Mehdi Snene
Jolita Ralyté
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LNBIP 82

Exploring Services Science

Second International Conference, IESS 2011
Geneva, Switzerland, February 2011
Revised Selected Papers

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Lecture Notes in Business Information Processing 82

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Preface

Services represent the fastest growing sector of the economy in industrialized nations. Services science, introduced by IBM in 2002, arises from the rapid development of services across the industrial world and the need to analyze and study the organization, deployment, maintenance and operation of services, where particular attention is given to the IT-based and IT-supported types. Services science represents a transdisciplinary approach to the systematic innovation in services systems, integrating management, social, legal and engineering facets of services. It aims to address the theoretical and practical aspects of the challenging services industry and its economy.

The second edition of the International Conference on Exploring Services Science – IESS1.1 – was held at the University of Geneva, Switzerland, during February 16–18, 2011. Built on the previous edition and the growing momentum in this emerging and exciting discipline, IESS further strengthened its position as an academic conference focusing on the exploratory aspects surrounding services science. Acknowledging the relative recency of this area and its essential transdisciplinary setting, the goal of IESS 2011 was to offer academics, researchers and practitioners of all disciplines this exploratory outlet to communicate and share their results. To achieve the best possible mix of disciplines and approaches, the call for papers kept its structure based on research topics and contexts of contribution. The research topics were structured around the service development lifecycle including: service innovation, service exploration, service design, service engineering, and service sustainability. The contexts of service contribution reflected the transdisciplinary atmosphere of services science and the particular role of information technology (IT) within them and included: application sectors (e.g., public administration, legal, food, entertainment, finance, healthcare, etc.), IT (e.g., mobile, SOA, social networking, etc.), foundations (e.g., evolution, methods, economics, ontologies, etc.), and governance and management (e.g., HR, marketing, strategy, innovation, etc.).

The 19 papers included in this volume were carefully selected by the international Program Committee out of 47 submissions. Seventeen full papers and two short papers were presented during the conference. Given the novelty of the domain of services science we would like to acknowledge and thank all the authors for their contributions and their trust and the Program Committee members for their valuable and professional work in reviewing the submissions and crafting the program of this second IESS conference.

The conference featured the keynote presentation of Ahmed Seffah from Concordia University, Canada, on “The Human/HCI Side of Services Science, Engineering and Management: On the Challenges Towards a User Quality Model of Services.” After the conference, a half-day Societal Forum was held and addressed issues in the areas of field intelligence for services innovation.

We would like to thank all the participants, the invited speaker and the organizers for their valuable contributions. In particular the Conference Chairs: Eric Dubois (Centre Henri Tudor, Luxembourg), Dimitri Konstantas and Michel Léonard (University of Geneva, Switzerland); the Organizing Committee: Giovanna Di Marzo Serugendo, Jean-Henry Morin, Wanda Opprecht, Jolita Ralyté, and Mehdi Snene (University of Geneva), and all the volunteers: Marie France Culebras, Aziz Khadraoui, Laurent Moccozet, Jean Marc Seigneur, Xavier Titi, Alfredo Villalba Castro, Katarzyna Wac, Carlos Ballester Lafuente, Akla-Esso Tchao (University of Geneva).

We wish you a pleasant reading and a fruitful use of these research results in your research and applications.

April 2011

Mehdi Snene
Jolita Ralyté
Jean-Henry Morin

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Dimitri Konstantas	University of Geneva, Switzerland
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Towards Hierarchical Modeling and Analysis of Web Services Choreography

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Abstract. Web services choreography as an important approach of composing web services describes the global model of service interactions among a set of participants. Modern software design paradigms promote hierarchy as one of the key constructs for structuring complex specifications. In development of complex service-oriented systems, hierarchical composition in which a composed service could also be composed into a high level system model is a great approach for system modeling, and behavioural equivalence which checks whether two choreographies in different levels describe essentially the same behaviour is an important aspect of system verification. This paper proposes a formal modeling and analysis approach for hierarchical web services choreographies. A formal language **Chor** which originates from WS-CDL describes dynamic behaviour of choreographies and a novel bisimulation is used for analyzing behavioural equivalence of **Chor** language. We introduce a hierarchical model for describing and analyzing complex choreographies. Abstract choreographies can be refined to detailed models and external and observable behaviour be preserved equivalently. Our approach can also be extended to formally analyze hierarchical and global interaction models for general concurrent systems.

