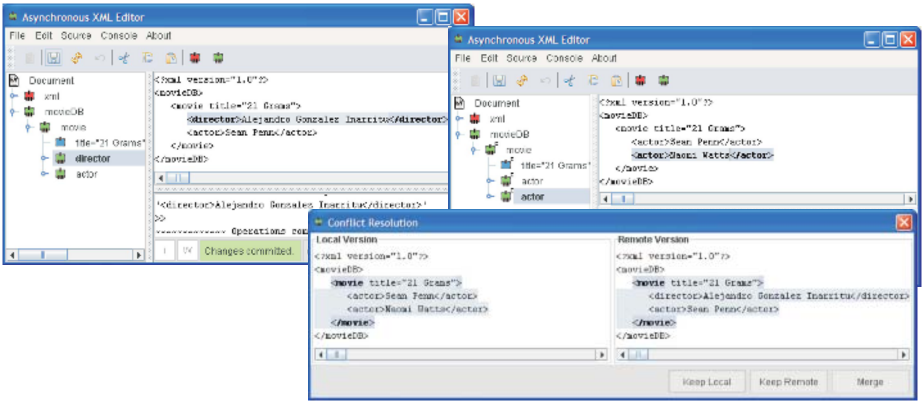

Fig. 2. Conflict Resolution for Merging

Suppose that the second user, concurrently with the first user, inserts a second `actor` element as child of the `movie` element, as shown in the right client window in Figure 2. In order to commit their changes, the second user has to update the local version of the document with the changes from the repository.

Assume first that the second user chooses the default merging policy, i.e. the automatic policy for resolution where no rules for the definition or resolution of conflicts are set. The merged version of the document combines the changes performed locally with the remote ones. The document obtained after merging is given below:

```
<?xml version="1.0"?>
<movieDB>
    <movie title="21 Grams">
       <director>Alejandro Gonzalez Inarritu</director>
       <actor>Sean Penn</actor>
       <actor>Naomi Watts</actor>
    </movie>
</movieDB>
```

Alternatively, assume the second user does not want to automatically merge changes, but prefers to set the detection of concurrent modifications targeting the `movie` element. Concerning the resolution of conflict, suppose that the user wants to manually choose between the conflicting versions of the `movie` element and, therefore, in the hierarchical representation of the document from the client interface, they can define the semantic detection for the node `movie`. In the case of an update, due to the fact that the node was concurrently modified, the user is then presented with the two versions of the `movie` element, as shown in

Figure 2. The user can then choose to keep either the local or remote version of the document or to perform an automatic merging of the changes.

In the case that the user wants to keep the local modifications if concurrent changes were performed on some elements of the document, they can lock those elements. For instance, in the above example, before performing an update, the second user can choose to lock node `movie` and keep the local changes performed on the element.

6 Conclusions

We have presented a customised approach for supporting collaboration over XML documents. We have shown that, by associating operations to the nodes that they target, conflicts can be defined and resolved in a flexible way. Our merging approach is operation-based rather than state-based and therefore provides a less complex and more appropriate way of detecting and handling conflicts.

An asynchronous collaborative editor application that allows the editing of XML documents has been implemented in our group based on the ideas described in this paper.

References

1. http://www.altova.com/products_ide.html
2. Cobena, G., Abiteboul, S., Marian, A.: Detecting changes in xml documents. Proc. of the Intl. Conf. on Data Engineering, San Jose, California, USA (2002) 41-52
3. Collins-Sussman, B., Fitzpatrick, B.W., Pilato, C.M.: Version Control with Subversion. O'Reilly, ISBN: 0-596-00448-6 (2004)
4. Davis, A. H., Sun, C., Lu, J.: Generalizing operational transformation to the standard general markup language. Proc. of CSCW, New Orleans, Louisiana, USA (2002) 58-67
5. Ellis, C.A., Gibbs, S.J.: Concurrency control in groupware systems. Proc. of the ACM SIGMOD Conf. on Management of Data, Portland, Oregon, USA (1989) 399-407
6. Ignat, C.-L., Norrie, M.C.: Flexible Merging of Hierarchical Documents. Intl. Workshop on Collaborative Editing. GROUP'05, Sanibel Island, Florida (2005)
7. Ignat, C.-L., Norrie, M.C.: Operation-based Merging of Hierarchical Documents. Proc. of the CAiSE'05 Forum, Porto, Portugal (2005) 101-106
8. Ignat, C.-L., Norrie, M.C.: Customisable Collaborative Editor Relying on treeOPT Algorithm. Proc. of ECSCW'03, Helsinki, Finland (2003) 315-334
9. La Fontaine, R.: A Delta Format for XML: Identifying Changes in XML Files and Representing the Changes in XML. XML Europe, Berlin, Germany (2001)
10. Molli, P., Skaf-Molli, H., Oster, G., Jourdain, S.: Sams: Synchronous, asynchronous, multi-synchronous environments. Proc. of CSCWD, Rio de Janeiro, Brazil (2002)
11. Shen, H., Sun, C.: Flexible merging for asynchronous collaborative systems. Proc. of CoopIS/DOA/ODBASE, Irvine, California, USA (2002) 304-321
12. Wang, Y., DeWitt, D.J., Cai, J.Y.: X-Diff: An Effective Change Detection Algorithm for XML Documents. Proc. of ICDE, Bangalore, India (2003)

An Ambient Workplace for Raising Awareness of Internet-Based Cooperation

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Abstract. This paper discusses a prototype desktop ambient display system known as the Ambient Workplace (AW) that is used to visualise some aspects of cooperation among a group of co-workers. The AW draws on the ambient technology paradigm by providing a visualisation that represents the interactions of the co-workers (either individuals or groups) in their peripheral attention zone. The paper discusses the development of a prototype system based on a series of indices and uses a maritime flags metaphor. The paper also presents some early results from a user study.

1 Introduction

The Internet has had a substantial impact on many areas of computing, including computer supported cooperative work (CSCW) and many software applications have been adapted or developed to harness its potential. The result has been a change in the nature of communication and work, from one where people communicated in closed-network groups to one where people can be working on the same project anywhere in the world. The change in working patterns has altered way that relationships start, develop and end among people in professional and private contexts. Software applications such as instant messaging, web mail, web-based videoconferencing, appeared at an impressive rate. More recently, new forms of Internet-based cooperation have appeared supported by emerging technologies, such as ‘Wiki’ for collaborative editing, ‘Blog’ for easy publishing or ‘Skype’ for voice communications.

The combination of information technology and social aspects such as co-operation has resulted in substantial interest within the scientific community, with researchers focussing on issues such as design methodologies, user testing and social aspects. In contrast this paper explores how to visualise co-operation within a group of co-workers.

The paper begins with an explanation of the motivations and background of the Ambient Workplace and continues with an outline of the metaphors used, a description of the system, results from a user study and finally some conclusions and future directions.

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[1] This work was carried out during the tenure of an ERCIM fellowship.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 275 – 286, 2006.

2 Motivation of the Research

Prior work in the field of CSCW stresses the importance of awareness. Gutwin and Greenberg [6] explain that 'it is becoming more and more apparent that being able to stay aware of others plays an important role in the fluidity and naturalness of collaboration'. Dourish and Belloti [3] introduced the concept of awareness that they defined as 'an understanding of the activities of others, which provides a context for your own activity'. Ellis [4] argued that 'the philosophy of groupware is to encourage cooperation by making it known and instantly apparent to all who is sharing what with whom'. Humphries et al. [9] define activity awareness as 'knowing what has happened, what is happening and what will likely happen in the future over extended periods of time'. Greenberg [6] indicates that there are many forms of awareness:

- *Informal awareness of a work community is the general sense of who is around and what they are up to.*
- *Social awareness is the information that a person maintains about others in a social or conversational context. For example, whether another person is paying attention, their emotional state, or their level of interest.*
- *Group-structural awareness involves covers aspects such as the roles and responsibilities of the participants, their views on certain issues, their status and the processes within the group.*
- *Workspace awareness* includes information about *the identity of those in the workplace, their location, their activity, and the immediacy of changes with which others' activities are communicated.*

This paper deals with workspace awareness in an Internet-based collaboration platform. It is acknowledged that being kept informed of what is happening in a shared environment is a crucial aspect of collaboration; it is therefore important to explore which techniques can be used to enhance awareness. Several solutions have been developed including: update notifications via email and displays indicating the number of people reading the same webpage [13]. Other methods make use of graphics for example: the icons indicating who is online in MSN Messenger, avatars [11], representing users as abstract shapes [2], visualisations on mobile phones [1] and representing the other users actions in virtual environment [12]. In many cases awareness cues are only provided when the client (CSCW) application is running. In the other cases, the user is not given any feedback on the interactions that are occurring in the collaborative environment

Ambient displays that provide unobtrusive awareness information could be seen as one way to avoid the problem of having to make people log in. Furthermore, displaying workspace awareness information in everyday tools such as email, wallpaper or an IM client provides an elegant way to make sure the information is always available. The purpose of ambient displays is to convey information in the user's peripheral attention and visual zone in a way that does not require their specific attention. This approach builds on the idea introduced by Heath and Luff [8] of peripheral or 'out of the corner of the eye' awareness, i.e. awareness present in the periphery of people's attention.

3 Ambient Workplace Concept

3.1 Workspace Awareness: Refining the Concept

A collaborative environment is composed of people and resources (e.g. shared calendars, shared virtual objects in industrial design and documents etc.). We group these people and resources under the term 'entities'. When the entities interact with each other interactions occur. Interactions among the entities include: connections to the collaborative environment, interpersonal communications and creating or updating resources. The research presented here is concerned with providing workspace awareness information which keeps people informed of these types of interactions.

One approach is to notify the user of information relating to specific entities within the workspace, we refer to this as, *Workspace Individual Awareness (WIA*). This is where information about a specific resource or user is provided. Examples include notification via email that a resource has been updated, or displaying an icon about the presence status of an entity (e.g. online, away, busy).

Another approach is to represent aggregated or anonymous information, we refer to this as *Workspace Global Awareness (WGA*). Aggregated information refers to the general level of activities in the workplace. In other words, it concerns some information that results from processing a set of individual information elements, but information about each individual element is not displayed. For instance, the number of users connected to the workspace is displayed but not their names. Anonymous information gives the user some feedback on what happens in the collaborative environment but does not explicitly indicate which entities it relates to. For instance, an icon is displayed when the user receives a message but the icon does not indicate the name of the sender or the subject of this message.

3.2 Information Being Visualized: What?

With respect to global awareness (*WGA)*, we have chosen to focus on aggregated information that makes the user aware of the level of activities on the collaborative platform. At this level, basic statistics are used, such as the number of connected users or the number of new documents since their last visit. This kind of information helps to communicate the volume of activity in the collaborative environment but gives little feedback on the quality of the collaboration. However, it is proposed that *WGA* should be expanded to include aspects about the quantity and quantity of interactions. The composite indexes proposed by Otjacques et al. [10] provide a starting point in the visualization of WGA and are outlined on the following page.

- *Coopadex* (*electronic Cooperation Activity Composite Index*) index is defined as the mean number of computer-mediated interactions by a member of the group for a given period. It represents the quantity of interactions.

- *N-Coopidex* (*Normalized electronic Cooperation Implication Composite Index*) is defined as the normalized weighted combination of the number of interactions according to their cooperative nature. It is intended to be an indicator of the mean quality of the interactions from a collaborative viewpoint.
- *Glocoopex* (*Global electronic Cooperation Composite Index*) is defined as the product of *Coopadex* and *N-Coopidex*. It provides a global metric of the cooperation from a quantitative and qualitative point of view.

The *Glocoopex* index provides one measure of *WGA*, however a visualization is more useful if it also provides information about individual entities (i.e. *WIA*). For this the system has focussed on monitoring the actions of individual users and not the modification of resources. In order to address this we have chosen to display the number of interactions that a given person has undertaken during a recent time period (e.g. last week). This allows users to see if the entities they have chosen to monitor have created many and/or interesting interactions during the selected time period. Another important aspect that supports WIA is the ability of people to communicate with others and to view the resultant interactions within a visualization.

3.3 Metaphors Used in the Visualization: How?

The technique described in this paper makes use of simple, easy to understand representations. Furthermore, the visualization exists out with the users main attention zone. In order that the visualization remains easy to understand, the same class of metaphor is applied to the elements used to display both global and individual awareness. Moreover, as Internet based cooperation frequently involves people from a variety of cultures it was decided to choose a metaphor that people from most countries would be able to understand. The maritime navigational metaphor fulfils this requirement as the basic concept is familiar to people from a variety of cultures and backgrounds.

The *Glocoopex* value provides an overall indication as to the level of activities within the group. We have chosen a beach flag as the metaphor to represent *Glocoopex*. Beach flags make use of a colour code to indicate whether it is safe to swim, they are clear, easy to understand and always present. The design of such a flag appears to lend itself to representing global information such as *Glocoopex,* as the intention is that such information should always be present and should be easy to understand.

WIA cannot be rendered by a unique graphical element. Any monitored entity must be associated with a specific representation. In the marine context, beacons show where dangerous places are located. They are mentally associated with specific information (e.g. location of a specific wreck). Beacons seem therefore appropriate to visualize the individual activities. In our design one beacon corresponds to one entity (e.g. a work sub-group or individual). The beacons use colour to convey information such as the level of activity and online status of a particular entity.

4 Use Case

The Ambient Workplace is being developed for and tested on a large European Union funded Network of Excellence (NoE). A NoE is essentially a group of research, academic and commercial organizations that join together to form a virtual-research community. A NoE is an ideal case study as it consists of a wide range of organizations, in this case around thirteen and in turn a diverse group of participants, such as professors, research assistants, students, administrators and technical staff. The main outputs are reports, academic papers and other printed or online materials, the members also meet regularly.

The NoE discussed here also trains new scientists in the field, this is achieved by arranging a number of PhD schools. These are organized on a regular basis throughout the lifetime of the NoE. Moreover, the NoE has a website that aims to bring people together and encourage communication and the creation of ideas. It is this website which forms the basis of the development of the AW and an ongoing study.

The NoE website contains a number of key features, such as the ability for people to submit information or files, a news page as well as a mailing list. Despite the range of features, the website and mailing list do not appear to be acting as a catalyst for new ideas or discussion. As a result there is a study being conducted into the nature of the interactions which people undertake, as well as with whom they undertake them with. Although the study is ongoing, anecdotal evidence would suggest there is a need to develop new tools or technologies that support interaction. It is this need to increase the level of interaction which has driven the development of the Ambient Workplace.

A database is used to store information about the range of participants, interactions and values for the *Glocoopex*, *N-Coopidex* and *Coopadex*. Information about the interactions consists of whether they are mandatory or optional and active or passive. The system outlined later makes use of the information in the database to generate the visualisation.

5 Ambient Workplace Prototype

5.1 Features

The current version of the AW consists of four elements which are based upon the work highlighted in previous sections. Figure 1 illustrates the Ambient Workplace (or visualization) displayed as part of the Windows desktop. As it is part of the Active Desktop the user is able to move, resize or close it at will. Moreover, there is no GUI, so no user interaction is required. In contrast with backgrounds (or wallpaper), items displayed in the Windows Active Desktop appear between the background and the icons. The diagram in figure 2 illustrates the AW displaying the *Glocoopex*, *N-Coopidex* and *Coopadex* values (the triangular flag), in contrast the three shapes at the bottom of the AW, known as beacons, represent other users of the system in terms of whether they are online and their level of activity.

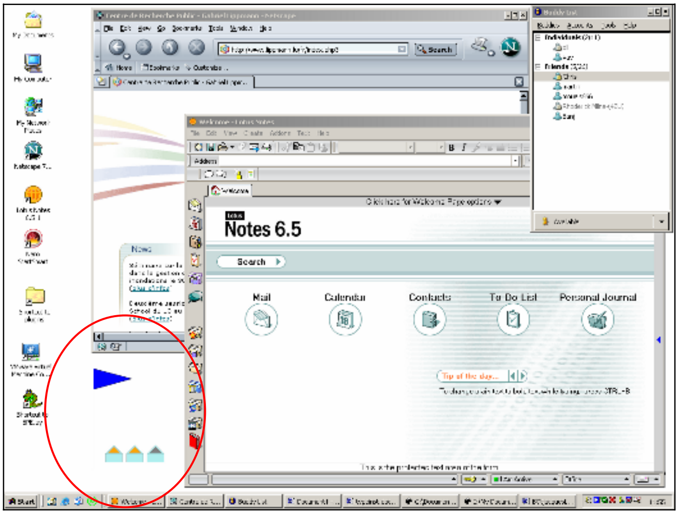

Fig. 1. A screenshot illustrating the Ambient Workplace (lower left), the GAIM client is pictured in the top right

The flag in figure 2 displays an overview of the nature and volume of activities within the system. Previous research has identified the concepts of integral and separable visual dimensions. These notions tells us that *'one display attribute (e.g. color) will be perceived independently from another (e.g. size). With integral display dimensions, two or more attributes of a visual object are perceived holistically and not independently. […] With separable dimensions, people tend to make separate judgments about each graphical dimension.'* [14] Ware provides a list of display dimension pairs ranked in order from highly integral to highly separable [14]. Based on his list it appears that the shape height and width form an integral dimension pair. In other words, if we want two variables (*Coopadex* and *N-Coopidex*) to be globally interpreted, it may be justified to link them to the x and y dimensions. This is of particular relevance as the intention is for the information to be understood holistically and as quickly as possible. Consequently, the length of the flag has been associated to the *Coopadex* value, or the mean rate of use of electronic cooperation tools. While the height of the flag represents the *N-Coopidex*, or the level of interest in the interactions i.e. the users undertook these actions on a voluntary basis. Note that height relates to the actual height of the flag, not its position on the flag pole.

The level of global activity (*Glocoopex*) is defined as the product of *Coopadex* and *N-Coopidex*. According to the graphical representation of those two last values, *Glocoopex* is proportional to the surface of the flag. However, in order to speed the recognition of its value, we have decided to adopt a double coding strategy. Therefore, *Glocoopex* is also represented by the colour of the flag, brighter blue meaning more activity and dark blue indicating less. Brightness has been chosen because it is a monotonic visual quality that is suited to represent a variable, such as *Glocoopex*, that evolves monotonically.