Keywords: Web Services Choreography, Behavioural Equivalence, Bisimulation, Hierarchical Model, Refinement.

1 Introduction

Web services technology that is an system implementation approach for Service-Oriented Computing(SOC) [1] has been becoming more and more important in recent years. Web services composition refers to the process of combining web services to provide more value-added services, which has been accepted as an effective approach in supporting enterprise application integration. One approach of composing web services is web services choreography [2] which describes peer-to-peer collaborations of participating services by defining, from a global viewpoint, their common and complementary observable behaviour, where ordered message exchanges(or interactions) result in accomplishing a common business goal. The interactions between two services are observable behaviour of them.

M. Snene, J. Ralyté, and J.-H. Morin (Eds.): IESS 2011, LNBIP 82, pp. 1–15, 2011.

The Web Services Choreography Description Language (WS-CDL) [3] is an typical XML-based choreography language.

Because the global viewpoint is easier to be understand for developers and conformances among local view models generated from choreographies are preserved automatically [4], choreography provides a more efficient and dependable system modeling approach than orchestration [2] or traditional process calculus [5] which are from local viewpoint of a service or process. The difference between this two viewpoint is that input/output communications are primitive actions in local viewpoint model, while interactions in global viewpoint. An interaction consists of an output action on a service and an input action on another service.

Modern software design paradigms promote hierarchy as one of the key constructs for structuring complex specifications. Formal semantics leads to definitions of semantic equivalence (or refinement) of specifications based on their observable behaviours, and compositional means that semantics of a service can be constructed from the semantics of some other services. Such formal compositional semantics is a cornerstone of concurrency frameworks such as CSP [6] and Pi Calculus [5], and is a prerequisite for developing modular reasoning principles such as compositional model checking and systematic design principles such as stepwise refinement. In development of complex service-oriented systems, hierarchical composition in which a composed service could also be composed into a high level system model is a great approach for system modeling, and behavioural equivalence which checks whether two choreographies in different levels describe essentially the same behaviour is an important aspect of system verification. Web services choreography models systems by services and their interactions and the services could also be refined to detailed choreography models. The existed behavioural equivalence checking approaches are almost based on local viewpoint models. By the reason of different primitive actions, they could not be applied directly on web services choreography.

This paper proposes a formal modeling and analysis approach for hierarchical web services choreographies. We introduce a formal language **Chor** to describe dynamic behaviour of choreographies. **Chor** originates from WS-CDL and contains basic activities and structural activities in WS-CDL. A novel bisimulation, τ-bisimulation, is proposed to analyze behavioural equivalence of choreographies described by **Chor** language in global viewpoint. This bisimulation considers that the *Silent* activity τ in **Chor** performs an action behind the scenes and will not affect the external behaviour. We introduce a hierarchical model for describing and analyzing complex choreographies. Abstract choreographies can be refined to detailed models and external and observable behaviour be preserved equivalently.

The contribution of this paper includes: (1) a formal language and its operational semantics for web services choreography which is compatible with WS-CDL language. (2) a novel bisimulation for behavioural equivalence in global viewpoint. and (3) hierarchical model of web services choreography which suitable for complex service-oriented systems, and analysis approach of reasoning about refinement of this hierarchical model. It is notable that our approach could also be extended to formally analyze hierarchical and global interaction model for general concurrent systems.

This paper is organized as follows. In Sect.2, we provide some related works. The preliminary, a brief introduction of WS-CDL language, and our idea is presented in Sect.3. The language **Chor** and its semantics are introduced in Sect.4. In Sect.5, we discuss behavioural equivalence of **Chor** language based on the τ-bisimulation. The hierarchical model of web services choreography and its analysis approach are presented in Sect.6. Finally, Sect.7 concludes this paper.

2 Related Work

Process algebra [5] is established on definition of process which describes observable behaviours of one computing node or a composition of several nodes. In general, it focuses on local behaviours of different processes. Whereas choreography considers interactions among different processes. Therefore, special process algebra should be established for web services choreography, and this paper try to accomplish the goal.