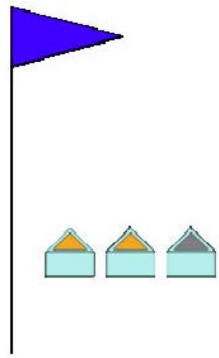

Fig. 2. A picture of the Ambient Workplace. From the top left, the *Glocopex* flag, the three beacons illustrating entities using the system.

The dimensions of the flag are calculated using means based on a 14-day time period (although it has also been tested using a 7-day period). Hence rather than using absolute values the flag is rendered relative to these mean values, this results in there always being some base point with which the flag be can related to. In order to prevent the graphics becoming too large, or the colours going beyond the range available certain limits are placed on the maximum and minimum values.

The examples in figure 3 illustrate a number of scenarios based on the values of the *Glocoopex*, *Coopadex* and *N-Coopidex* values. The first flag (figure 3, left) illustrates that there has been a large amount of activity relative to the previous 14 days (the flag is bright blue), there has been a large amount of voluntary activity (the flag height is high) and there has been a large use of cooperation tools (as represented by the length of the flag). Figure 3 (centre) indicates a slight variation, with there being less interest in the interactions, as represented by the flag height and figure 3 (right) indicates there has been little in the way of voluntary activity and use of electronic cooperation tools. This is represented by the flag height being less, the colour being dark blue and the length of the flag being shorter.

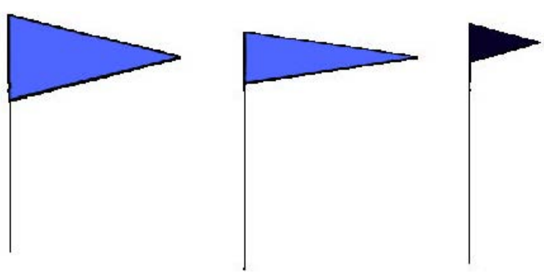

Fig. 3. Three activity flags indicating the volume and type of interactions taking place within the system

Figure 4 illustrates the beacons, the colour of the triangle indicates the number of interactions for that particular entity (a group or an individual), these are grey, orange and red indicating no interactions, some interactions and a lot of activities (within the set time period). If the entity is online this is indicated by a green border within the triangular area (this feature is not currently implemented and is hence not displayed in figure 4).

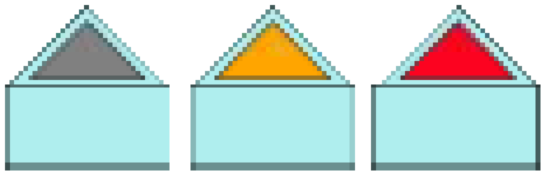

Fig. 4. The Entity Beacons, the further to the right (red) the more interactions or activities that entity has initiated

5.2 System Architecture

The AW consists of a number of core components, including a client and server (BOT) which form the basis of the system. The AW components are in turn linked with a number of parts built by third parties such as MySQL, Wildfire server (Jabber) and GAIM (an instant messaging client). The Wildfire (jabber server) is used to send information to and from the client and server machines.

5.3 Study

In order to improve the design of the visualisation a multi-phase study is planned, the initial phase consisted of asking people to complete a questionnaire and is reported here.

Participants

The study consisted of twenty one participants (six female, fifteen male), all were employees or students working at CRP- Gabriel Lippmann. Their age and subject area varied, with many coming from areas such as computing, materials sciences and environmental sciences. Some were also potential users of the system.

Procedure

A questionnaire was administered to groups of between three and eight people at any given time, each participant was also supplied with some coloured pens or pencils. They were also supplied with a description of the project, including its objectives, the indices and a monochrome version of the currently implemented system. They were informed that they were free to draw what they liked provided it made use of the basic metaphor (i.e. flags and/or beacons), but could alter properties such as size, shape, position and color. Participants were also asked to indicate whether they preferred to use flags or beacons to represent each case.

The questionnaire contained thirteen questions, the majority of which asked the participants to draw some aspects of the visualisation. Part one of the questionnaire focused on global awareness such as representing *Glocoopex*, *Coopadex* and *N-Coopidex*. Part two looked at representing specific items such as email, forum posts and news articles. Part three looked at representing users and their interactions. The final section drew all this together by asking the participants to draw a complete visualization, they were free to base this on the previous representations or draw something completely new. This step by step approach was adopted so that participants would become familiar with representing the various concepts prior to drawing an entire visualization. It also permits us to provide subjects in later parts of the study with many more design options.

Results

In this section we will focus on the results which directly relate to the aspects of the prototype visualization illustrated earlier (see figures 1 and 2). In particular the preferences people had for visualizing the indices and user presence. It should be noted that this part of the study is not intended to provide any decisions; rather it is to obtain series of design options which can then be provided to the focus group(s) who will be asked to provide a series of designs. In the following discussion f=number who chose flags b=number who chose beacons.

When asked to draw flags or beacons representing the indices the results were mixed. For example, when asked to draw individual flags the participants indicated a preference for having a flag which represented all three values (f=10 b=4). This would appear to back up our earlier design decision, however when asked to draw a complete visualization they preferred a flag which contained the *Glocoopex* value (f=8 b=3). However in both cases the number of responses is less than half the total number of participants.

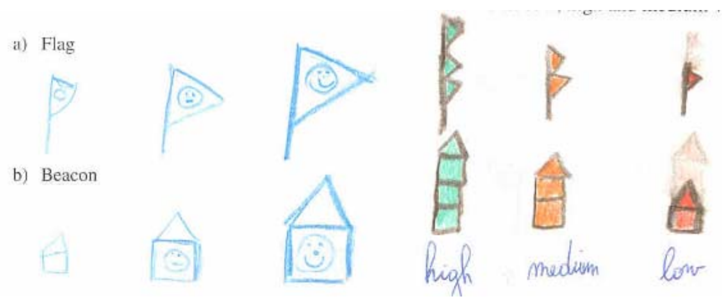

Fig. 5. Two examples of the Glocoopex flags and beacons. On the left the person has used a combination of size and symbols (smaller = lower value), on the right they have used colour and the number of flags or beacons.

For the most part the designs of the flags or beacons followed expected patterns, with size, colour and position being used to indicate value. However some also drew multiple flags or beacons often combined with colour to indicate value. For example, the higher the *Glocoopex* value the bigger the flag. Colour was also used to indicate values, for example with green, orange and red indicating high, medium and low values (see figure 5).

The use of flags or beacons to represent online status and the number of interactions produced varying results. When asked to draw this as part of the visualization there was a small preference towards the use of beacons (b=10 f=8).

When asked to draw only flags or beacons of the *Gloocopex* value the vast majority of participants preferred flags (f=14 b=5). Online status was typically indicated by the use of colours (see figure 6). Interactions were represented by a number of methods including height or level of shading (see figure 6).

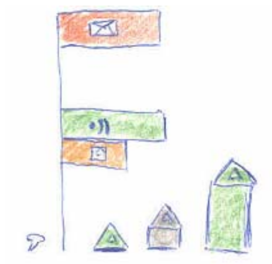

Fig. 6. A drawing of the complete visualization, the height of the beacons indicates the number of interactions be each entity, green is online and black offline

To summarize, it seems that the participants agreed with the basic aspects of the maritime flags metaphor and that our early designs provide a good starting point. Users mentioned some ideas to improve our initial design. For instance, some proposed replacing the 'color – size' double coding of *Glocoopex* by another double coding based on size and explicit value of the index placed within the flag. Others propose to add some new flags associated to the still to be processed interactions (e.g. e-mail to be read, meetings to attend). In addition the use of drawings to prototype ambient display technologies appears to be a useful one as it removes the focus on technical aspects of the system. Moreover, this kind of approach was especially suited to the AW prototype where the emphasis is on simple displays which do not require interaction by the end user.

6 Future Directions

The intention is to complete the user study so that the designs of the visualization can be improved. Other areas of future work include addressing issues related to privacy and the underlying technical platform, as well as exploring other media for the distribution of information such as smart boards and mobile phones.

7 Conclusion

This paper has described a working prototype known as the Ambient Workplace which his capable of visualising cooperation relating to global and individual workspace awareness. The AW draws on the principals of ambient technologies, for example that the information should be presented in the users peripheral attention zone, that it should not distract them and should be comparatively simple to understand. The design draws upon ongoing work in to developing metrics to capture information about cooperation, in particular *Glocoopex*, *N-Coopidex* and *Coopadex*.

Although the Ambient Workplace is in the early stages of development it is currently in a usable form. Also it makes use of lightweight and several pre-exiting technologies, therefore making it easy to improve or display on other platforms such as smart boards.

Acknowledgements

The research conducted in this paper was funded by a grant from the Fonds National de la Recherche (FNR), Luxembourg. We also acknowledge the assistance of those involved in the NoE and other members of staff at CRP- Gabriel Lippmann.

References

1. Bardram, J.E. and Hansen T.R. The AWARE Architecture: Supporting Context-Mediated Social Awareness in Mobile Cooperation. In *Proceeding of the ACM Conference on Computer-Supported Cooperative Work (CSCW'04)* (Chicago, Illinois, November 6-10, 2004). 192-201.
2. Donath, J., Karahalios, K., and Viegas, F., Visualizing Conversation. In *Proceedings of 32th Hawaï International Conference on System Sciences (HICSS-32)*, (Maui, Hawaii, January 5-8, 1999).
3. Dourish, P. and Belloti, V. Awareness and coordination in shared workspaces. In *Proceedings of the ACM Conference on Computer-Supported Cooperative Work (CSCW'92)* (Toronto, Canada, October 31 - November 4, 1992). 107-114.
4. Ellis, C. Keepers, Synchronizers, Communicators and Agents. In *ACM SIGOIS Bulletin*, April 1995, Vol. 15, N° 3, 10-14. Special issue: workshop write-ups and positions papers from CSCW'94.
5. Gaim Instant Messaging Software, http://gaim.sourceforge.net/, accessed 24 March 2006.
6. Greenberg, S., Gutwin, C., and Cockburn, A. Awareness Through Fisheye Views in Relaxed-WYSIWIS Groupware. In *Proceedings of the Graphics Interface 1996 Conference* (Toronto, Canada, May 22-24, 1996).
7. Gutwin, C. and Greenberg, S. The effects of Workspace Awareness Support on the Usability of Real-Time Distributed Groupware. *ACM Transactions on Computer-Human Interaction*, Vol. 6, N° 3, September 1999, 243-281.
8. Heath, C. and Luff, P. Collaborative activity and technological design: task coordination in London Underground control rooms. In L. Bannon, M. Robinson and K. Schmidt (eds.) *Proceedings of the 2nd European Conference on Computer-Supported Cooperative Work (ECSCW'91)* (Amsterdam, The Netherlands, September 24-27, 1991). 65-80.
9. Humphries, W. D., Neale, D., and McCrickard D. S. Laboratory Simulation Methods for Studying Complex Collaborative Tasks. In *Proceedings of the 48th Annual Meeting of the Human Factors and Ergonomics Society (HFES'05)* (New Orleans, Louisiana, September 20-24, 2004). 2451-2455.
10. Otjacques, B., Noirhomme M., Figueiredo, J., and Feltz, F. (2006), Composite Indexes as Metrics of Cooperative Activity. In *11ème Conférence de l'Association Information & Management* (AIM 2006), (11th French-speaking Conference on Management of Information Systems) (Luxembourg, June 7-9, 2006).

11. *The Palace User Software Guide for Windows*, version 3.5, http://www.palacechat.us/documentation.php, accessed 24 March 2005.
12. Pinho, M.S., Bowman, D.A., and Freitas C.M.D.S. Cooperative Object Manipulation in Immersive Virtual Environments: Framework and Techniques. In *Proceedings of the ACM symposium on Virtual Reality Software and Technology (VRST'02)*. (Hong Kong, China, November 11-13, 2002). 171-178.
13. Robinson, M., Pekkola, S., Korhonen, J., Hujula, S., Toivonen, T. and Saarinen M.-J. O. Extending the Limits of Collaborative Virtual Environments, in Churchill, E.F., Snowdon D. N. and Munro A. J. (eds): *Collaborative Virtual Environments*, London, UK, Springer, 2001.
14. Ware, C. *Information Visualization, Perception for Design*. Morgan Kaufman Publishers, 2004, 176-183.

A Building's Refurbishment Knowledge and Device Based Decision Support System

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Abstract. The integration of knowledge-based, devices-based and decision support systems have a very promising future in scientific research. The authors of this paper participated in the project Framework 6, 'Bringing Retrofit Innovation to the Application of Public Buildings' (BRITA in PuBs). One of the project's goals was to develop a Building's Refurbishment Knowledge and Device Based Decision Support System (BR-KDDSS), which consists of a Decision Support Subsystem, Knowledge Subsystem and Device Subsystem. In order to demonstrate the integration of knowledge, device and decision support systems, the BR-KDDSS will be considered as an example.

1 Introduction

The major players in a building's refurbishment can use neural networks, genetic algorithms, fuzzy, knowledge-based and decision support systems, etc.

The major players in a building's refurbishment can use various purpose decision support systems (EPIQR, TOBUS, INVESTIMMO, etc.). EPIQR is a decision tool that combines financial, technical, energy, and comfort analysis [5]. EPIQR has been developed to act as an assisting tool for surveyors, architects or building owners in selecting the most suitable refurbishment actions for an apartment block by enabling them to upgrade the physical and functional state of the building, to improve tenant's indoor conditions and to reduce energy consumption [2].

Knowledge systems today generally serve to relieve a 'human' professional of some of the difficult but clearly formulated tasks. For example, Mazouz et al. [9] have presented a description and analysis of various knowledge systems in architectural design for such purposes.

Recent research in building and related artificial intelligence areas have shown that 'smart control techniques' such as fuzzy systems and neural networks can contribute to the reduction of energy consumption while maintaining indoor comfort within acceptable margins [7]. Chow et al. [3] introduced a new concept of integrating neural networks and genetic algorithms in the optimal control of an absorption chilling system. Based on a commercial absorption unit, neural networks were used to model the system's characteristics and the genetic algorithm as a global optimization tool. Many questions are raised during the integration of building's refurbishment automation systems. In Kusuda's opinion [8], the integrated system should be capable of

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 287 – 294, 2006.

representing and analyzing details in as much as the user wants to pursue his/her purpose. With this program, one can determine the cause of unwanted moisture condensation, noise, odour, and glare, the malfunction of mechanical, electrical and plumbing systems [8]. According to Dorer and Weber [4], only a few computer programs allow for the evaluation of comfort and integrated aspects such as air quality, thermal, visual and acoustic comfort.

Integration of neural networks, multimedia, knowledge-based, decision support and other systems have a very promising future in scientific research.

When the authors of this paper participated in the project Framework 6, ‘Bringing Retrofit Innovation to the Application of Public Buildings’ (BRITA in PuBs), one of the project’s goals was to develop the Building’s Refurbishment Knowledge and Device Based Decision Support System (BR-KDDSS) which is presented in Section 2. The implementation of the System is described in Section 3. Finally, some concluding remarks are provided in Section 4.

2 Building’s Refurbishment Knowledge and Device Based Decision Support System

Based on an analysis of the existing information systems, neural networks, genetic algorithms, fuzzy, knowledge-based and decision support systems and in order to determine the most efficient versions of building refurbishment, a Building’s Refurbishment Knowledge and Device Based Decision Support System (http://dss.vtu.lt/renovacija/index_educational.asp) was developed. The results obtained in these initial [1, 6, 10, 11, 12] studies may be found in the authors’ publications. The architecture of BR-KDDSS system consists of the Decision Support, Knowledge and Device Subsystems. Below we shall briefly analyse these subsystems.

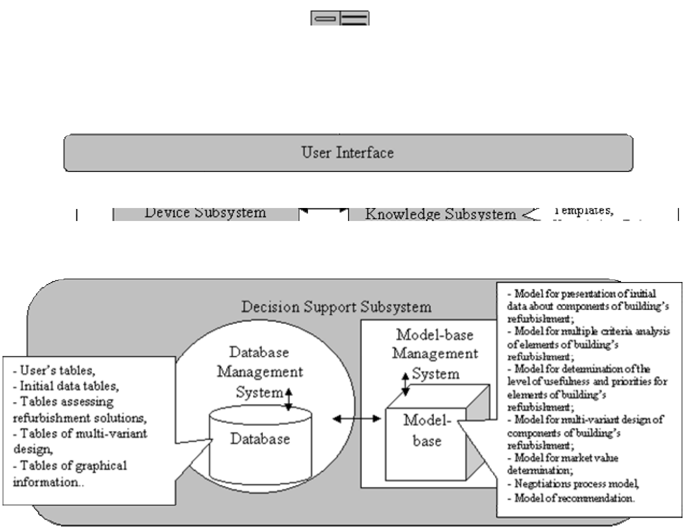

Fig. 1. The architecture of BR-KDDSS system

BR-KDDSS *Decision Support Subsystem (BR-DSS)* consists of a database, database management system, model-base, model-base management system and a user interface. The BR-DSS allows users to: present information of the general physical and functional state of the building; present information of the physical state of the building's envelope; calculate the volume of work to be carried out; rationalize the energy consumption of the building; propose required measures to increase the quality of air and indoor environment and analyze the refurbishment scenarios by taking into account the system of criteria, etc.

All buildings' refurbishment market players can use the created subsystem. They are advised to base their decisions on as much of their knowledge as possible. For example, goals, needs, available finances and existing explicit and implicit knowledge of all stakeholders (clients, users, designers, manufacturers of construction materials, suppliers, contractors, facilities management organisations, financial institutions, municipalities, etc.) must be analysed thoroughly while developing possible alternatives for the building's refurbishment and making multiple criteria analysis of alternatives.