There have been some works on formalizing choreography specifications. A theoretical model of choreography has been proposed by Qiu et al [7]. A language for choreography and a language for roles are introduced. The focus of their work is the projection from choreography to local behaviours of roles. Trace equivalence which is a basic kind of behavioural equivalence is dealt with partially. Another great research on web services choreography is the global calculus in communication centred programming theory [4,8,9]. It is the theory foundation of WS-CDL and focuses on programming paradigm and implementation instead of verification. Especially, typing mechanism is used to present the type structures and type reasoning for the global calculus and end-point calculus based on session types [10]. Guidi [11] has proposed a language for SOC including service orchestration and choreography. Their bipolar approach addresses system design issues by exploiting choreography and orchestration languages related by means of a mathematical relation called conformance. Behavioural equivalence is not discussed in these papers.

One noteworthy approach for verifying web services choreography uses model checkers for concurrent systems to verify correctness properties of local behaviours which are generally projected from choreographies. Li. et al [12] presents the semantics of WS-CDL in terms of process algebra CSP [6], and then maps WS-CDL instances to CSP processes for verification using process algebra to find inconsistency. Some researchers [13,14] translate WS-CDL to Promela language in SPIN [15] and verify Lineal Temporal Logic(LTL) properties by SPIN model checker. These approaches enable design time or static validation and verification of choreographies to ensure logical correctness properties such as livelock, deadlock, and leak freedom, or to ensure that the runtime behaviour of participants conforms to the choreography plan. Moreover, functionality verification which checks whether a choreography system exhibits expectedly complex behaviours is also another most important aspect of correctness of choreographies. This functionality verification is the goal of our paper.

3 Overview of WS-CDL and Our Approach

The overview of web services choreography and WS-CDL language [3] is presented in this section, followed by overview of our approach based on WS-CDL.

The purpose of the WS-CDL is to define multi-party contracts, which describe the externally observable behaviour of web services and their clients (usually other web services), by describing the message exchanges between them. A WS-CDL choreography description is contained in a package and is essentially a container for a collection of activities that may be performed by one or more of the participants. There are three types of activity in WS-CDL, namely control-flow activities, workunit activities and basic activities.

The control-flow activities include sequence, parallel and choice. A *sequence* activity describes one or more activities that are executed sequentially. A *parallel* activity describes one or more activities that can be executed in any order or at the same time. A *choice* activity describes the execution of one activity chosen among a set of alternative or competing activities. A workunit describes the conditional and repeated execution of an activity. Basic activities describe the lowest level actions performed within a choreography, including *Interaction*, *NoAction*, *SilentAction*, *Assign*, and *Perform*. Interaction is the most important activity in WS-CDL. An interaction activity may be composed of: (1) the participant roles involved; (2) the exchanged information and the corresponding direction(s); (3) the observable information changes; (4) the operation performed by the recipient. The information exchange type of interactions is described by the possible actions on the WS-CDL channel, which falls into three types: request, respond, or request-respond. According to the exchange type, there are three kinds of interactions. The operation in an interaction activity is performed after the request (if there is one) and before the response (if there is one).

For complex service-oriented systems, the flattened model for system description will be too complicated. The hierarchical model is a feasible approach to reduce complexity. We design a hierarchical model for web services choreography as in Fig.1.

Roles are connected via directed channels on which roles interact with each other. A choreography on one abstract level(for instance *level n*) could be refined to a detailed choreography that is described on a low level(*level n+1*). The choreography in level 0 is the top abstract of a system and is relatively simple. As the level increases, choreography will gradually become detailed and complex. The refinement of a choreography means that one role in high level could be implemented as a *Image* in the low level choreography. A image is a part of a choreography. For instance, the role r_{14} is refined to a image that consists of roles r_{27}, r_{28} and r_{29}. In this refinement, the external channels and interactions of a role must be preserved. In other words, there must be two same channels in *level n+1* between the two images of roles r_{11}, r_{14}, and interactions between these two images must be same to interactions between r_{11} and r_{14} in *level n*. Channel preservation is relatively simple by the reason of their static structure, while there are difficulties in preservation of dynamic interactions.