It is possible to create numerous alternatives for a building's refurbishment. At first, clients are offered a system of criteria, on the basis of which building refurbishment specialists and clients usually analyze the alternatives. On the basis of their needs and this system of criteria, clients may devise their own system of criteria. Similarly, initial weights of criteria and values of qualitative indices are determined. Clients receive typical weights of the criteria and values of the qualitative indicators describing the analyzed objects. On the basis of their experience and needs, clients can then change the provided initial weights of the criteria and values of the qualitative indices. In such a case, each client receives a personalized decision support matrix adapted to his/her needs. The process of developing the system of criteria, determining the weight of the criteria and values of qualitative indices is open not only for one person but to a group of stakeholders (e.g. the client, users of a building, etc.) as well.

The presentation of information and knowledge needed for decision-making in the BR-DSS may be in a tacit (digital/numerical, textual, graphical, diagrams, graphs and drawing, etc), photographic, sound, video) and in explicit forms. The presentation of explicit information involves criteria systems and subsystems, units of measurement, values and initial weight that fully define the provided variants. Tacit knowledge means a conceptual description of alternative solutions, the criteria and ways of determining their values and the weight, etc.

The following tables form the BR-DSS's database:

- Initial data tables. These contain general facts about the building considered and information of its deterioration and obsolescence. Reasons for refurbishing and their significance as well as the money to be spent on it are also included.
- Tables assessing refurbishment solutions (walls, windows, roof, floors, volumetric planning and engineering services, etc.). These contain explicit and tacit information and knowledge about alternative building refurbishment solutions relating to a building's enclosures, utilities and space planning, etc.
- Tables of multi-variant design. These provide explicit and tacit information and knowledge on the interconnection of elements to be renovated, their compatibility and possible combinations as well as data on the complex multi-variant design of a building's refurbishment.

A relational database is used in the System and all data can be described by mathematical relations. Data in the System is held in a single database, which consists of several different tables and which is independent of the Model Base. Tables are bound by relations, which allow getting all necessary information for decision-making. The Database Management System is able to manage an enormous amount of structured data and supports simultaneous work of numerous users. Models are created in such way that several system users can use them simultaneously. ASP technology is used for calculations or database operation.

In order to design and realize an effective building refurbishment project the available alternatives should be analyzed. A computer-aided multi-variant design requires the availability of tables containing data on the interconnection of the elements to be renovated and the solutions made. It also requires their compatibility, possible combination and the multi-variant design.

The efficiency of a building's refurbishment variant is often determined by taking many factors into account. These factors include an account of economic, aesthetic, technical, comfort, legal, social and other factors. The model-base of a decision support system (BR-DSS) should include models that enable a decision-maker to do a comprehensive analysis of the available variants and to make a proper choice.

The more alternative versions that are investigated before making a final decision, the greater the possibility to achieve a more rational end result. Basing oneself on the collected information and the BR-DSS, it is possible to perform a multiple criteria analysis of the refurbishment project's components (walls, windows, roof, floors, volumetric planning and engineering services, etc.) and select the most efficient versions. After this, the received compatible and rational components of a refurbishment are joined into the projects. Having performed a multiple criteria analysis of the projects in this way, one can select the most efficient projects.

A model base allows the BR-DSS's user to select the most suitable refurbishment alternatives by comparing the measures that promote the greatest energy savings and increase a building's quality within budget constraints of the building's inhabitants.

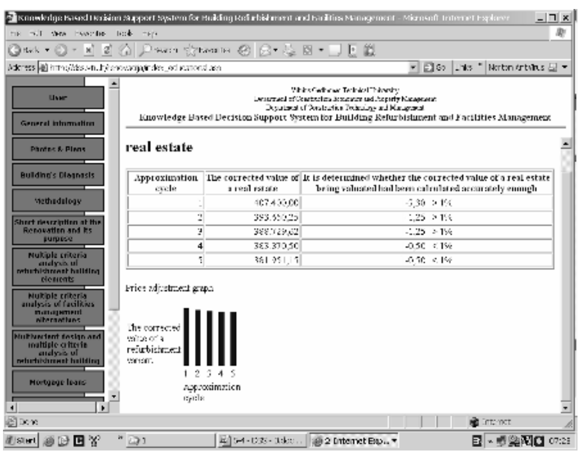

Fig. 2. Calculation of window market value

The following models of a model-base aim at performing the functions of: a model for developing alternative variants of a building's enclosures, a model for determining the initial weight of the criteria (using experts' methods), a model for the establishment of the criteria weight, a model for the multi-variant design of a building's refurbishment, a model for multiple criteria analysis and for setting priorities, a model for the determination of a project's utility degree and market value and a model for negotiations.

Based on the above models, the BR-DSS can make up to 100,000 building refurbishment alternative versions, perform their multiple criteria analysis, determine the utility degree, market value and select the most beneficial variant without human interference. The BR-DSS presents information about the building's diagnosis and questionnaires as well as different scenarios for the building's refurbishment. The report contains information about the estimation of potential energy savings and improvement of the quality of a building: thermal insulation of a building's envelope (walls, roof, and windows); potential impact of refurbishment to increase the quality of a building to the level of present standards. This is useful software for the selection best possible scenarios.

There are four main categories of rules and procedures in the BR-*KDDSS Knowledge subsystem (BR-KS)*:

1. Formation of alternatives for the elements of a renovated building. This set of rules forms possible alternatives for the elements (e.g. windows, walls and etc.) of a renovated building.
2. Formation of the criteria describing the generated alternatives. This category consists of rule sets for formation of the system of criteria that describe the generated alternatives and provides values and weights of these criteria.
3. Development of suggestions with what suppliers to use and for what reasons further negotiation should be carried out. With the help of a decision support subsystem (BR-DSS) having determined the sequence of priority, the degree of utility and market value of the elements of a renovated building, the rules in a knowledge subsystem suggests what suppliers to use and for what reasons further negotiations should be carried out. The main goal of this set of rules is to establish the most rational suppliers on the basis of the following factors: the amount of money the customer is willing to pay for the elements (e.g. windows, walls and etc.) of a renovated building; the cost of the alternatives; the priority, utility degree and market value of the elements of a renovated building; the reliability of the suppliers based on their past performance with their customers;
4. Composition of comprehensively reasoned negotiation e-mail for each of the selected suppliers. By using information inherited from previous BR-DSS calculations and predefined rules and procedures, the knowledge subsystem composes a negotiation e-mail for each of the selected suppliers, where it reasonably suggests that the price of a product should be decreased or a product of better quality should be sold for the offered price. The e-mail includes references to the calculations performed by BR-KDDSS.

The above functions are performed according to the description of a building's renovation requirements and the user's constraints, as well as knowledge and data that are contained in the knowledge subsystem's rules and the knowledge base. Having a significant number of the above rules one can then acquire quite an advanced and complete diagnosis of the analysed situation.

Knowledge used by BR-KS is of at an expert's level and comprises of cause and effect relations that are triggered by experts' experiences participating in the creation of the BR-KS. By revealing non-formal knowledge, BR-KS allows the solving of the afore-mentioned tasks without detailed analysis of the situation.

Devices in the Device Subsystem measure internal microclimate parameters (illumination, volume flow, air velocity, air temperature, relative humidity, dew point temperature, vibration impulse amplitudes (see Fig. 2)) and house allergens, e.g. house dust mites, dermatophagoides pteronysinus allergen, etc. The data is passed on to the Decision Support and the Knowledge subsystems. Let us analyze the internal volume flow and relative humidity as an example. Insufficient speed of the internal volume flow determines the lack of oxygen. As a result, internal hygiene conditions are worse, flowers wither and people feel unwell and their productivity decreases. Dry air in premises causes nasal mucous to dry and creates discomfort, thus productivity and good moods decrease. The discomfort may be removed by pipetting oil into the nose. Quite a few people encounter this problem. Other microclimate parameters may be described in a similar way.

The concentration of house dust mites (%) strongly depends on the temperature of premises and humidity. When air temperature in premises is 20-25 C°, the concentration of house dust mites is 100%. When the temperature is lower (by 10 degrees) the concentration of house dust mites decreases by 40%. When humidity in premises is 60-70%, the concentration of house dust mites is 80%. When humidity is 50%, the concentration of dust mites decreases four times and makes up 20%. It is clear that allergic people feel bad due to temperature and humidity fluctuations in premises, i.e. when the concentration of house dust mites increases. Mites cause allergic reactions and make people feel worse.

Data about internal microclimate parameters and house allergens measured by devices are passed on to the Decision Support and Knowledge subsystems. These subsystems then use the data in further calculations.

The reliability of the system depends on the applied software, on the reliability of databases and also on qualifications of users. The system is installed in a server,

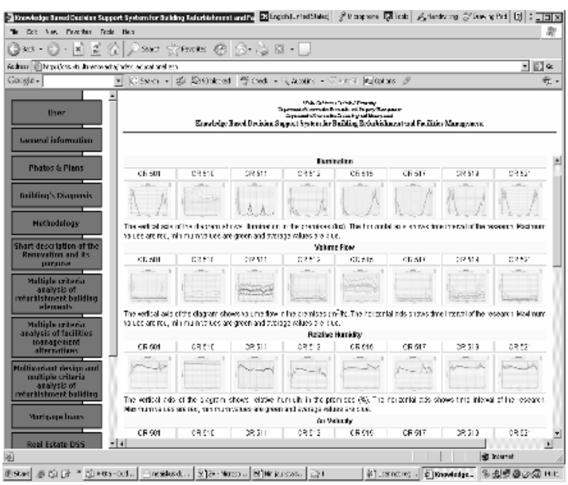

Fig. 3. Charts of internal microclimate parameters measured by devices

which runs on *Windows XP Server* and *Internet Information Services* and is based on the client/server model. HTML, ASP and ActiveX internet technologies are applied in the system; the technologies were used to design and develop the user interface of the subsystem and in the automation process. A mixed-type user interface is used in the system: different types of interface for different types of tasks. Therefore, the system for users is rational, simple and accessible to users with various background education and knowledge.

3 Implementation of the System

BR-KDDSS was implemented during the renovation of the central building of Vilnius Gediminas Technical University within the frame of the project *BRITA in PuBs*. The most rational variant of renovation was determined based on the results of its calculations. Later, this variant was implemented in practice. Several directions for BR-KDDSS efficiency improvement were offered during implementation of the system. For example, it was noted that the created Knowledge Subsystem does not meet all needs of stakeholder groups in modern knowledge society conditions. The following offers were provided for improvement of the Knowledge Subsystem:

- Construction Tacit Knowledge Base of Best Practice consists of informal and unrecorded procedures, practices, and skills. An enormous volume of construction innovation knowledge is generated during the phases of brief, design, planning, construction, maintenance, facilities management and demolition of a facility. Throughout the whole life cycle of a construction project, stakeholders rely on their experiences, professional intuition, and/or other forms of tacit knowledge to accomplish satisfactory work.
- Tacit Knowledge Base of Construction Experts (KB-CE). By using of KB-CE and BR-KDDSS is it possible to search for experts and facilitates communication with those experts. Logging into BR-KDDSS, the stakeholders can search for an expert with the relevant knowledge, and will connect with him in real time by using instant messaging, e-mail, telephone, or Internet conferencing. As a result, the stakeholders could receive direct tacit help from an expert who had recently experienced a similar problem. At the time of communication, experts' tacit knowledge will be transferred in the most appropriate forms and applied in business processes. Their dialogue would be audited and stored in enterprise database systems to be searched by others. In this way, the stakeholder extracts valuable tacit knowledge from employees' human brains and applies those assets to the work process.

4 Conclusions

In order to design and realize an efficient building refurbishment, it is necessary to carry out exhaustive investigations of all the solutions that form it, i.e. planimetric and volumetric changes, the elimination of building deterioration and obsolescence, the improvement of architectural and aesthetic appearance and indoor environmental quality, etc. The efficiency level of the considered building's refurbishment depends on a great many factors, including: cost of refurbishment, annual fuel economy after refurbishment, tentative pay-back time, harmfulness to health of the materials used, aesthetics, maintenance properties, functionality, comfort, sound insulation and longevity, etc. The presented BR-KDDSS enables one to form up to 100,000 alternative versions. This system allows one to determine the strongest and weakest points of each building's refurbishment project and its constituent parts. Other BR-KDDSS functions include creating and maintaining customer's personalized objectives, preferences, and evaluation criteria; participation of various stakeholders in joint determination of criteria (criteria system, values and weights) defining building refurbishment; provide device-based data about indoor microclimates and allergens causing allergy in buildings, etc.

References

1. Ambrasas, G., Kaklauskas, and A., Zavadskas, E.K. Demonstration system for development of efficient projects. Statyba (Journal of Civil Engineering and Management), Vol. 2, No 4 (1996) 84–100.
2. Caccavelli, D., Genre J.L. Diagnosis of the degradation state of building and cost evaluation of induced refurbishment works. Energy and Buildings, Vol. 31, No 2 (2000) 159-165.
3. Chow, T.T., Zhang, G.Q., Lin, Z., and Song, C.L. Global optimization of absorption chiller system by genetic algorithm and neural network. Energy and Buildings, Vol. 34, No 1 (2002) 103-109.
4. Dorer, V., Weber, A. Air, contaminant and heat transport models: integration and application. Energy and Buildings, Vol. 30, No 1 (1999) 97-104.
5. Genre, J.L., Flourentzos, and F., Stockli, T. Building refurbishment: habitat upgrading. Energy and Buildings, Vol. 31, No 2 (2000) 155-157.
6. Kaklauskas, A., Zavadskas, E. K., AND Raslanas, S. Multivariant design and multiple criteria analysis of building refurbishments. Energy and Buildings, Vol. 37. No 4 (2005) 361–372.
7. Kolokotsa, D., Tsiavos, D., Stavrakakis, G.S., Kalaitzakis, K., and Antonidakis, E. Advanced fuzzy logic controllers design and evaluation for buildings' occupants thermal–visual comfort and indoor air quality satisfaction. Energy and Buildings, Vol. 33, No 6 (2001) 531-543.
8. Kusuda, T. Building environment simulation before desk top computers in the USA through a personal memory. Energy and Buildings, Vol. 33, No 4 (2001) 291-302.
9. Mazouz, S., Zerouala, M.S. The integration of environmental variables in the process of architectural design. The contribution of knowledge systems. Energy and Buildings, Vol. 33, No 7 (2001) 699-710.
10. Trink nas, V., Kaklauskas, A., and Zavadskas, E.K. Selection of rational construction products regarding building refurbishments. Property Management (International Journal of Strategic Property Management), Vol. 6, No 2 (2002) 74-82.
11. Zavadskas, E.K., Kaklauskas, A., and Turskis, Z. Multicriteria decision-making system for building refurbishment. Statyba (Journal of Civil Engineering and Management), Vol. 3, No 4 (1997) 62–68.
12. Zavadskas, E.K., Kaklauskas, A., and Raslanas, S. Evaluation of investments into housing renovation, International Journal of Strategic Property Management Vol. 8, No 3 (2004) 177–190.

Verbal Analysis of Risk Elements in Construction Contracts

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Abstract. The paper aims to analyse the construction contracts provided by FIDIC (International Federation of Consulting Engineers) and to determine their usefulness in respect of technical risk management. Contractors of international construction projects are often faced with complicated situations working with design documentation. One of the potential financial risk factor is associated with the frequent changes of documents and improper channels of communication between project partners. One of the major aspects is project financial and technical risk management. Project developers need various models of managing large and complex projects.

1 Introduction

Methods of risk assessment with use of the quantitative tools are very often not sufficient. Authors of this paper present the verbal method of construction contracts types comparison. This method allows estimating the verbal criteria of contracts solutions quality and risk connected with contractual issues.

Errors made high in the managerial chain have a noticeable influence on errors committed by operatives. However, they often remain latent and the direct causes are those related to poor workmanship of an individual worker. Nevertheless in complex processes like running the construction project in its full life cycle the problem relates to all people involved – from designer to operative and from the senior manager to junior trainee [11]. Although a great deal of technical information is already available on the causes of building defects, there is no evidence of any significant reduction in the incidence of defects and failures in recent years. The financial consequences of deficiencies of buildings and building components (or 'cost of defects') amount to approximately 3 to 5 % of the yearly costs of construction. About the same percentage

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 295 – 302, 2006.

cost is attributable to losses due to defects in the building process, as a result of errors, shortcomings, waste of material, idle time, and the like. The total cost of deficiencies in building thus range from around 6 to 10 % of total industry costs. Of course, this figure will vary from sector to sector within the industry. Nevertheless it is unacceptable, both socially and purely from the economic point of view [7]. Therefore, as failures and defects always mean extra costs (significantly influencing financial risk of construction projects), additional actions that need to be taken and delays in project delivery, the problem of avoiding defects in construction has been given more attention in recent years. It is noticeable in an increasing number of constructions, designing or consulting companies making efforts to implement ISO standards in services they supply. Yet, although implemented it is often not well understood and followed by the companies' key workers.

Efficient project management is about risk management [6]. Technical risk management at the construction stage of the project life cycle influences not only the economic effect of the investment but also future efficient functioning of the building. Lack of proper actions during construction can increase the probability of defects, failures, accidents or even catastrophes occurring.

2 Contract Type as a Tool for Technical Risk Allocation

Risk allocation is one of the construction contract's prime functions. To fulfil this aim construction contracts' provisions define among others:

- rights and obligations of the parties,
- sanctions for non-compliance, or incentives to comply,
- sets of procedures to be followed by the parties,
- how parties will bear the risks of unforeseen events.

Available forms of contracting construction works, and thereby risk allocation, are influenced by the following procurement strategies:

- TGC (Traditional General Contracting) in which design is procured independently of construction; design is provided by independent or in-house designers in direct contract with the client, while a separate contract for the construction of the project is placed with a contractor, who then sublets elements of the work; there is the matter of subcontracting clauses in the contract as the client may request:
    - nominated subcontractors/ suppliers - when the client has reserved the final selection and approval of the subcontractor to the contractor; works of such subcontractors are partially the responsibility of the client and the general contractor,
    - domestic subcontractors/ suppliers - any person or company to whom the contractor sublets any portion of the works and for whom the contractors remains wholly responsible;
- D&B (Design and Build) in which the design and construction form an integrated package - a single organization undertakes the responsibility and risks for both the design and construction phases; there may be various levels of employer involvement in the design, e.g. in:

- Turnkey Design and Build - the client engages a building contractor at the outset of the project; the contractor is responsible for the design and for the construction,
- Novated Design and Build - the client employs the design team for the early stages of the project (typically up to building permission stage) to prepare the outline design. The design team is then novated to the successful contractor, for whom they then prepare a detailed design;
- Design and Develop – the contractor takes on a design produced by the employer's design team and then develops it into a working design, using either in-house or sub-consultant designers [8];

- MC (Management Contracting) that treats not only design but also management as a separable input to the construction process; the client appoints a design team with responsibilities as in the traditional method and a management contractor; the construction is carried out by specialist works subcontractors who are contracted to the management contractor;
- CM (Construction Management) in which the specialist works contractors are contracted to the client directly. The construction manager remains as a member of consultancy team, to concentrate on the organization and management of the construction operations [1].