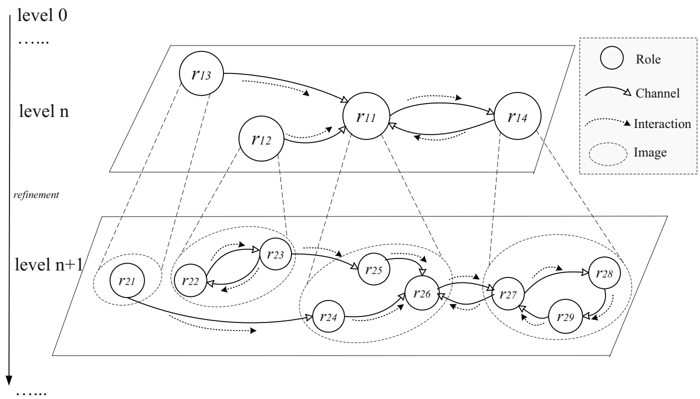

Fig. 1. Hierarchical Model of Choreographies

To verify equivalence of observable behaviours between choreographies in two neighbouring levels, activity traces semantic of choreography should be given. We use **Chor** language to describe choreographies and adapt bisimulation as basic approach for analyzing behavioural equivalence between **Chor** documents. Based on this general bisimulation of **Chor**, we need a technique to support checking whether choreographies in different levels are behavioural equivalent, because these choreographies have different abstract granularities. Thus, a behavioural mapping is designed to transform a detailed choreography in low level to an abstract choreography in high level by considering roles in images as internal roles and interactions among internal roles as internal activities. Then, this transformed choreography can be checked equivalently with original choreography in high level.

To support hierarchical modeling, a hierarchical choreography model is proposed. We are concerned with two distinct notions of hierarchy. Static structure of choreographies is focused on roles and channels among them. In architectural hierarchy, static structure of choreographies are considered. In behavioural hierarchy, the behaviour of choreographies is described by **Chor** language. Hierarchical choreographies are connected by refinement relations. Therefore, hierarchical choreography models will construct a tree. Behavioural equivalence among choreographies in neighbouring levels and soundness of refinements can be analyzed.

4 The Language Chor

In this section we define a small language **Chor**, which describes behaviour of web services choreography. We present the syntax and operational semantics of **Chor** that are foundations of behavioural equivalence.

4.1 Syntax

The syntax of **Chor** language is defined as below. This syntax accords with basic and control-flow activities in WS-CDL.

Definition 1. *Syntax of* **Chor** *language:*
BASIC ACTIVITY:

$$\begin{array}{rlr} a ::= & r_a \rightarrow r_b(c, x, y) & (\text{INTERACTION}) \\ | & \tau & (\text{SILENT}) \\ | & 0 & (\text{INACTION}) \\ | & r[\![x := y]\!] & (\text{ASSIGN}) \\ | & \mathcal{A}(y_1, ..., y_n) & (\text{PERFORM}) \end{array}$$

CONTROL-FLOW ACTIVITY:

$$\begin{array}{rlr} \mathcal{C} ::= & a & (\text{BASIC ACTIVITY}) \\ | & \mathcal{C}_1 ; \mathcal{C}_2 & (\text{SEQUENCE}) \\ | & \mathcal{C}_1 \parallel \mathcal{C}_2 & (\text{PARALLEL}) \\ | & \mathcal{C}_1 + \mathcal{C}_2 & (\text{CHOICE}) \end{array}$$

DEFINITION:

$$\mathcal{A}(x_1, ..., x_n) \stackrel{\text{def}}{=} \mathcal{C} \ (\textit{where } i \neq j \Rightarrow x_i \neq x_j)$$

where $\mathcal{C}$, $\mathcal{C}_1$, $\mathcal{C}_2$*..., are choreographies,* r, r_a, r_b*..., are roles,* **c** *is a channel,* x, x_1, x_2*,... and* y, y_1, y_2*,... are variables.*

In **Chor** language, a role groups together those parts of the observable behaviour that must be implemented by the same logical entity or abstract organization. A channel realizes a point of collaboration between roles by specifying where and how information is exchanged. Variables are used to represent three different types of information: application-dependent information (e.g. order code), state information (e.g. order received), and channel information. Variables can belong to one named role or to all roles in a choreography.