The chosen system of project procurement has a major impact on management and allocation of risks, which is illustrated in Table 1.

Table 1. Simplified view of risks relative to some procurement systems [8]

Procurement system	Balance of Risk
	Client / Contractor
Traditional (TGC)	FINANCE DESIGN PRODUCTION
Design and build (D&B)	FINANCE DESIGN PRODUCTION
Novated Design and Build	FINANCE DESIGN PRODUCTION
Management Contracting (MC)	FINANCE DESIGN PRODUCTION
Construction Management (CM)	FINANCE DESIGN PRODUCTION

The risk allocation is provided by the standard forms of contracts (e.g. FIDIC - Fédération Internationale Des Ingénieurs-Conseils, JCT – Joint Contracts Tribunal), however if it does not suit the particular purposes of the parties, they can agree alternatives that are more appropriate in terms of the ideal amount of risk to accept, or to transfer, parties' risk attitudes and the relative costs of reducing risk.

A contract of any type should be well prepared and carefully reviewed and clarified to avoid any misunderstandings between the parties.

In terms of technical risk management the contract should include:

- all requirements of the client clearly and unambiguously defined in the drawings, specifications, bills of quantities and other attached documents (e.g. performance specifications, programmes) in terms of scope of services, expected quality, costs and timing,
- procedures to be obeyed by the parties referring in particular to design and instructions delivery procedures, control procedures (plus formal communication standards), variation and approval procedures, safety procedures, inspections of works, commissioning procedures, defects remedying procedures, claims procedures,
- requirements on quality assurance by the contractor including sub-contracted works,
- requirements on quality and reliability of supplied plants, materials and workmanship (method statements , samples, inspection, testing, remedial works),
- defects liability,
- contractual penalties for delays (e.g. liquidated damages for culpable delay),
- required performance security (e.g. performance bonds, retentions), indemnities, insurances (for works, equipment, against injury to persons, damage to property) and warranties,
- others, relevant to the particular contract [2].

It is essential that there is an understanding of all the terms and conditions of the contract by all concerned. A precisely defined, unambiguous, legally sound and honestly complied with contract will eliminate many sources of risks. On the other hand when any of the forms of the risk occur they let us allocate blame and provide us with necessary tools to require remedial actions and rectification of undesired effects (defects, failures, poor quality of the final product).

3 Verbal Analysis of Contract Conditions

Strategic economic and political decision-making and research planning are referred to non-structured problems. Since the essential characteristics of such problems are qualitative, they can hardly be used in the analysis. On the other hand, the quantitative models are not sufficiently reliable.

Non-structured problems have the following common characteristics. They are unique decision-making problems, i.e. every time a decision-maker is faced with an unknown problem or the one having new features compared with the previously considered case. These problems are associated with the uncertainty of the alternatives to be evaluated, caused by the lack of information for making a decision. The evaluation of the alternatives is of qualitative nature, being usually expressed verbally (in statements).

Very often, experts cannot measure qualitative variables against an absolute scale where the level of quality does not depend on the alternatives. When the uncertainty is high, experts can only compare the alternatives qualitatively, based on particular criteria. Experts first use the extended verbal evaluation, making then the comparisons in terms of ’better-worse’; ‘nearly equal’.

The following aspects of behaviour are evaluated by verbal methods of decision-making [4-6]: qualitative measurements allow for an adequate description of an unstructured problem; formulation of final decision making rules according to data processing principles of humans and allow for explaining the methods psychologically; the procedures used to screen the conflicting data ensure the reliability of the information obtained, allowing a Decision Maker (DM) to formulate the final rules.

The suggested method is needed to arrange a number of alternatives according to the DM preferences. First, the preferences are stated based on qualitative parameters and then a logical scheme for comparing the alternatives is developed. The criteria are considered against the scales with the estimates expressed verbally by statements. A survey may be conducted to elicit the DM preferences and to eliminate the dependence of the criteria. Some special procedures are suggested to identify and eliminate the criteria dependence, which makes the use of the obtained information more effective.

The essential principles of verbal analysis used to assess the profitability of investment in construction project may be briefly described in the following way:

- Problem description used by decision-maker and his environment should not be altered at any stage of analysis.
- According to psychological research findings, methods of obtaining the information from people should comply with the human data processing system.
- Logical operations on verbal variables (i.e. alternative evaluation based on various criteria) should be mathematically correct.
- The information obtained from decision maker should not contain conflicting data.

Verbal analysis helps to reduce the gap between the demand for effective decision-making methods and the capacity of human data processing system.

First, the suggested method takes advantage of computer technology which is used to make pair wise comparison of the alternatives according to the specified rules aimed to identify their common and diverse features without the participation of decision makers. A survey made by decision maker is also computer-aided, allowing larger numbers of alternatives to be analysed.

Second, some quantitative criteria (i.e. values) may also be expressed verbally in evaluating the alternatives and stating their priorities. Thus, the suggested method allows us to operate with both qualitative and quantitative criteria to describe the alternatives. In this way, the described technique extends the possibilities of the available verbal analysis systems.

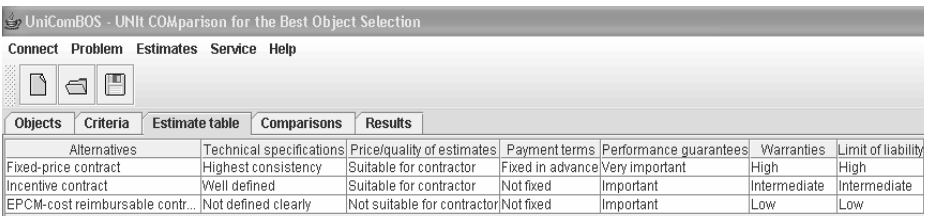
4 Determining the Effectiveness of Construction Contracts

To evaluate the effectiveness of construction contracts, a classification consisting of evaluation criteria and final decisions should be developed. A verbal decision support system [3] is taken from the Internet (http://iva.isa.ru).

In determining the effectiveness of construction contracts, the following six factors are taken into consideration: (1) technical specifications; (2) costs; (3) terms of payment; (4) performance guarantees; (5) insurance costs; (6) liability limit. Every criterion is assigned an estimate, e.g. large, average, small, etc. Entering the estimates, a matrix (3*6) is constructed and the evaluation table (Fig. 1) is obtained. When all the criteria are entered, the contracts of three various forms will be evaluated: fixed price contract; incentive contract; cost reimbursable contract. The comparison (Fig. 2) is made in the following way: the program provides an estimate of each criterion and their combinations. An expert gives his/her preferences for each combination. The program allows for four evaluation variants to be considered:

- the first alternative is more preferable than the second;
- both alternatives are equally preferable;
- the first alternative is less preferable than the second;
- don't know.

When the DM decides which estimate is more significant, the program chooses the estimates of two criteria and alternatives and makes their combinations (Fig. 3). When the DM has performed this operation, the program provides the table of intermediate results and a coloured comparison of the alternatives' ratios (better results coloured gray and worse estimates presented in black, see Fig. 4 upper line). To achieve more objective evaluation of construction contract effectiveness, the program provides the DM with two alternatives and three criteria for determining which criteria are more significant (Fig. 4 second and third line).



Alternatives	Technical specifications	Price/quality of estimates	Payment terms	Performance guarantees	Warranties	Limit of liability
Fixed-price contract	Highest consistency	Suitable for contractor	Fixed in advance	Very important	High	High
Incentive contract	Well defined	Suitable for contractor	Not fixed	Important	Intermediate	Intermediate
EPCM-cost reimbursable contr...	Not defined clearly	Not suitable for contractor	Not fixed	Important	Low	Low

Fig. 1. Evaluation table

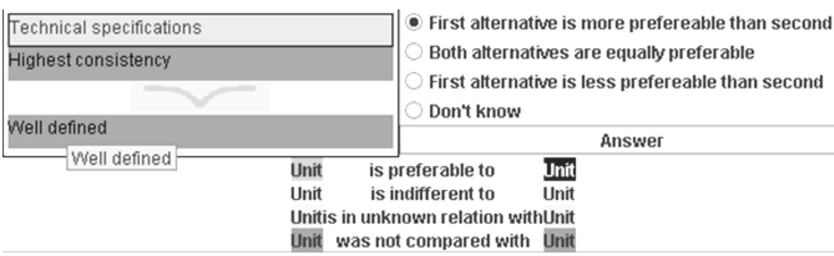


Fig. 2. Making a query for comparative assessment of criteria

When this operation is performed, the program provides the table with the results (Fig. 4). A comparison of construction contracts of three forms by a verbal method yielded the results (Fig. 5) according to which the second form of contract (incentive contract) was found to be better than the first form (fixed price contract), while the alternative number 3 (reimbursable contract) was rated third.

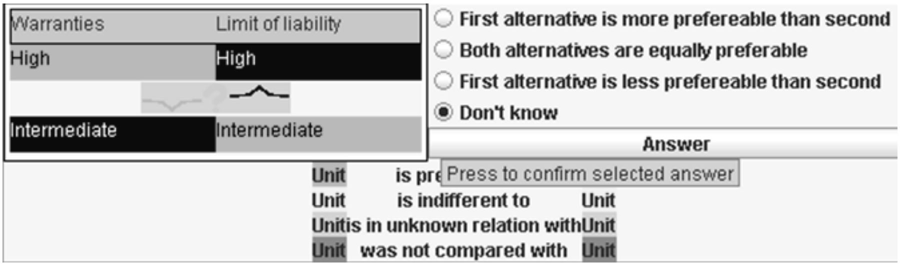


Fig. 3. Comparative evaluation of the estimates of two criteria

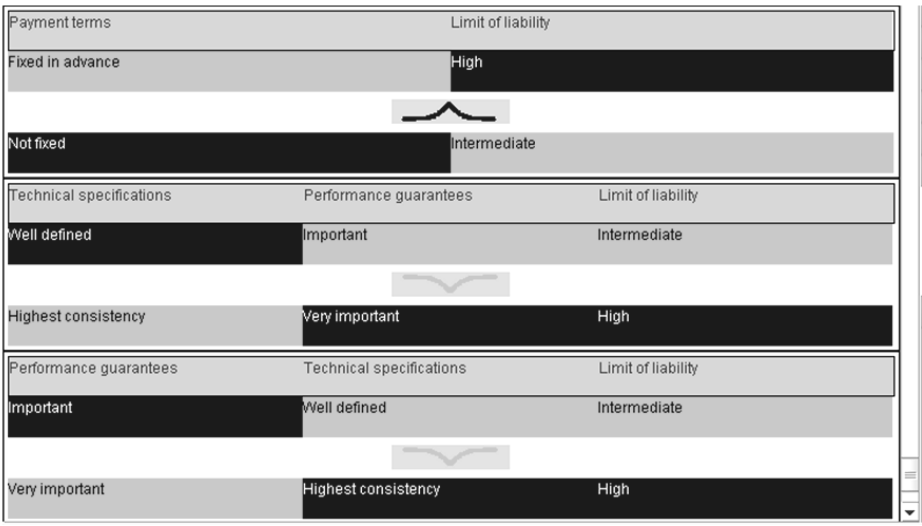


Fig. 4. Comparative assessment of two alternatives and two or three criteria

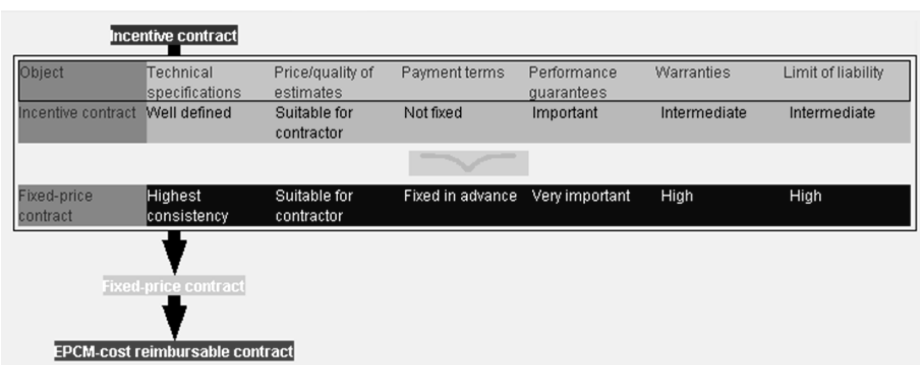


Fig. 5. Results of comparative assessment of alternatives

5 Conclusions

Six key criteria for contract evaluation have been developed based on the analysis of engineering projects performed by the largest international enterprises. They include technical specifications, price (precise cost estimates), terms of payment, performance guarantees, insurance costs and liability limits. The logic clarity and fairness of these factors help to determine project performance, providing the basis for a well-managed project.The analysis has shown that LSTK (Lump sum turn key) concept gives the priority to responsibility and the reduced number of interfaces. Therefore, according to the suggested evaluation criteria, this type of contract is most suitable in the construction industry.

References

1. Code of practice for PM for construction and development, CIOB Longman, Ascot, 1996.
2. Conditions of Contract for Construction (FIDIC 1999), Cosmopoli, Warszawa 2000.
3. Ashihmin, I. V., Furems, E. M.: System of support of a decision making UNICOMBOS for choice of the best object by many criteria. Artificial Intelligence (Искуственный интелект) Proceedings of the Ukrainian Academy of sciences, Kiev, 2 (2004) 243–247 (in Russian).
4. Korhonen, P., Larichev, O., Moshkovich, H., Mechitov, A., Wallenius, J.: Choice behavior in a Computer-Aided Multiattribute Decision Task. J. Multicriteria Decision Analysis, Vol. 2(2), (1997) 43–55.
5. Larichev, O. I.: Cognitive Validity in Design of Decision-Aiding Techniques. J. Multicriteria Decision Analysis, Vol. 1(3), (1992) 59–62.
6. Ustinovichius L.: Determination of Efficiency of Investments In Construction. International Journal of Strategic Property Management, Vol. 8(1), (2004) 25-44.
7. Report of the international symposium in Varenna 1994: The prevention of defects in buildings – state of the art and future developments, CIB Information (5) 1994.
8. Walker P., Greenwood D.: Construction Companion to Risk and Value Management, RIBA Enterprises, London, 2002.
9. Slowinski R., Zopounidis C.: Application of the rough set approach to evaluation of bankruptcy risk. International Journal of Intelligent Systems in Accounting Finance and Management, Vol. 4(1), (1995) 27-41.
10. Lunkevichius S., Ustinovichius L., Zavadskas E. K.: Substantiation of financing approach for rural property. Statyba (Civil Engineering). Vilnius: Technika, Vol. 7(2), (2001) 148–157.
11. Zavadskas, E. K., Kaklauskas, A., Raslanas, S. and Malienė, V.: The application of multi-criterion methods for valuation recreation property. Statyba (Civil Engineering), Vol. 7(4), (2001) 327-333.

Application of Association Rules for Finding Correlations Among Students Preliminary Knowledge

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Abstract. This paper aims at finding an efficient way for discovering which specific knowledge each student does not possess in order to successfully start a new course or to proceed with another section in a current subject. Most existing tutoring systems respond to students' mistakes by providing links to a collection of teaching materials. Such an approach does the individual needs of each student. Our idea is to apply a holistic approach that involves looking at the whole system of each student knowledge within an subject rather than just concentrating on single mistakes, lack of knowledge or misconception.

1 Introduction

Association rules are widely used for detecting relationships between variables. Association rules show attribute value conditions that occur frequently together in a given dataset. They deal with statements of the form 'the presence of attributes α and β often also involves attribute γ'. This approach has an application in different fields such as market basket analysis [5], medical research [7], web clickstream analysis [14] and census data [10].

The process of determining the set of association rules that hold in a context can be broken down into two steps - finding all frequent subsets of attributes, and generating confident rules from the frequent itemsets. Traditional approaches to find frequent itemsets rely on a minimum support threshold in order to reduce the amount of candidates they have to work with [6].

Most existing tutoring systems provide links to a collection of teaching materials. Such an approach does not relate each student's needs to the suggested help. Our idea is to apply a holistic approach that involves looking at the whole system of each student knowledge within an subject rather than just concentrating on single mistakes or lack of knowledge.

To make everything more clearly visible a graphic display of objects and attributes in a lattice structure is provided. Reducing the computational complexity while searching for association rules in the case at least one attribute

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 303–310, 2006.

included in the 'if' part of the statement is known, is presented. A dataset partitioning technique is used to efficiently discover association rules with some given information in the antecedent and without the constraint of support threshold.

The rest of the paper is organized as follows. Related work and definitions and statements from formal concept analysis and rule mining may be found in Section 2. The main results of the paper are placed in Section 3 and Section 4. The paper ends with a conclusion in Section 5.

2 Related Work

A Web-based tutoring tool with mining facilities to improve learning and teaching is described in [12]. An intelligent system for assisting a user in solving a problem was developed in [9].

A system using assessing Bayesian nets for assizing students' knowledge is proposed in [11].

Formal concept analysis [15] started as an attempt of promoting better communication between lattice theorists and users of lattice theory. Since 1980's formal concept analysis has been growing as a research field with a broad spectrum of applications. Various applications of formal concept analysis are presented in [8].

The complexity of mining frequent itemsets is exponential and algorithms for finding such sets have been developed by many authors such as [4] and [6].

Mining association rules is addressed in [1] and [2]. Algorithms for fast discovery of association rules have been presented in [3], [13] [16], and [17].