The INTERACTION activity expresses a one-way communication on channel c from r_a to r_b, sending the value of variable x at r_a to y at r_b. The SILENT activity is used for marking the point where role specific actions with non-observable operational details must be performed. The INACTION activity is used for marking the point where a role does not perform any action. The ASSIGN activity computes the value of variable y on role r and assigns the value to variable x. The PERFORM activity enables a choreography to specify that another choreography is performed at this point in its definition. To support PERFORM, the performed choreography should be defined previously. The DEFINITION defines a performed choreography with parameters. Before performing choreographies, free variables of the performed choreography should be substituted by bound variables of the performing choreography. This substitution is denoted as $\mathcal{C}\{\tilde{y}/\tilde{x}\}$, where $x_1, ..., x_n$ are shortened as $\tilde{x}$.

Control-flow activities are ordering structural composition of basic activities and other control-flow activities in **Chor**. The SEQUENCE activity contains two activities which will be to executed sequentially in the same order that they are defined. Activities in the PARALLEL activity will be enabled concurrently. Especially, we consider that the two activities in a parallel structure are independent which means that the traces of parallel structure are interleaving [16] of the two activities' action sequences. The CHOICE activity enables specifying that only one of two activities can be executed. It is assumed that selection criteria is non-deterministic and non-observable.

4.2 Operational Semantics

In this section, structural operating semantic(SOS) of **Chor** is presented. Transition is introduced to describe evolution of choreographies when executing activities. A transition is in the form of $\mathcal{C} \xrightarrow{a} \mathcal{C}'$. Intuitively, this transition means that a choreography $\mathcal{C}$ evolves into $\mathcal{C}'$ after performing a basic activity a (Interaction, Silent and Assign activity). SOS rules of **Chor** is listed below.

$$\frac{-}{a \xrightarrow{a} 0}(a \neq 0) \text{ (BASIC ACTIVITY)}$$

$$\frac{\mathcal{C}_1 \xrightarrow{a} \mathcal{C}_1'}{\mathcal{C}_1; \mathcal{C}_2 \xrightarrow{a} \mathcal{C}_1'; \mathcal{C}_2} \text{ (SEQUENCE1)} \quad \frac{-}{a; \mathcal{C}_1 \xrightarrow{a} \mathcal{C}_1} \text{ (SEQUENCE2)}$$

$$\frac{\mathcal{C}_1 \xrightarrow{a} \mathcal{C}_1'}{\mathcal{C}_1 + \mathcal{C}_2 \xrightarrow{a} \mathcal{C}_1'} \text{ (CHOICE1)} \quad \frac{\mathcal{C}_2 \xrightarrow{a} \mathcal{C}_2'}{\mathcal{C}_1 + \mathcal{C}_2 \xrightarrow{a} \mathcal{C}_2'} \text{ (CHOICE2)}$$

$$\frac{\mathcal{C}_1 \xrightarrow{a} \mathcal{C}_1'}{\mathcal{C}_1 \parallel \mathcal{C}_2 \xrightarrow{a} \mathcal{C}_1' \parallel \mathcal{C}_2} \text{ (PARALL1)} \quad \frac{\mathcal{C}_2 \xrightarrow{a} \mathcal{C}_2'}{\mathcal{C}_1 \parallel \mathcal{C}_2 \xrightarrow{a} \mathcal{C}_1 \parallel \mathcal{C}_2'} \text{ (PARALL2)}$$

$$\frac{\mathcal{C}\{\tilde{y}/\tilde{x}\} \xrightarrow{a} \mathcal{C}'}{\mathcal{A}(\tilde{y}) \xrightarrow{a} \mathcal{C}'} \textbf{ where } \mathcal{A}(\tilde{x}) \stackrel{\text{def}}{=} \mathcal{C} \text{ (PERFORM)}$$

a is basic activity of **Chor**. a is minimal and atomic. Thus, execution of a evolves a into 0. For sequence structure, if the first choreography, $\mathcal{C}_1$, may perform an activity a and envolve into $\mathcal{C}_1'$, $\mathcal{C}_1; \mathcal{C}_2$ can perform a and evolve into $\mathcal{C}_1'; \mathcal{C}_2$. If $\mathcal{C}_1$ is just a basic activity a, $\mathcal{C}_1; \mathcal{C}_2$ can perform a and evolve into $\mathcal{C}_2$. The choice structure leads two possibilities of performing activities. If the first choreography performs an activity, the second choreography will be excluded and the system behaves as the first choreography. It is in the same way for the second choreography. By reason that execution of interactions that are basic activities is independent, two parallel choreographies will run independently and performing activities of one choreography does not affect another.