3 Association Rules Applied to a Calculus Test

Consider students enrolled in a subject where preliminary knowledge is a prerequisite for understanding new content. Students are first suggested to take a test (Test P, Fig. 1) detecting lack of necessary preliminary knowledge or skills. Suppose the test outcome implies insufficient knowledge or skills. The system then provides personalized help to each student based on his/her individual needs. If the test outcome does not imply lack of preliminary knowledge or skills the student is then directed to Chapter 1. In order to proceed with Chapter 2 the student has to take Test 1 (Fig. 1). The procedure is similar to the one describing Test P. However, tests differ in content.

Below we propose an approach for deriving association rules that involves matrices and vectors. The idea is best described with the following example.

For this scenario we consider freshmen enrolled in bachelor program. Students are divided in sixteen groups $G_1, G_2, ..., G_{16}$, according to gender and results from a test providing information about their preliminary knowledge in calculus. The goal is to find the association rules that relate attributes in Table 1 to students' results from the test.

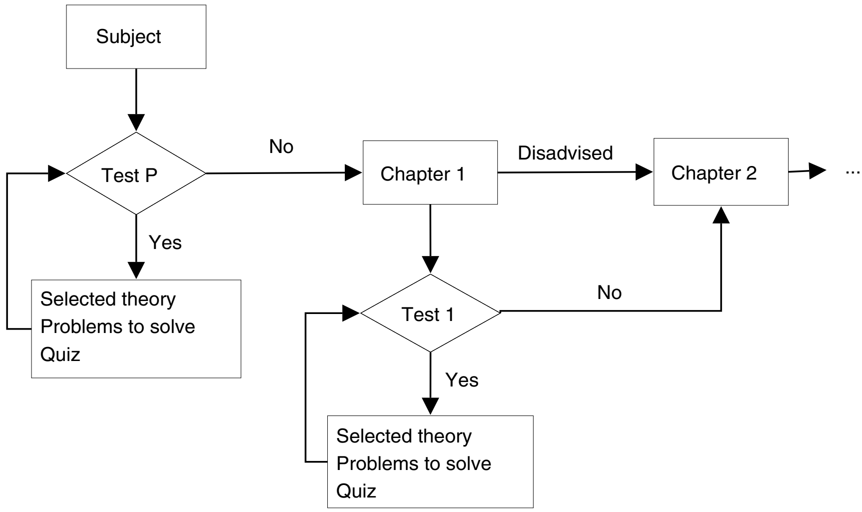

Fig. 1. Tests in a subject

For the sake of simplicity we limit the amount of attributes that may effect students' performance to the ones included in Table 1. The corresponding concept lattice is shown in Fig. 2.

Based on this context a binary matrix G with rows and columns corresponding to the rows and columns in Table 1 is generated. The rows in G are denoted by $g_i, i = 1, ..., 16$. An element in the matrix is set equal to 1 if the corresponding entry in the context is marked and to 0 otherwise.

$$\begin{array}{rl} g_1 : & 1111111110111 \\ g_2 : & 1111111010110 \\ g_3 : & 1101011001110 \\ g_4 : & 1101101010100 \\ g_5 : & 1001000000100 \\ g_6 : & 1101001000000 \\ g_7 : & 1101000000000 \\ g_8 : & 1000000000000 \\ g_9 : & 1111111101111 \\ g_{10} : & 1111111010111 \\ g_{11} : & 1101011000110 \\ g_{12} : & 1111011101110 \\ g_{13} : & 1000010001100 \\ g_{14} : & 1110000010100 \\ g_{15} : & 1100011000100 \\ g_{16} : & 1001000000000 \end{array} \qquad G$$

Suppose we are interested in the association rules that involve the attribute 'can divide fractions'. We then choose all vectors that have 1 as their sixth

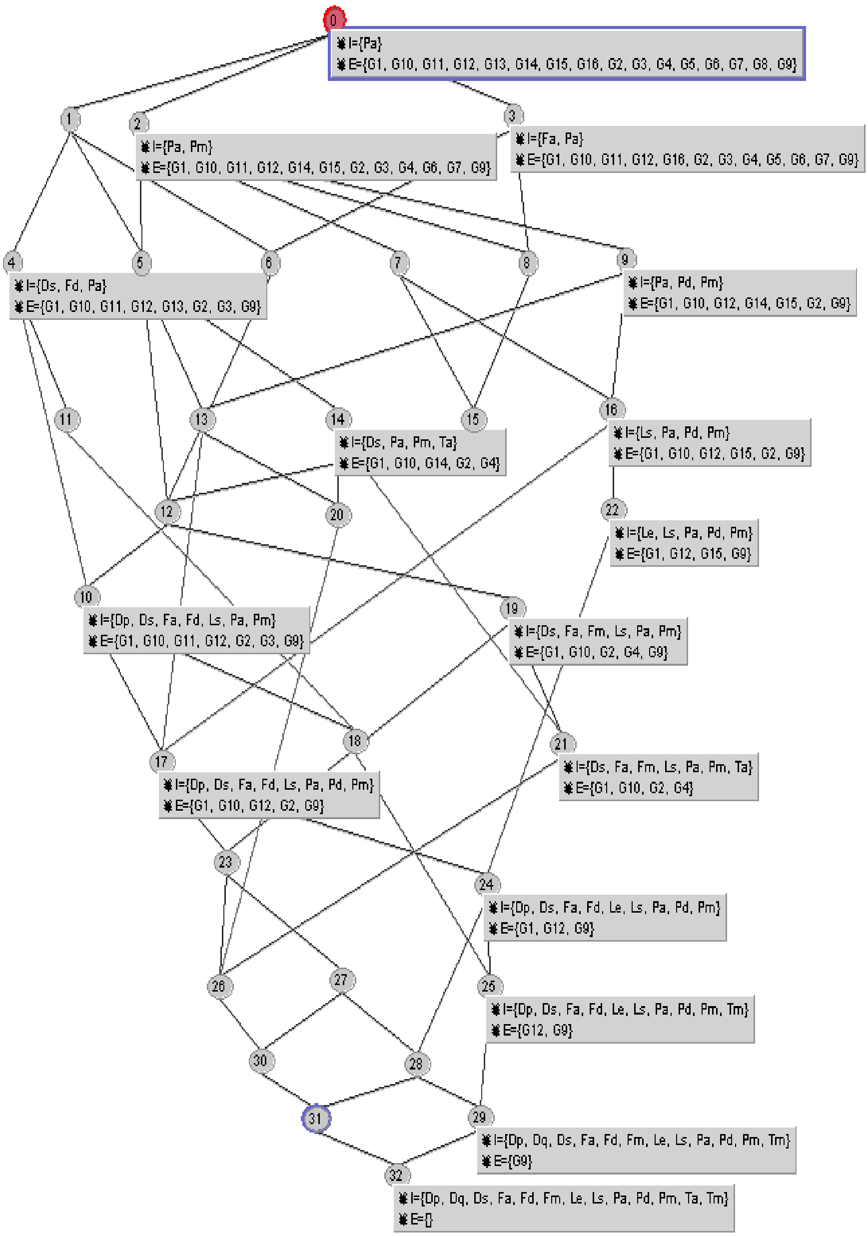

Fig. 2. Concept lattice for the context in Table 1

Table 1. Context for students groups

	Polynomials			Fractions			Logarithms		Trigonom. functions		Differentiation		
	add.	mult.	div.	add.	mult.	div.	symb.	expr.	add.	mult.	sum	prod.	quotient
G 1	×	×	×	×	×	×	×	×	×		×	×	×
G 2	×	×	×	×	×	×	×		×		×	×	
G 3	×	×		×		×	×			×	×	×	
G 4	×	×		×	×		×		×		×		
G 5	×			×							×		
G 6	×	×		×			×						
G 7	×	×		×									
G 8	×												
G 9	×	×	×	×	×	×	×	×		×	×	×	×
G 10	×	×	×	×	×	×	×		×		×	×	×
G 11	×	×		×		×	×				×	×	
G 12	×	×	×	×		×	×	×		×	×	×	
G 13	×					×				×	×		
G 14	×	×	×						×		×		
G 15	×	×				×	×				×		
G 16	×			×									

coordinate. The obtained matrix is denoted by $G_{i,j}$ (in this particular case $G_{9,6}$), where the value of i shows the number of rows in $G_{i,j}$ and the value of j shows which attribute has been chosen.

$$\begin{array}{rl} g_1: & 1111111110111 \\ g_2: & 1111111010110 \\ g_3: & 1101011001110 \\ g_9: & 1111111101111 \\ g_{10}: & 1111111010111 \\ g_{11}: & 1101011000110 \\ g_{12}: & 1111011101110 \\ g_{13}: & 1000010001100 \\ g_{15}: & 1100011000100 \end{array} \qquad G_{9,6}$$

This way we considerably reduce the number of any other following operations that involve the attribute 'can divide fractions' in the 'if' part of our search. We then add g_1 to each of the remaining vectors in $G_{9,6}$ and thus obtain $G'_{9,6}$.

$$\begin{array}{rl} g_1+g_2: & 2222222120221 \\ g_1+g_3: & 2212122111221 \\ g_1+g_9: & 2222222211222 \\ g_1+g_{10}: & 2222222220222 \\ g_1+g_{11}: & 2212122110221 \\ g_1+g_{12}: & 2222122211221 \\ g_1+g_{13}: & 2111121111211 \\ g_1+g_{15}: & 2211122110211 \end{array} \qquad G'_{9,6}$$

Remark: At this point we can again reduce the number of rows in $G'_{9,6}$ by deleting all rows with 0's and 2's only.

The next step is to look for positions in $G'_{9,6}$ with value 2, beginning with the first row. Those positions indicate association rules. Two of the association rules that have the attribute 'can divide fractions' as an antecedent are shown below

- Q: a student can divide fractions, differentiate sum of functions and add polynomials
- R: the student can differentiate product, add fractions, work with logarithms of symbols and multiply polynomials
  support $Q \rightarrow R = 43\%$ *confidence* $Q \rightarrow R = 87\%$

- Q: a student can divide fractions, differentiate sum of functions and add polynomials
- R: the student can multiply trigonometrical functions
  support $Q \rightarrow R = 25\%$ *confidence* $Q \rightarrow R = 50\%$

4 Working with Several Attributes

Below we propose two ways to reduce the computational complexity of calculating association rules.

A) The first one aims at working with a subset of the vectors in the binary matrix G. The subset contains parewise different vectors only. Let the vectors in G be $g_1, g_2, ..., g_n$.

1. Add g_1 to all other vectors $g_2, g_3, ..., g_n$ and search for vectors with 0's and 2's only in the obtained subset of $n-1$ vectors.
   - If there are such vectors, denote their number by k_1 and continue the same procedure with the rest of the $n-k_1-1$ vectors.
   - If there are no such vectors, delete g_1 and repeat the same procedure with g_2 and so on.
2. Denote the matrix of the above chosen $n-k_1-1$ vectors by G_{n-k_1-1}. Add then the first vector in G_{n-k_1-1} to the rest of the $n-k_1-2$ vectors and search for vectors with 0's and 2's only in the obtained subset of $n-k_1-2$ vectors.
   - If there are such vectors, denote their number by k_2 and continue the same procedure with the rest of the $n-k_1-k_2-2$ vectors.
   - If there are no such vectors, delete the first vector in G_{n-k_1-1} and repeat the same procedure with the second vector in G_{n-k_1-1} and so on.
3. The search process ends when $n-k_1-k_2-...-k_s-s=0$, i.e. there are no more vectors to be compared.
4. Compare the numbers $k_1, k_2, ..., k_s$ and take the one with a max value say k_j. Continue calculating association rules using the reduced matrix G_{n-k_j}.

B) The idea in the second one is to only work with a subset of vectors with a number of nonzero coordinates higher or equal to the number of attributes included in the 'if' part of our search.

– Calculate the number of nonzero coordinates of each vector in G. Suppose the number of attributes in the 'if' part of our search is l. Continue then working with a submatrix of vectors G^l that have at least l nonzero coordinates.
– If we search for a particular relation we can further reduce the the number of vectors in G^l by choosing only vectors with nonzero coordinates in the position indicating that particular attribute included in the 'if' part of our search.

5 Conclusion

In this paper association rules have been used for finding correlations among students' preliminary knowledge. In addition we have shown two approaches for reducing computational complexity of extracting association rules in a case of multiple attributes when a preliminary knowledge about inclusion of at least one attribute in the 'if' part of the statement is present. The main advantage of the proposed approaches is that they reduce the size of the initial set of vectors on which association rules are applied afterwords.

References

1. Agrawal, R., Imielinski, T., and Swami, A.: Mining association rules between sets of items in large databases. Proceedings of ACM SIGMOD international conference on management of data, Washington, DC, USA, (1993) 207-216
2. Agrawal, R. and Srikant, R.: Fast algorithm for mining association rules. Proceedings of the 20th very large data base conference, Santiago, Chile, (1994) 487-489
3. Agrawal, R., Mannila, H., Srikant, R., Toivonen, H., and Verkamo, A.I.: Fast discovery of association rules. (Uthurusamy, F., Piatetsky-Shapiro, G., Smyth, P. eds) Advances in Knowledge discovery of association rules, MIT Press, (1996) 307–328
4. Bastide, T., Taouil, R., Pasquier, N., Stumme, G., and Lakhal, L.: Mining frequent patterns with counting inference. SIGKDD explorations, Special issue on scalable algorithms, **2**(2) (2000) 71–80
5. Brin, S., Motwani R., Ullmann, J.D., and Tsur, S.: Dynamic itemset counting and implication rules for market basket data. Proceedings of the ACM SIGKDD international conference on management of data, Tuscon, AZ, USA, (1997) 255–264
6. Carpineto, C. and Romano, G.: Concept Data Analysis: Theory and Applications, John Wiley and Sons, Ltd., (2004)
7. Delgado, M., Sanchez, D., Martin-Bautista, M.J., and Vila, M.A.: Mining association rules with improved semantics in medical databases. Artificial Intelligence in Medicine, **21**(1-3) (2001) 241-5
8. Ganter, B, Stumme, G., and Wille, R.: Formal Concept Analysis - Foundations and Applications. Lecture Notes in Computer Science, Springer Verlag, **3626** (2005)
9. Liu C., Zheng L., Ji J., Yang C., Li J., and Yang W.: Electronic homework on the WWW. First Asia- Pacific Conference on Web Intelligence (2001) 540–547
10. Malerba, D., Lisi, F.A., Appice, A. and Sblendorio, F.: Mining spatial association rules in census data: a relational approach. Proceedings of the ECML/PKDD'02 workshop on mining official data, University Printing House, Helsinki (2002) 80–93

11. Martin J. and Vanlehn K.: Student assessment using Bayesian nets. International Journal of Human- Computer Studies **42** (1995) 575–591
12. Merceron, A. and K. Yacef: A Web-based Tutoring Tool with Mining Facilities to Improve Learning and Teaching . Proceedings of 11th International Conference on Artificial Intelligence in Education. F. Verdejo and U. Hoppe (eds) Sydney, IOS Press (2003)
13. Mueller, A.: Fast sequential and parallel algorithms for association rule mining: A comparison. Technical Report Technical Report CS-TR- 3515, University of Maryland, College Park, MD, (1995)
14. Sweiger, M, Madsen, M.R., Langston, J., Howard Lombard, H.: Clickstream data warehousing, John Wiley & Sons, Canada (2002)
15. Wille, R.: Concept lattices and conceptual knowledge systems. Computers Math. Applic., **23**(6-9) (1992) 493–515
16. Zaki, M.J.: Generating non-redundant association rules. Proceedings of the 6th ACM SIGKDD international conference on knowledge discovery and data mining, Boston, USA (2000) 34–43
17. Zaki, M.J. and Hsiao, C.-J.: CHARM: An efficient algorithm for closed itemset mining. Proceedings of the 2nd SIAM international conference on data mining, Arlington, VA, USA (2002) 34–43

Specifying Collaborative Tasks of a CSCL Environment with IMS-LD

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Abstract. The standardization of eLearning environments is causing a constant evolution of the standards, the specifications, the reference models and the best practices of these specifications. Mainly, this evolution is a consequence of the educational and computational paradigms which the standardization applies and of the pedagogic and cognitive requirements of the learner using these environments. *"Instructional Design"* or *"Learning Design"* (LD) is an approach on specifications in the standardization process centred on cognitive characteristics and on the learning process itself. In this case, the learning process is isolated from the learning object design. This is, LD is centred on *"how to learn"*, not in *"what to learn"*. IMS Learning Design (IMS-LD) is the specification used to describe the learning design. We are working in the AULA_IE project whose objective is to evaluate different standards and to check their application and contribution in Computer Supported Collaborative Learning (CSCL) environments. As a consequence of this evaluation we have observed a lack of semantics when some activities and tasks are specified. Based on this result, we propose a reference model inside the IMS specifications core.

1 Introduction

Nowadays we are witnessing a constant evolution of the standards, specifications, reference models and best practices in e-Learning environments in order to support reuse and interoperability. This is a consequence of applying these standards to several educational and computational paradigms. The effectiveness of these specifications can only be tested with real applications and experiences.

Working groups such as IEEE LTSC[1], IMS Global Learning Consortium or ADL[2], are working in this way to provide a set of standards specifications that allow these principles of reuse and interoperability in the e-Learning industry. Standards provided by IEEE LTSC, specifications such as those provided by IMS Global Consortium, or reference models such as those provided by ADL make up the standards framework

[1] IEEE Learning Technology Standards Committee.
[2] Advanced Distributed Learning Network.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 311 – 317, 2006.

where developers and engineers of e-Learning systems should work. In this framework, AULA_IE[3] (PIB-05-006) is a project whose objective is to evaluate different standards and to check their application and contribution in Computer Supported Collaborative Learning (CSCL) environments. The CSCL is based on an interdisciplinary paradigm that merges the information and communication technologies and Collaborative Learning. Specifications for describing CSCL systems should include support for collaborative activities where a set of actors participate in collaborative learning activities [5].

One specification evaluated in the AULA_IE project is IMS-LD [7]. This specification takes as a basis the Educational Modelling Language (EML) [3], which was proposed by the Open University of the Netherlands and aims to be centred on cognitive characteristics and on the learning process itself. So the learning process is isolated from the learning object design.