Based the SOS rules, operational semantics of a choreography can be given in terms of automata, labelled transition systems(LTS) [17]. Choreography expressions are considered as the states of a LTS which is expressed by a transition graph in graph fashion. In the transition graph, nodes are names of choreography expressions and edges connect two choreographies if there is a transition between them. Edges are labelled by activities which trigger corresponding transition.

We define the (choreography) expression set of a choreography $\mathcal{C}$, $\mathbf{R}(\mathcal{C})$. $\mathbf{R}(\mathcal{C}) = \{\mathcal{C}' | \exists t = \langle a_1, a_2, ..., a_n \rangle (n \geqslant 0) \mathcal{C} \xrightarrow{a_1} \mathcal{C}_1 \xrightarrow{a_2} ... \xrightarrow{a_n} \mathcal{C}'\}$. Thus, $\mathcal{C}$ itself and 0 are in $\mathbf{R}(\mathcal{C})$.

5 Behavioural Equivalence

This section discusses behavioural equivalence theory for **Chor** language, the τ-bisimulation and some theorems.

5.1 τ-Bisimulation

The *Silent* activity in **Chor** performs an action behind the scenes that does not affect the rest of the choreography. Thus, its execution does not affect the observable behaviours of choreographies and it can be abstracted when analyzing behavioural equivalence. For instance, we consider that two choreographies $\mathcal{C} = a_1; \tau; \tau; a_2$ and $\mathcal{C}' = a_1; a_2$ are equivalent from external viewpoint.

In order to define a notion of bisimulation that allows us to abstract from *silent* activities in choreographies, we begin this section by introduction of a new transition between choreographies.

Definition 2 (τ-Transition). *Let $\mathcal{C}$ and $\mathcal{C}'$ are choreographies. For each activity a, we shall write $\mathcal{C} \stackrel{a}{\Rightarrow} \mathcal{C}'$ iff*

either $a \neq \tau$ and there are choreographies $\mathcal{C}_1$ and $\mathcal{C}_1'$ such that

$$\mathcal{C}(\xrightarrow{\tau})^* \mathcal{C}_1 \xrightarrow{a} \mathcal{C}_1'(\xrightarrow{\tau})^* \mathcal{C}'$$

or $a = \tau$ and $\mathcal{C}(\xrightarrow{\tau})^* \mathcal{C}'$,

where we write $(\xrightarrow{\tau})^*$ for the reflexive and transitive closure of the relation $\xrightarrow{\tau}$.

Thus $\mathcal{C} \stackrel{a}{\Rightarrow} \mathcal{C}'$ holds if $\mathcal{C}$ can reach $\mathcal{C}'$ by performing an a labelled transition, possibly preceded or followed by sequences of τ labelled transitions. For instance, $a; \tau; 0 \stackrel{a}{\Rightarrow} 0$ and $a; \tau; 0 \stackrel{a}{\Rightarrow} \tau; 0$ both hold.

Now, we define the τ-Bisimulation based on the notion of weak bisimulation in Pi Calculus [5].

Definition 3 (τ-Bisimulation). *A binary relation $\mathcal{S}$ on choreographies is a τ-simulation if $\mathcal{C}_1 \mathcal{S} \mathcal{C}_2$ implies that:*

$$\text{If } \mathcal{C}_1 \xrightarrow{a} \mathcal{C}_1' \text{ then for some } \mathcal{C}_2', \mathcal{C}_2 \stackrel{a}{\Rightarrow} \mathcal{C}_2' \text{ and } \mathcal{C}_1' \mathcal{S} \mathcal{C}_2'$$

The relation $\mathcal{S}$ is a τ-bisimulation if both $\mathcal{S}$ and its inverse are τ-simulations. The relation $\approx$, bisimilar or observation equivalent, on choreographies is defined by $\mathcal{C}_1 \approx \mathcal{C}_2$ if and only if there exists a τ-bisimulation $\mathcal{S}$ such that $\mathcal{C}_1 \mathcal{S} \mathcal{C}_2$.