IMS-LD represents instructional strategies using the theatre metaphor. Hence, an instructional method is divided in *play* elements that contain several *acts* where different *roles* bring *activities* in specific *environments*. These activities can be classified into three kinds: 1) *learning-activities* that lead the learner to get the knowledge; 2) *support-activities* that do not contribute to the learning process itself, but are needed for the success of learning activities; 3) *structure-activities* that allow structuring learning activities, support-activities or other structure-activities in sequence or selection order. All these activities can be brought into specific *environments.* These environments have *learning objects* and *services* that the different roles can use in the activities.

In this paper the IMS-LD specification applied to CSCL environments will be analyzed, showing its deficiencies and the proposals of other authors in order to solve them. Then, our proposal of a reference model specifying CSCL environments based on IMS-LD and other IMS specifications will be made.

This paper is structured as follows: we will begin showing the deficiencies of IMS-LD when applied to CSCL environments. Then, we will refer to some related works that try to solve them. Next, our proposal of a reference model based on IMS-LD and other IMS specifications will be made. We will end with some concluding remarks and future works.

2 Applying IMS-LD to CSCL Environments

One of the IMS Learning Design Workgroup (LDWG) goals is that the specification needs to *"support multiple learners and multiple roles in a learning activity, reflecting learning experiences that are collaborative or group-based"* [7]. That is, it could be used in CSCL environments. Nevertheless, there are some works that point in the opposite direction. In [1], IMS-LD is criticised from a CSCL viewpoint, and a proposal is presented considering new components as necessary in the IMS-LD sequencing and act models.

[3] Educative standards integration to AULA e-Learning system. http://chico.inf-cr.uclm.es/AULA_IE.

Probably, the major weakness of IMS-LD from a CSCL perspective is its strict sequencing model. From the IMS-LD specification [7] next sequential model can be extracted:

- *Plays* of a *method* will be run in parallel.
- *Acts* of a *play* will be run in sequence, each one being triggered by the end of the preceding one.
- *Role-parts* of an *act* will run together in parallel.
- *Activities* grouped in *activity-structures* will run in sequence or selection mode depending on an attribute called *structure-type*.

This strictness makes designers organize learning activities thinking in this sequential model, not in the theatre metaphor semantic model (method, play, acts and role-parts). Furthermore, this model only allows little sequencing combination.

Additionally, from the IMS-LD specification [7] the following capabilities for model collaborative activities can be extracted:

- If multiple individuals have to collaborate, this has to be done using a service (such a conferencing system) in the environment associated with the activity in which they must work together.
- In IMS-LD level C, notifications are introduced for allowing triggering activities across roles. This notifications support collaborative events where activities of roles are dependent on the state of the activities of other roles.

The first point seems to indicate that the specification does not specify the collaborative activity itself, leaving the responsibility in hands of the service that allows the collaborative activity. However, the second point indicates a mechanism that allows triggering activities across roles to specify collaboration. Nevertheless, this mechanism does not seem to support communication into individuals of the same role in the same activity.

As a solution to all these IMS-LD deficiencies for CSCL support, [2] and [2] propose a set of extensions to IMS-LD focused on the definition of a new type of service for supporting collaborative group interactions called *groupservice*. This service allows specifying awareness, communication skills, interaction type, etc. However, that proposal only allows binding the activity with an environment that has a *groupservice*, leaving the liability of the collaborative activities in hands of the application that implements the service. Furthermore, the collaborative activities cannot be specified due to the fact that it only takes into account services, not activities or the roles that do the activities.

Alternatively, in [4] a CSCL script that allows modelling collaborative learning processes is presented. This CSCL script explicitly introduces groups, artefacts (files generated by users), loop control structure, etc. to provide CSCL support. However it is strongly oriented to CSCL support, leaving the generic goal being searched for by other EMLs.

On the other hand, several modelling graphical languages and tools can be used to specify units of study, group activities, workflow, etc. These languages provide a high abstraction level to specify the different aspects involved in the CSCL modelling, and a subsequent translation to the appropriated low level specification (for instance, IMS-LD). However, it can be observed that all the IMS-LD semantics can be modelled with these graphical modelling languages, but the opposite is not always clear. This is, some of these modelling languages are semantically richer than IMS-LD in some aspects.

In the next section we will analyze in which aspects these modelling languages are semantically richer than IMS-LD and a proposal of a reference model will be made trying to solve the problems described in this section.

3 Proposal of a Reference Model

We start from the assumption that each part of a system is modelled with the specification that provides the best representation. There are some relationships among different specifications. As a consequence, we will try to join several specifications that allow us to specify all the learning activities in a CSCL environment. That is, a reference model that allows specifying CSCL systems using IMS-based specifications will be shown.

With modelling languages and tools such as UML[4], MOT+[5], LAMS[6], etc. the units of study can be modelled at a high abstraction level. These modelling languages are semantically richer, easier to understand and more flexible thanks to their graphical notation. Therefore, different aspects of these graphical modelling languages could be mapped to a set of computer-understandable specifications. These aspects are the models on which the graphical modelling languages are based. The models that we have identified to specify CSCL environments are:

- The unit-of-study model: that can be subdivided in the same way as IMS indicates [7]:
  - Packaging model: in which the resources needed in the instructional process are organized and packaged.
  - Educational model: in which the learning/teaching strategy is defined.
- The sequencing model: in which the sequencing of activities are defined.
- The user model: in which the user's characteristics are defined.

These models have their corresponding specification into the IMS specifications core. Thus, the unit-of-study model is covered in merging IMS Content Packaging (IMS-CP) [10] and IMS-LD, the sequencing model is covered in IMS Simple Sequencing (IMS-SS) [8], and the user model is covered in IMS Learner Information Package (IMS-LIP) [9].

The IMS-CP specification purpose is to identify and to organize the instructional resources needed in learning activities. The IMS-SS specification allows representing sequencing descriptions needed to provide a sequence of learning activities. These two specifications make up the core of SCORM2004 [11]. IMS-LIP specification allows describing learner information, goals, accomplishments, learning experiences, etc.

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[4] http://www.uml.org/
[5] http://www.licef.teluq.uquebec.ca/gp/eng/productions/mot.htm
[6] http://www.lamsinternational.com/

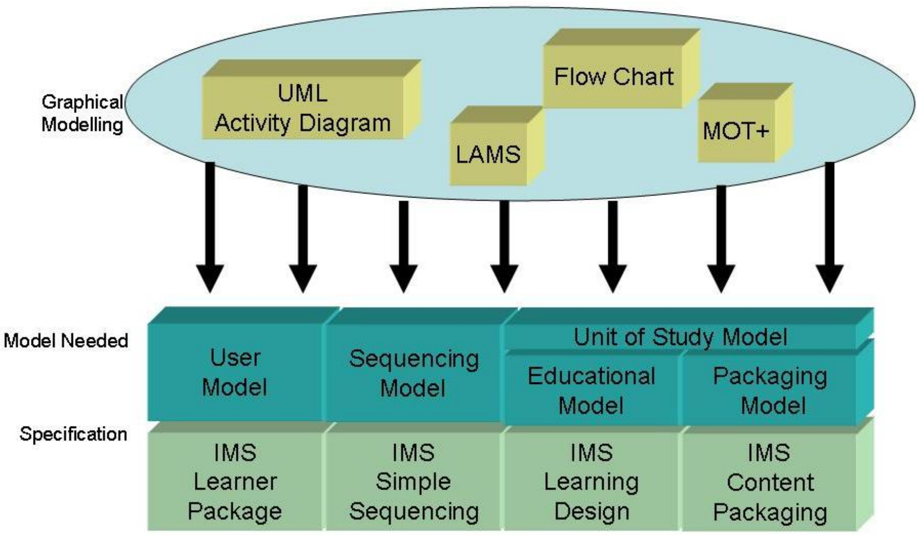

Fig. 1. IMS support for CSCL specifications

With this, we propose the use of IMS-LIP and IMS-SS to solve the lacks in IMS-LD:

- With IMS-LIP enough information can be introduced to specify the role characteristics that must be used in the role-part to indicate the way in which roles can participate in an activity. We can see several examples of adaptation to the learners' characteristics in [6].
- With IMS-SS a full new sequencing model is introduced that allows a great flexibility. We have the best example in SCORM2004 [11], where IMS-SS is used in its sequencing model to specify the sequence of learning activities.

The proposed reference model is shown in fig. 1. As can be seen in the top level of this figure, graphical notations can be used for modelling units-of-study with a high abstraction level. These graphical notations are based on user, sequencing and unit-of-study models that have their corresponding information model and specification inside the IMS specifications core, as it is shown at the bottom level of the figure. Thus, the unit-of-study specified with some of that graphical notation is mapped in the corresponding IMS-CP and IMS-LD specification. For sequencing information modelled with these graphical techniques which cannot be supported by IMS-LD, could be introduced using IMS-SS. In the same way, IMS-LIP can be used for specifying learners' individual characteristics necessary in IMS-LD for indicating the way in which each person interacts in the collaborative activity.

In conclusion, sequencing specification can be included to provide a flexible workflow using IMS-SS in the learning-activities, the structure-activities and the act elements of IMS-LD. In addition to this, IMS-LIP can be embedded in role-parts of IMS-LD definitions to allow a more precise definition about how learners interact in a collaborative learning activity.

4 Summary

Before a brief introduction to the e-learning standards growth, the attention here has been focused on IMS-LD, and concretely on its application to CSCL environments. Consequently, the major lacks in IMS-LD to support CSCL are described. After this, several contributions to solve these lacks have been shown and analyzed. Finally, we have offered an alternative based on the integration of several specifications in the IMS core. This specification integration aims to cover all those necessary aspects that should be taken into account to specify CSCL environments. Then, the use of IMS-SS and IMS-LIP has been suggested in order to decrease the lacks observed in IMS-LD.

We have found that in some cases these specifications cannot be directly merged. This could be due to the fact that they were not initially conceived to work together. This is the case of IMS-SS and IMS-LD. These two specifications seem to have been conceived as an alternative to structure the sequences of learning activities. With this, the xml-schemas that define these specifications should be modified to allow their integration, and the information models of this specifications should be reviewed having in mind that they can work together to produce higher cohesion in the IMS specifications set.

Acknowledgements

This research work has been partially supported by the Junta de Comunidades of Castilla-La Mancha, Spain through the "AULA_IE: Educative standards integration to the AULA e-Learning system" project (PIB-05-006).

References

1. Caeiro, M., Anido, L., Lamas, M.: A critical analysis of IMS Learning Design, In: B. Wasson; Luís Anido , Ulrich Hoppe, (eds.): Proceedings of the International Conference on Computer Support for Collaborative Learning (CSCL 2003), Bergen: Luwer Academic Publishers, June 2003, (2003) 363-367.
2. Hernández, D., Asensio, J.I., Dimitriadis, Y.S.: Computational Representation of Collaborative Learning Flow Patterns using IMS Learning Design. In: Educational Technology and Society, International Forum of Educational Technology and Society (IFETS), (2005) 75-89.
3. Koper, R.: Modelling units of study from a pedagogical perspective. The pedagogical metamodel behind EML, Online http://eml.ou.nl/introduction/docs/ped-metamodel.pdf (2001).
4. Miao, Y., Hoeksema, K., Hoppe, U., Harrer, A., CSCL Scripts: Modelling Feautres and Potential Use. In: Proceedings of Computer Supported Collaborative Learning (CSCL) conference 2005. (2005)
5. Koschmann, T. , Erlbaum, L., (eds.): CSCL: Theory and practice of an emerging paradigm. (1996)
6. Towle, B., and Halm, M.: Designing Adaptive Learning Environments with Learning Design. In R. Koper and C. Tattersall (eds.), Learning Design. A Handbook on Modelling and Delivering Networked Education and Training. The Netherlands: Springer, (2005) 215-226.

7. IMS Learning Design. Information Model, Best Practice and Implementation Guide, XML Binding, Schemas. Version 1.0 Final Specification, Technical report, IMS Global Learning Consortium Inc, Online, http://www.imsglobal.org/learningdesign/. (2003)
8. IMS Simple Sequencing. Information Model, Best Practice and Implementation Guide, XML Binding, Schemas. Version 1.0 Final Specification, Technical report, IMS Global Learning Consortium Inc, Online, http://www.imsglobal.org/simplesequencing/. (2003)
9. IMS Learner Information Package. Information Model, Best Practice and Implementation Guide, XML Binding, Schemas. Version 1.0 Final Specification, Technical report, IMS Global Learning Consortium Inc, Online, http://www.imsglobal.org/profiles/. (2001)
10. IMS Content Packaging, Best Practice and Implementation Guide, XML Binding, Schemas, Information Model. Version 1.2 Public Draft - Working Draft 4, Technical report, IMS Global Learning Consortium Inc, Online, http://www.imsglobal.org/content/packaging/. (2005)
11. SCORM 2004. Overview. Technical report, ADL (Advanced Distributed Learning), Online, http://www.adlnet.gov/scorm/index.cfm. (2004)

Concurrent Engineering of Mechatronic Products in Virtual Enterprises: Selection and Deployment of a PLM System for the Machine Tool Industry

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Abstract. The development of mechatronic products requires the integration of different technical disciplines by personnel who reside in separate locations, a fact that is particularly evident for the case of virtual enterprises. Concurrent engineering of these products can be enhanced significantly through the use of sophisticated data management and visualization tools such as Product Lifecycle Management (PLM). The key benefit of a PLM system is its ability to facilitate the coordination of the activities among geographically distributed team members. This paper describes models and procedures that were developed and implemented during the selection and configuration of a PLM environment for machine tool design and construction in a virtual enterprise. The experiences from this case, particularly the bottlenecks and how they were addressed are discussed in detail. Finally, recommendations for better deployment of PLM for similar conditions are presented.

1 Introduction

Mechatronic products for today's markets are complex components whose design and production require the integration of multiple disciplines. Examples of mechatronic products range from consumer goods such as coffee makers and cameras, to high performance / low volume systems such as machine tools. Development of these products is typically done by teams whose member's expertise span a variety of fields, from marketing through engineering, manufacture and support. The specialists responsible for the development of the different systems of the product work in an asynchronous manner and even in separate locations, while bounded by stringent budgets and schedules.

The above conditions are particularly evident for the case of virtual enterprises. A virtual enterprise (VE) is a temporary alliance of companies, who combine their resources to integrate a service or product that could not be provided otherwise. Upon completion of the alliance's goals, the members return to their original niches.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 318 – 326, 2006.

Lately, the use of Product Life Management systems (PLM) has gained wide acceptance among producers of consumer goods. A PLM facilitates the process of concurrent engineering of these products, because it enhances the coordination of the activities among all the actors involved in the development and support of these products. Given the variety of PLM systems available in the market, the selection and configuration of such a system for a particular application or industry has become an important activity, whose result affects the capacity of the development team to deliver successful products. In general, PLM require high initial investments and costly maintenance. Consequently, their economic application is particularly suited for the case of companies that specialize in products for a significant sector, and whose volumes justify the investment. The use of PLM in virtual enterprises and for high performance product, on the other hand, presents unique challenges that have not been addressed yet. This paper describes the experiences obtained during the selection and configuration of a PLM environment for the machine tool industry in a virtual company.

2 Literature Review

Products for current markets require complex management. Hahn [1] describes a concept and architecture for product modeling and integration, which encompass all the necessary product inter-relations. Information is administrated by an integrated PLM system functionality combined with knowledge management technologies. The proposed platform reduces product administration efforts during the design, and manufacture, presenting a PLM architecture that can easily integrate all product lifecycle activities, as documentation, integration, installation and maintenance.

Information technology and communications had evolved at a very fast rate. In his work Sharma [2] attempts to integrate three topics: collaboration, product development, and innovation, using an information technology framework based on process alignment that can be adopted to realize the benefits of a collaborative environment. Challenges raised by factors such as location, human behavior, culture and the adoption of PLM are exposed. He points out that companies that produce automotive and pharmaceutical products seem to be ideal candidates to embrace collaboration to their full potential.

Atkinson et al. [4] present the strategies that Denso used after evolving from a provisional supplier to Toyota to one of the largest suppliers of the automotive industry. Denso proposes a Global New Product Innovation and Development framework in a way to reduce costs and improve quality of new products, a PLM in essence. As with Sharma, this work presents and example of the benefits of the use of a PLM in a company that produces goods for mass consumption– Roller et al. [5] describe methods to reduce iterations during product design and development, using techniques for parallel development processes. Their work identifies certain product attributes to solve common security and consistency problems that arise during distributed product development processes.

Sudarsan et al. [3] proposed a PLM system framework, which supports all different information needs. He bases his framework on the National Institute of Standards and Technology Core Product Model, with four main components: Open Assembly

Model, Core Product Model, Design Analysis Integration and Product Family Evolution Model. This framework, integrated with a PLM, can access, store, serve and reuse all product information throughout the entire product lifetime, and it supports product data management from tolerances to post production evolution. They concluded that further research is needed to identity and model components of the framework to support the development of an Application Program Interface between PLM systems and the framework.

Application specialists state that PLM systems are particularly useful and applicable to virtual enterprises, allowing manufacturers to explore multiple business strategies, among them virtual manufacturing and engineer-to-order to improve efficiencies and maintain product advantage. Camarinha et al. [6] claim that the cooperation among virtual enterprises has to be supported by computer networks. Nevertheless, while great benefits are expected from the application of PLM systems in virtual enterprises, a case of PLM deployment in VE is not documented in his work.

3 VE for High Performance Product Development: Characteristics and Issues

As shown in the literature review, there is a considerable amount of experience in the use of PLM by companies that produce consumer goods. To date, the deployment of PLM systems for virtual enterprises that manufacture high performance products has not been addressed with the same level of detail.

A PLM is a system that brings together all product-related data into a single place for use across a larger team and external to the organization, can share, comment on, modify, and track a product throughout its lifecycle. PLM systems allow manufacturers to improve their efficiencies and maintain competitive product advantage. The key is to provide information on a timely basis to facilitate the decision making process.

Virtual enterprises are companies that are formed by the temporary alliance of smaller firms who join their resources to generate a product or service that none of them could provide individually. Once the goal of this alliance is met, the individual firms go back to their original duties. The strength of this concept lies in the fact that it allows for an extremely lean operation. On the other hand, the authors' experiences with virtual enterprises show that these companies are at disadvantage in handling and managing information and knowledge when compared to traditional firms. Furthermore, product maintenance and follow up are not easily handled within a VE environment [7].

High performance products (HPP) possess unique characteristics that make them unsuitable for development and deployment processes that are more typical of consumer goods. In general, high performance products can be defined as devices that are expected to perform critical functions in harsh environments with high reliabilities. Prototyping is hardly ever an option, that is, the prototype is the actual product. Successive generations of the product are in many cases updates of the original product. Development ad deployment of these products is done within fixed schedules and with predefined budgets. Satellites, race cars, and machine tools for special applications are examples of HPP.

It has been argued that the use of PLM could help to overcome the limited capacity of VE's to manage product life cycle information. Even more critical, VE's that manufacture HPP have to overcome significant obstacles when trying to manage and handle life cycle information and knowledge about their product. No studies have been found in the literature regarding this case. In the following sections, the selection and deployment of a PLM for a VE to produce a machine tool under a special order is presented. The bottlenecks and strategies for addressing them are also explained..

4 Mechatronic Product Deployment Supported by a PLM in VE

The use of PLM in companies that manufacture consumer goods has become more common lately. While the application of a PLM system for virtual enterprises offers potential benefits, the issues of implementing a PLM in such a system have not been addressed in the literature. In the case of HPP development in VE, time and budget constraints limit the resources that can be allocated for training, acquisition of licensing or development of computer applications. In addition, while the interactions among design engineers, manufacturing engineers and suppliers is very intensive, it is also very brief, while the product is under development.

Development of HPP requires the configuration of a VE and the configuration of a PLM environment for each specific case. Criteria and architecture for the successful configuration of the VE and the PLM environment have not been defined. Figure 1 presents the tasks that a PLM supports for mechatronic product development: Knowledege and Information Management, Product Modeling and Simulation Tools, Supplier Management, Customer Needs, Design Development.

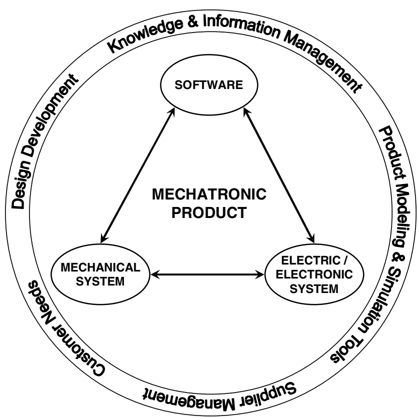

Fig 1. Mechatronic product deployment supported by a PLM. The characteristics of the PLM that are relevant to the development process are shown around the product.

High performance mechatronic products are complex devices that integrate mechanical systems, electrical / electronic systems and software. Referring to Figure 1, during deployment of a mechatronic product, multidisciplinary teams interact asynchronously to design, manufacture, test, transport and support the product. Timely and transparent information flow is critical to the success of this interaction. The implementation of PLM for these products consists of the administration of information and interaction procedures between the different disciplines in charge of the mechatronic product development.

An architecture for HPP is proposed, which integrates the following participants: customer, project leader, design cluster and supply cluster. This model is presented in Figure 2.

For all practical purposes, the Customer is the final user of the product and is responsible for providing all the information for product design and process. The Project Leader is responsible for generating a project plan, managing the project budget, selecting members of the VE, defining the infrastructure and the rules that govern the life of the VE and the relationships among its members during the project.

The Design Cluster is represented by three groups, one per discipline (mechanic, electric, software). Each one of the disciplines is responsible for selecting modeling and simulation tools to develop a modular architecture in the final product. Supply Cluster groups manufacturing and purchasing activities. Suppliers are responsible for helping in the selection and design process of the equipment.

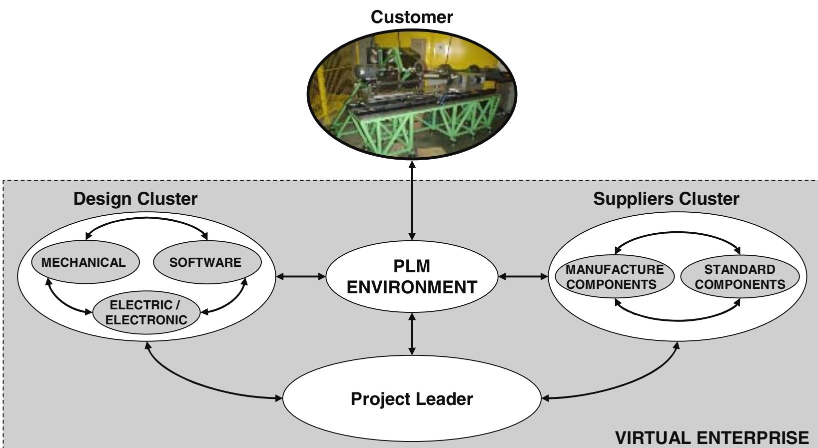

Fig. 2. Proposed model for PLM configuration in a VE for advanced mechatronic products. PLM activities are represented by the hollow arrows.

The unique conditions found in VE's that produce HPP are best illustrated schematically. Figure 3 shows a proposed model that integrates stakeholders, information and material flow in such a company, and supports the model described above. This model details the processes that take place within the PLM, that have been introduced in Figure 2.

As shown in Figure 3, the PLM process begins with a clear definition of a need in a customer environment. To begin the development process, information is transferred to the service supplier or VE. Job assignments for the different working teams are immediately defined. This triggers the emergence of smaller cycles of information and knowledge transfer.

The software team begins planning the code generation process by defining the tasks to be satisfied and how this code is going to interact with the hardware. The design process consists of defining a structure where the software modules will be implemented and defining the code tasks sequence to be executed. Definition of the modules for interaction between software and hardware, control procedures for I/O tasks and how the human interaction with the final product is achieved is also specified. Development implies the translation of the design process into a computer based language that has to be suitable for the Data Acquisition Card (DAC) selected. A testing activity provides feedback regarding software errors.

For the electrical team, a planning procedure at macro and micro electrical level is prepared to define the project objective and to establish relationships with the mechanical team for the implementation of the electromechanical systems. Common issues are: circuit design, electrical circuit protections, motors definition, etc. Information required for manufacturing or assembly of electric/electronic parts is delivered downstream. Electrical tests provide information useful for design improvement or reporting manufacturing errors. The final product of this team consists not only of information but also an electric/electronic part.

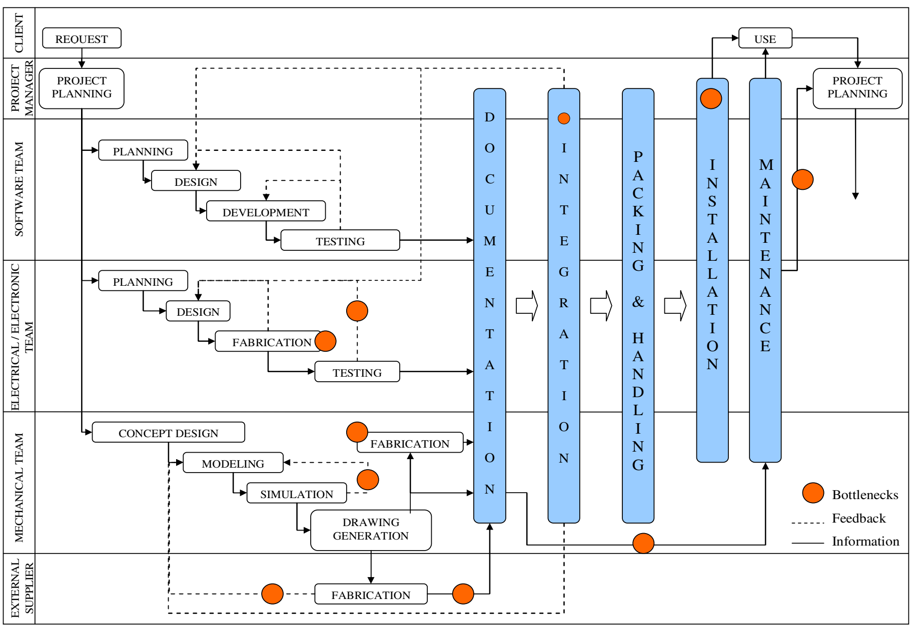

Fig. 3. Modeling stakeholders, and information and material flow in VE that produce HPP

The mechanical design process starts with a conceptual design activity performed by a group of engineers in charge of the definition of static and kinematics requirements followed by the definition of a general configuration. Components of the main product are precisely defined and assembled virtually in CAD software to ensure that parts fit together and product targets such as volume or mass are satisfied. The CAD model is then inserted into CAE tools for kinematics simulations and finite elements analysis when required to model performance and identify errors in design. Feedback information is adopted into the original configuration, to make adjustments in the design. When approved for manufacturing, CAD drawings of each component are generated and transferred digitally to suppliers. Throughout this process, information is compiled and managed to support product maintenance.

The final phase of fabrication requires the integration of the different modules. Once the product is assembled, packaging, transporting and installation in the customer's site take place. Feedback from these activities and the customer is used by the project manager to initiate a new product lifecycle for future updates of the product. In the case of HPP, in which the prototype is also the final product, upgrades are implemented directly on the prototype.

5 Application of the Model: Analysis and Discussion

The concepts developed in this paper were tested in a project to develop a high performance grinding machine tool. The customer was a company in the energy sector and was responsible for testing and maintaining the product after the development process. The first issue was defining the project leader. A Research Center was selected as the project leader because of its experience in project management and VE configurations. The Supplier Cluster was formed by two participants due to their physical proximity and resource availability. A supplier was responsible for the manufacturing and assembly of the mechanical product and a second one supplied equipments for the electric system and provided technical support during the selection process of equipment with special attention to delivery time and availability.

In accordance with the project plan and budget, a peripheral target was to configure a PLM environment in a short period of time and at low cost. Ideally, such system would not require additional licensing, training or an administrator to manage the environment. At the beginning of the project and for the purpose of Process Coordination, a freeware tool for project management was selected and made available on Internet for the project members of the VE. All users had login and passwords and they could access the application to learn about the project plan. The site displayed project progress and allowed for the display of communications and comments from the different stakeholders. The bottlenecks and their solutions that arose during this project are presented in Table 1.

The table summarizes the bottlenecks that were found in the development process, and how they were addressed by the PLM system. Three types of bottlenecks were found: Type I refer to information flow, Type II is concerned with registration of information, and Type III represents material flow issues. Information flow bottlenecks refer to inconsistencies in information interchange between different participants in sequenced stages having multiplicity of product versions. Registrations of information bottlenecks are those where information is not properly documented or registered making difficult to track changes and enhancement of future versions. Material flow issues refer as inconsistencies between the information provided by third parties and the physical part obtained delaying assembly and installation stages.

Table 1. Typical bottlenecks and solutions found during the project

Bottleneck	Consequence	Type	Solution
Multiplicity of product versions in design stages	Difficult interaction between disciplines	I	Implementation of a commercial PDM (Product Data Management)
Information transfer from the OM to the modeling or design activities.	Delays in updating of versions	I	Increase communication channels: E-mail, chat, forums.
Unrecorded updating of versions in designing stages	Difficult maintenance activities	II	Workflow procedure for tracking changes.
Incomplete Documentation about problems encountered by during fabrication of outsourced components	Increase maintenance costs and hinders repair parts availability	II	Hand notes feedback on manufacture drawings.
Deficient maintenance reporting	Avoids enhancement of future versions of product	II	Registering performed maintenance activities.
Increased integration time of multidisciplinary components (mechanical, electrical and software)	Affects project schedule	III	Modularity added in design stages.
Product integration of Outsourcing Manufacturer delayed by supply parts	Delays assembly of modules. Modifies project schedule	III	Substitution of materials and components to equivalent parts from local suppliers.
Working space preparation by the customer for installation	Delays final product installation.	III	Integrate customer to previous stage of product.

The Solutions column represents actions that were taken, or actions that have been proposed to eliminate each problem. It is important to note that one of the bottlenecks was not fully addressed: product maintenance beyond installation. This is caused by the fact that once the product is delivered, the association that produced it is dissolved. In this particular case, maintenance was expected to be handled by the customer. This was possible because the customer carries a maintenance department. In addition, the customer appointed a technician to be part of the machine's development process. However, after installation of the product, the technician left the company and the product's performance dropped significantly. It was realized that information about the products design was not totally sufficient and readily available to the customer. In essence, the PLM did not provide for proper management of the information associated with the practical experience about the product's use.

Referring to Figure 1, in general all the PLM tasks were implemented successfully except for one: Knowledge and Information Management about the product's performance. For the PLM system to be implemented successfully in a VE for production of HPP, models, tools and procedures must be developed to guarantee proper management of Knowledge about the product's use, which was as much a limitation of the PLM used, as the procedures that were in place to capture this knowledge.

6 Conclusions and Future Work

This paper described the experiences obtained during the selection and configuration of a PLM environment for machine tool design and construction in a virtual enterprise. A model for the deployment of the PLM was proposed and tested. The scope of the PLM environment developed was: Cooperative Design, Knowledge management, Product Modeling, Product Simulation and Analysis, and Management of Customer - Supplier Interactions. Overall, the system was successfully implemented, except for management of the knowledge associated with the product's performance. The integration of more complex and expensive PLM applications, the development of proper procedures, and their impact on the business model of the VE should be analyzed in future cases.

Acknowledgements

The authors wish to acknowledge the support of the Research Chair in Mechatronics and Intelligent Machines at ITESM Campus Monterrey in the preparation of the manuscript.

References

1. Hahn, A. "Integration and Knowledge Management Platform for Concurrent Engineering". Proceedings of the 9th International Conference on Concurrent Enterprising pp. 153-160, ISBN 0-85358-119-3.
2. Amit, Sharma. "Collaborative product innovation: integrating elements of CPI via PLM framework". Computer-Aided Design 37 (2005) 1425–1434.
3. Sudarsan R., Fenves, S.J., Sriram, R.D., Wang, F. "A product information modeling framework for product lifecycle management". Computer-Aided Design 37 (2005) 1399–1411.
4. Atkinson, David., Al-Ashaab, A. "Strategy and Direction of Global New Product Introduction and Development within the Automotive Industry". Proceedings 9th International Conference on Concurrent Enterprising, pp. 73-77, ISBN 0-85358-119-3.
5. Roller, Dieter., Mešina, M., Lampasona, C. "Concurrency Control and Locking in Knowledge Base for Rapid Product Development". LNCS, Vol. 3675, Sep. 2005, pp. 79 - 85
6. Camarinha, L.; Afsarmanesh, H. "The emerging discipline of collaborative networks". Virtual Enterprises and Collaborative Networks. IFIP 18th World Computer Congress. Touluse, France. August 2004. pp 3-16.
7. Aca, Joaquin, "Reference model and methodology to configure/reconfigure integrated product, process and facility development processes", Master Thesis, ITESM, 2004

An Application Service Provider (ASP) Based Project Management System

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Abstract. The construction industry has continuously tries to improve the productivity of construction projects through Information Technologies (IT). It is not easy for the subcontractor to apply IT towards their projects due to the smaller scale of operations and the problem of the cost of equipment, programmer, and operator to introduce IT. To overcome the high investment risk we need a device. This paper presents IT outsourcing for subcontractors that effectively accommodates the demand of project information management. The purpose is the conceptual design of an Application Service Provider (ASP) based project management system. This paper offers the conceptual proposal for the mutual communication and information collection between the construction industry subjects through collaboration and the coordination.

1 Introduction

Computer integrated construction (CIC) and automation were the main issues for couple of decades. More recently it is, Project Management Information System (PMIS), which integrates all applications related to the project, systematically manages information on the project life cycle and leads to smooth communication. PMIS based construction industry aims to optimize the value chain of companies. Using it they can control the project information and the historical data. Therefore, the choice of project management tools and systems used is an important factor in improving the productivity and core competencies of a construction project. Construction industries need systematic management tools and communication systems such as PMIS. The Korean government is driving the Construction Continuous Acquisition & Life cycle Support (CALS) as the strategy to be adopted for change of environment under information and knowledge intensive. Due to lack of information management system, Subcontractors experience difficulties. Apart from developing a model PMIS for subcontractors (to be evaluated), the existing ASP based system comprise a simple document management function called EDMS.

Y. Luo (Ed.): CDVE 2006, LNCS 4101, pp. 327 – 335, 2006.

Subcontractors are unable to invest directly in information infra because they typically have more inclination for field work (unlike general contractors).

The current study in to management of project and information have certain limitations such as, the technical and administrative unification has never been completed, it is totally focused on the management system of big projects from the point of view of orders, there is in fact no conception of a management system for subcontractors and small projects, there is a lack of analyses about cases of success or failure, as it is at the beginning of project management systems based on internet, the conception for collaboration between the main bodies joining in projects is still incomplete, there is no proper method to make administration of information more efficient. Therefore we need to approach the system for inducement of information intensive subcontractors and study the models that can administer the project information which needed by the contractors for small projects, which will also harmonize the conversations between those who join in the project.

2 ASP and Project Information Management System

In the information part Centralization, Specialization and Standardization for information management have been continuously developed in every industry region. Even though there are lots of trials of information classifications in the construction field, but useful standardization has never been emerged. Standardization of information and its classification are essential in project and development of the company, its efficient management will reduce the cost.

2.1 Information Intensive e-Business of Subcontractor

Information and e-Business requires digitization of information, purchase, and contract. In addition it will help the company to survive and even gain competitive power by increasing production. As seen on Fig.1. It can be the main body for the construction industry.

e-Project management system: e-PMS is an internet based system of real time management. The productivity and management of project needs to be part of the e-Business for project based industry such as construction.

e-Procurement: It is a part of electronic procurement that includes bidding, cost estimating, contract, and material supply. Construction CALS is a representative sample of public section in Korea. Korean government is driving an electronic procurement system. It is important to reduce the procurement cost and time.

e-Information Management: It is an efficient plan of managing digitalized information. In a situation of progressive information intensification, the efficient management acts as a tools for risk, claims and swift decision making.