We proceed to investigate further the theory of $\approx$ by stating and proving a collection of algebraic laws.

Theorem 1. *For all choreographies, the relation $\approx$ is an equivalence relation, i.e. the following hold:*

- $\mathcal{C} \approx \mathcal{C}$ *(reflexivity)*
- $\mathcal{C} \approx \mathcal{C}'$ *implies* $\mathcal{C}' \approx \mathcal{C}$ *(symmetry)*
- $\mathcal{C} \approx \mathcal{C}_1$ *and* $\mathcal{C}_1 \approx \mathcal{C}_2$ *imply* $\mathcal{C} \approx \mathcal{C}_2$ *(transitivity)*

Proof. For reflexivity and symmetry, it is obvious from Definition 3. For transitivity, $\mathcal{C}\mathcal{S}_1\mathcal{C}_1$, $\mathcal{C}_1\mathcal{S}_2\mathcal{C}_2$, we must show that $\mathcal{S}_1\mathcal{S}_2$ is τ-bisimulation.

Because $\mathcal{C} \approx \mathcal{C}_1$, thus, if $\mathcal{C} \xrightarrow{a} \mathcal{C}'$ and $a \neq \tau$, there exists some $\mathcal{C}_1'$, $\mathcal{C}_1(\xrightarrow{\tau})^*$ $\mathcal{C}_{11} \xrightarrow{a} \mathcal{C}_{12}(\xrightarrow{\tau})^*\mathcal{C}_1'$ and $\mathcal{C}'\mathcal{S}_1\mathcal{C}_1'$. Because $\mathcal{C}_1 \approx \mathcal{C}_2$, there exists a transition $\mathcal{C}_2(\xrightarrow{\tau})^*$ $\mathcal{C}_{21}(\xrightarrow{\tau})^*\mathcal{C}_{22} \xrightarrow{a} \mathcal{C}_{23}(\xrightarrow{\tau})^*\mathcal{C}_{24}(\xrightarrow{\tau})^*\mathcal{C}_{25}$. Thus, there exists some $\mathcal{C}_{25}$, $\mathcal{C}_2 \overset{a}{\Rightarrow} \mathcal{C}_{25}$. We conclude that $\mathcal{C} \approx \mathcal{C}_2$. if $\mathcal{C} \xrightarrow{a} \mathcal{C}'$ and $a = \tau$, $\mathcal{C} \approx \mathcal{C}_2$ can be also concluded easily.

So $\mathcal{S}_1\mathcal{S}_2$ is a τ-simulation, it is also easy to show that inverse of $\mathcal{S}_1\mathcal{S}_2$ is a τ-simulation. □

Theorem 2. *If* $\mathcal{A}(\tilde{x}) \overset{\text{def}}{=} \mathcal{C}$ *then* $\mathcal{A}(\tilde{y}) \approx \mathcal{C}\{\tilde{y}/\tilde{x}\}$.

Proof. It is straightforward to show that the relation

$$\mathcal{S} = \{(\mathcal{A}(\tilde{y}), \mathcal{C}\{\tilde{y}/\tilde{x}\})\} \cup \mathbf{Id}$$

is a τ-bisimulation, where **Id** is the identity on choreographies. **Id** of $\mathcal{C}$ is $\{(\mathcal{C}', \mathcal{C}')|\mathcal{C}' \in \mathbf{R}(\mathcal{C})\}$. □