IT Outsourcing: It is a mean of procuring information infra. Companies that try to develop their own IT have lots of risk on direct investment construction companies need to consider off the shelf, partnered systems, and lease systems such as ASP on the way to an efficient solution.

2.2 ASP (Application Service Provider)

An application service provider is a company that offers individual or enterprises access over the internet to applications and related services that would otherwise have to be located in their own personal or enterprise computers. Sometimes referred to as "apps-on-tap" ASP services are expected to become an important alternative, not only for smaller companies with low budget for information technology, but also for larger companies as a form of outsourcing. Early applications include, remote access serving for the users of an enterprise, off premises local area network to which mobile users can be connected, with a common file server, specialized applications that would be expensive to install and maintain within own company or on own computer.

Fig.2. displays an ASP business model. ASP makes and sells Application software and solutions. In addition, as a kind of lending firm that can take fees for the service on the internet, it can be understood as a kind of business or outsourcing of the application. Its basic structure is to add a host software application to company's server for users to connect via internet. ASP requires several techniques such as networking, service, and application. It may be hard to classify ASP exactly because it covers a whole range of internet business such as IDC, network service. For example a network company is classified to be the main communication and the IDC Company as subsidiary.

ASP is also classified as a software lending business so that it can be protected by law like a subsidiary communication company. Generally ASP providers cooperate with each other because they have trouble in providing the services independently. IDC, NSP (Network Service Provider) and application provider cooperate with each other closely, also ongoing support and security provider cooperate with respective service providers. According to the needs of business, an e-mail service (which is rather simple), ERP, PMIS, CRM, SCM, KMS (which are rather complex) could be utilized. There are many ASP providers possessing the monopoly of special purpose application (Vertical ASP) so PMIS outsourcing may be the proper system for subcontractor. Table 1.Shows the suitability of quality, cost, labor control, and form of system structure evaluated from the construction company's standpoint. Introduction of ASP is more profitable than self development in terms of constructing

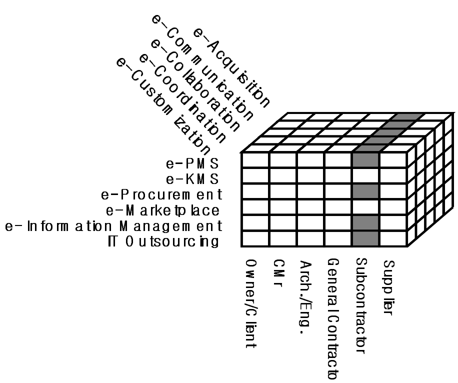

Fig. 1. e-Business matrix

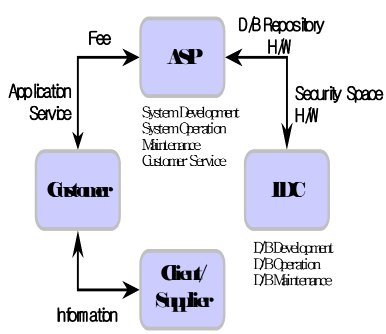

Fig. 2. ASP Business Model

Table 1. Feature of system development types for subcontractor

Area		Internal Team	External Team (SI/IT)	Partnered System	Off the Shelf	Another company System	ASP
System Quality	Development Time	-	-	△	◎	◎	◎
	Satisfaction	△	△	△	-	-	△
	Optimization	◎	◎	○	△	-	△
	Translation	◎	◎	○	△	-	○
	Quality	△	○	○	△	△	△
Cost	Initial	-	-	△	-	-	◎
	Developing	-	-	△	△	△	◎
	Maintenance	-	-	-	-	-	◎
Human Resource	Initial	-	-	△	△	△	◎
	Developing	-	-	△	△	△	◎
	Maintenance	-	-	-	-	-	◎

◎: Most Suitable, ○: Suitable, △: Normal, -: Not Suitable

costs and human resources even though the quality becomes rather lower. Other methods may have merits or demerits but these require constant cost and expense, this cause's financial problem. This paper recommends the introduction of ASP for information intensive constructors. In general, as the number of full timers becomes over 10 it recommends the use of the application based on ASP. ASP is apt to reduce the expense of computerized system formation by outsourcing the IT task. But it is still the introduction stage of this technology, so there are a limited number of business models for particular business field and the distribution of ASP is also low. The demand for ASP will increase constantly because small and medium sized Enterprises in traditional part have been required to be computerized. Therefore, the system based on ASP will be profitable for the construction industry because it makes possible the standardization of business and information. The model this investigation tried to display is based on ASP.

3 Case Studies of C/S (Client/Supplier) Based and ASP Based PMIS

Case 1 C/S based PMIS of Enterprise Formation: As a part system of EP (Enterprise Portal), it consists of Just in time (JIT) control techniques, integrated application of work security work control, and decision making process based on real time data. For the joint ownership of the information with the project related company and for the improvement of efficiency through the reduction of the unnecessary processes, it intends to use the communication system and material management bar coding. It provides the major functions such as personal control, drawing up the daily reports, drawing control, motion and image system. This consists of running a self sever at the site where the information giver inputs all the information directly.

Case 2 C/S based PMIS of single Project Formation: It is a system developed by the construction management entrepreneur and set up for the single construction work aiming to jointly own the information sharing among the , construction management entrepreneur and the construction worker/company/firm. The basic environment (constructed using C/S with PSDN (Packet Switch Data Network)) Data is transmitted one time every day. The composing Modules consists of 10 kinds of standardized modules such as present business status, process management, expense management, quality management, design management, purchasing management, construction work management, security management and document management. Since it is neither the internet foundation nor real time environment, it is weak in the communication function and run according to the point of view of management.

Case 3 ASP based PMIS of Multi Project Formation: The enterprise providing the major ASP based project management system using EDMS document management as the basic axis provide the module which enables one to make review and management of the design drawing through the drawing management of catalogue patterns. Also in the organization management level they provide basically the grouping function per business affairs and the function enable to control the personal daily schedule and document management. In some products a messaging function and video conference system are provided but the video conference system was found to be insufficient in its practical effect. Project.net is the system provided by Bidcom known as major construction related Internet enterprises and is intended for the project collaboration and e-business. Instead of a simple system there are 3 kinds of modules, such as ProjectNet Docs, projectNet LT and ProjectNet Process supplied for general projects as well as for construction. 500 individual controlled projects were examined and the important customers like BAA, McDonalds, BT, GlobalSwitch, Bechtel and Laing reported to perform the part of the project using Project.net. The readymade management, purchasing management, cost management and the practice information management is served, about 250 standard documents are provided and the synchronization is preceded using daily work schedule management, proceedings management and PDAs. Also the function to make copies and to make use of the past project system is provided in order to assist in undertaking similar projects. The security structure has three step security networks and another independent security system is run at the data center.

4 Strategy of ASP Based PMIS for Subcontractor

The system for project management needs various applications. It needs a platform to efficiently operate the applications; also, these applications need to be flexibly controlled. Internet based system has not yet reached the phase of practical usage for the whole construction industry. Most of the project management systems among project participants are not real time systems; they are PSDN based systems, which exchange data and information at the appointed time. The current framework of developed and developing C/S systems is divided into service module, information module, information management, system infra, and information source. Some systems head toward intranet or internet and furnish information module that classifies the works for functional types. It may even use the module of weak utility of the system on project types because the information module is a conventional framework. Service module offers the limited information management and work coordination of internal organization. The large private & public companies are developing closed internal system (Intranet-based) for project management, which include KMS (Knowledge Management System) and ERP (Enterprise Resource Planning), called Enterprise Portal. This kind of system excludes other project participants. This paper proposes an improvement plan; Fig.3.shows the framework.

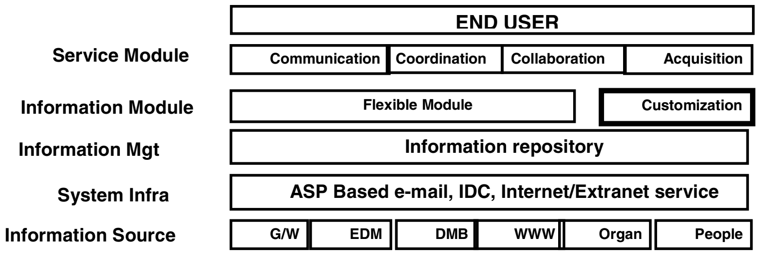

Fig. 3. Framework of SubPMIS

The conceptual model is based on Extranet-based open system, an extension from the conventional framework of information module and limited service module. The information module is endowed with flexibility instead of the module of conventional framework, and the system platform can be operated to selectively set optimal module for a project. Since the service module heads toward collaboration, it is able to expend internal and external communication. At the point of risk management, it offers a module to reduce decision-making time through coordination. Finally, acquisition module induces digitalization of project information through gathering new IT by means of PDA (Personal Digital assistant).

5 Information Repositories and Information Module

An Information repository is a kind of database, it means not simple repository of data, but a managerial repository that stores required project data such as standard document, manual, and historical data. Table 2 shows the items of external entities and data stores designed through DFD. The external entities are not all of project participants. The Data stores compose code D/B, standard work process, historical D/B, project information D/B, and standard document D/B, but it is managed as an integrated D/B by IDC (Internet Data Center). Also, the company must device IBS (Information Breakdown Structure) of user subcontractor by itself to efficiently operate the information repository. This is basic information to easily acquire the necessary information through IBS. Fig.4. shows the connection of system for subcontractor proposed by this research with general contractor. Management areas of subcontractor’s system are divided according to the project Phase. Support of the existing functional system is merely a document management system or a development of the conventional framework. Both of these, however, are unsuitable to the subcontractor. It, also, properly includes the license for the use of cost estimating and scheduling application that can be had 'off the shelf'. The important point is not the conventional framework, but customization of module to coincide with company and project situation. Project Format (Customization) changes along with the change of contract and project type, it needs a flexible system to optimize the construction project. Coordination supports “Team Grouping” and “Scheduling/ Calendar”, it is a module for integrating each system.

5.1 Service Module

Communication (Internal Communication)**:** IT of the communication module is based on Intranet, and expended GroupWare offers Electronic Decision, e- Mail, Personal Time Management, and Information Sharing.

Table 2. Data store and External Entity of SubPMIS

Section		Items
External Entities	CEO	Chief Of Executive
	Client	Owner, G/C
	Supplier	Material, Equipment
	Market	Market Cost, Environment
Information Repository	Code D/B	WBS, CBS, IBS, Material, Equipment
	Standard Work Process	Standard Schedule, Workflow, To Be List, Work Package, Area Survey Guidelines
	Historical D/B	Cost, Schedule, Agreements, Drawing, specification, Productivity, Quality Test Data, Material, Equipment, Information Plan, Acquisition Plan, Others
	Project Information D/B	Cost, Schedule, Agreements, Drawing, specification, Productivity Quality Test Data, Photo, Material, Equipment, Performance Reports, Periodical Reports (Daily, Weekly...), Information Plan, Acquisition Plan, BOQ, Time Sheet, Payment Report, Others
	Standard Document D/B	Quotation, Invoice, Check List, Agreement, Contract Force Report, Periodical Report, BOQ, Time Sheet, Payment Report

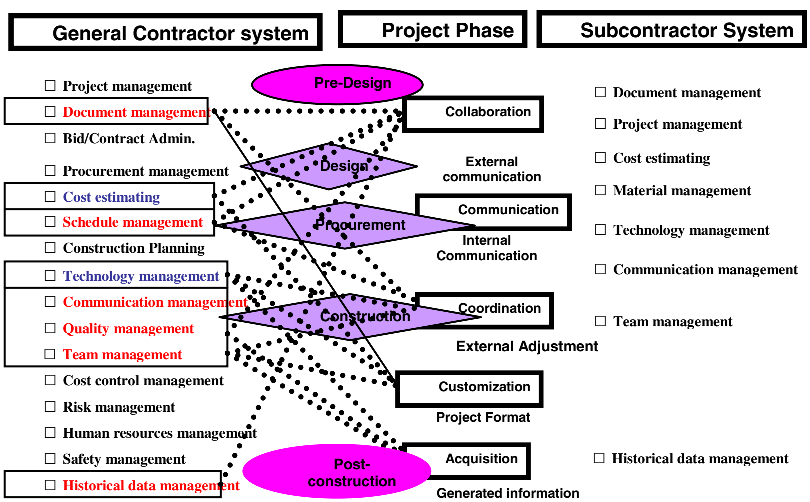

Fig. 4. Relationship Value chain with System Modules of Subcontractors

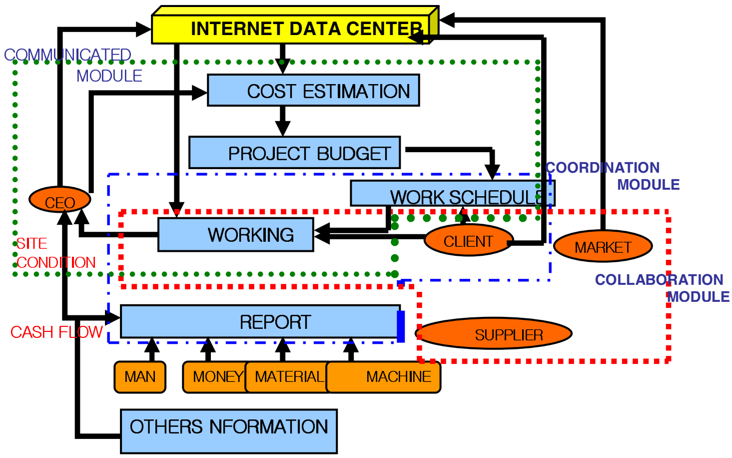

Fig. 5. Business Model of SubPMIS

Collaboration (External Communication)**:** It is a part of communication within project Participants. IT of the collaboration module is based on Extranet: An Extranet can be viewed as part of a company's Intranet that is extended to users outside the company, and composes EDMS and viewer (CAD or word files) etc. to share the information. The document management connected with general contractor's system is intended for handling electronic documents. It is used for cost control and scheduling.

Coordination (External Adjustment)**:** Due to the fact that construction projects have comparatively complicated decision-making line, external adjustment is able to do the decision coordination and reduces the decision-making time among project participants. The reduced time leads to reduced cost and has the effect of preventing claims and dispute. To connect with general contractor's system, it serves efficient work on set of 'Workflow' and 'To do list'.

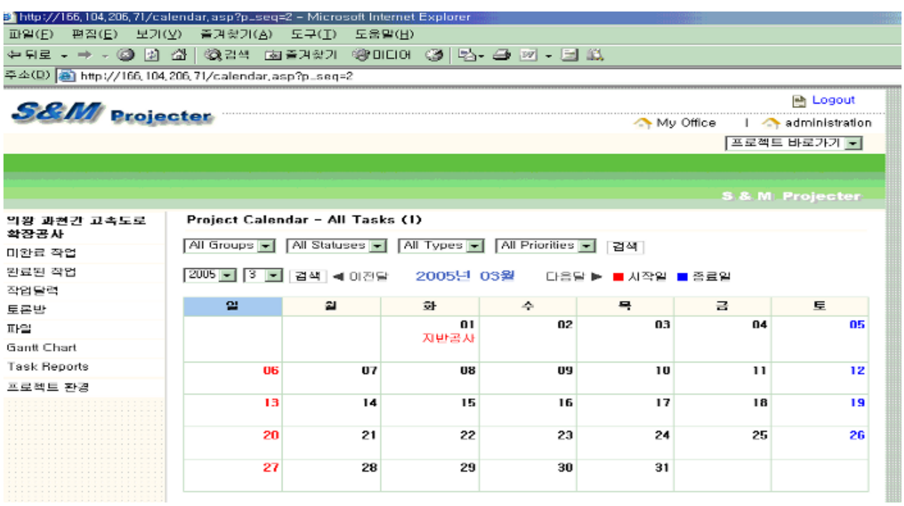

Fig. 6. Constructed PMIS

Acquisition (Generating Information)**:** The generation of information as well as Information management is an important element. Fig.5. shows a business model proposed for SubPMIS for subcontractor. To increase the effectiveness of a computerized system, it is important to digitalize project information. It is possible to acquire information on the material, equipment, and labor management using tools, such as 'Bar-code' and 'RFID'. New digital IT such as PDA, are handy during site inspection and utilization of information. The record of construction progress can also be captured by digital camera and digital camcorder .The Project Performance step will check the suitability of technique, construction method on the ground of standard Work Process, estimation, purchase of material, equipment with Collaboration Module and Coordination Module. It also saves the information of Acquisition Module to Project Information D/B and other information certified by Clients to Historical D/B. Fig.6. Shows constructed PMIS that is an example PMIS for subcontractor. To connect with general contractor's system, the acquisition is a major part of information management. The system should be able to capture and transmit in real time information on generating phase of information by general contractor.

6 Conclusions

The introduction of ASP based PMIS is necessary as an overcoming means to protect the subcontractor business. ASP based system for subcontractor is proposed based on subcontractor business, work process and the information stream. Some of its benefits includes: Getting out of the existing stiff patterns, aiming at the Customization, overcoming the simple communication based system, granting the flexibility to the Module. It can be proposed as the solution to the current method against the construction CALS and EC also it reduces the risk for the investment. The H/W part is limitedly treated. The internal information environment improvement with the S/W which each company should be ready for, will be the key point to become informative. The precedence of the work standardization and to construct the various kinds of applicable code systems will become informative in the effective and efficient subcontractor business

References

1. Barry, Ann Marie, "Web Management and Integrative Procurement Communication", Project Management Journal, PMI, 1999
2. Cherry Tree & Co., "Application Service Providers"(ASP) Sportlight Report, 1999
3. Forbes, Donald E., "Project Management Information Systems", Transportation Research Board, 2000
4. Issa, Raja R. A., "Web-Based Construction Document Processing VIA Malleable Frame", Journal of Computing in Civil Engineering, July 2001, 157-169
5. Karen, A. Brown., "Developing Project Management Skills: A Service Learning Approach", Project Management Journal, PMI, 2000
6. Liberatore, Matthew J., "Project Management in Construction: Software Use and Research Directions", J. of Const Engg Mgmt, March/April 2001

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