Theorem 3

$$\begin{array}{lr}
\textsc{Association}: & \\
(\mathcal{C}_1; \mathcal{C}_2); \mathcal{C}_3 \approx \mathcal{C}_1; (\mathcal{C}_2; \mathcal{C}_3) & (a)\\
(\mathcal{C}_1 \parallel \mathcal{C}_2) \parallel \mathcal{C}_3 \approx \mathcal{C}_1 \parallel (\mathcal{C}_2 \parallel \mathcal{C}_3) & (b)\\
(\mathcal{C}_1 + \mathcal{C}_2) + \mathcal{C}_3 \approx \mathcal{C}_1 + (\mathcal{C}_2 + \mathcal{C}_3) & (c)\\
\textsc{Symmetry}: & \\
\mathcal{C}_1 \parallel \mathcal{C}_2 \approx \mathcal{C}_2 \parallel \mathcal{C}_1 & (d)\\
\mathcal{C}_1 + \mathcal{C}_2 \approx \mathcal{C}_2 + \mathcal{C}_1 & (e)\\
\textsc{Unit \& Idempotent}: & \\
\mathcal{C}; 0 \approx \mathcal{C} & (f)\\
0 \parallel \mathcal{C} \approx \mathcal{C} & (g)\\
0 + \mathcal{C} \approx \mathcal{C} & (h)\\
\mathcal{C} + \mathcal{C} \approx \mathcal{C} & (i)\\
\tau \parallel \mathcal{C} \approx \mathcal{C} & (j)\\
\tau; \mathcal{C} \approx \mathcal{C} & (k)\\
\textsc{Choice Distribution}: & \\
(\mathcal{C}_1 + \mathcal{C}_2); \mathcal{C} \approx (\mathcal{C}_1; \mathcal{C}) + (\mathcal{C}_2; \mathcal{C}) & (l)
\end{array}$$

Proof. To prove law(a), we can construct three relations $\mathcal{S}_1$, $\mathcal{S}_2$, $\mathcal{S}_3$. $\mathcal{S}_1 = \{((\mathcal{C}'; \mathcal{C}_2); \mathcal{C}_3, \mathcal{C}'; (\mathcal{C}_2; \mathcal{C}_3))\ |\mathcal{C}' \in \mathbf{R}(\mathcal{C}_1)\}$. $\mathcal{S}_2 = \{((\mathcal{C}'); \mathcal{C}_3, (\mathcal{C}'; \mathcal{C}_3))|\mathcal{C}' \in \mathbf{R}(\mathcal{C}_2)\}$. $\mathcal{S}_3 = \{(\mathcal{C}', \mathcal{C}')|\mathcal{C}' \in \mathbf{R}(\mathcal{C}_3)\}$. The relation $\mathcal{S}_a = \mathcal{S}_1 \cup \mathcal{S}_2 \cup \mathcal{S}_3$ is easily seen to be a τ-bisimulation.

For law(b), relation $\mathcal{S} = \{((\mathcal{C}_1' \parallel \mathcal{C}_2') \parallel \mathcal{C}_3', \mathcal{C}_1' \parallel (\mathcal{C}_2' \parallel \mathcal{C}_3'))|\mathcal{C}_1' \in \mathbf{R}(\mathcal{C}_1), \mathcal{C}_2' \in \mathbf{R}(\mathcal{C}_2), \mathcal{C}_3' \in \mathbf{R}(\mathcal{C}_3)\}$ can be constructed and it is a τ-bisimulation.

For law(c), relation $\mathcal{S} = \{((\mathcal{C}_1 + \mathcal{C}_2) + \mathcal{C}_3, \mathcal{C}_1 + (\mathcal{C}_2 + \mathcal{C}_3))\} \cup \mathbf{Id}_{\mathcal{C}_1} \cup \mathbf{Id}_{\mathcal{C}_2} \cup \mathbf{Id}_{\mathcal{C}_3}$ is a τ-bisimulation.

The proofs of symmetry, unit and idempotent laws are straightforward.

For law(j), relation $\mathcal{S} = \{((\mathcal{C}_1 + \mathcal{C}_2); \mathcal{C}, (\mathcal{C}_1; \mathcal{C}) + (\mathcal{C}_2; \mathcal{C}))\} \cup \mathbf{R}(\mathcal{C}_1; \mathcal{C}) \cup \mathbf{R}(\mathcal{C}_2; \mathcal{C})$ can be constructed and it is a τ-bisimulation. □

Especially, we conclude that $\tau + \mathcal{C}$ is not τ-bisimilar with $\mathcal{C}$ ($\mathcal{C} \neq \tau$). By Theorem 3, we could see that $\tau; \tau \approx \tau$, $\tau + \tau \approx \tau$, $\tau \parallel \tau \approx \tau$. These equations mean that ordering structures of τ can also be ignored in equivalent checking.

Theorem 4. *$\mathcal{C}_1 \approx \mathcal{C}_2$ implies*

$$\begin{array}{rl} \mathcal{C}; \mathcal{C}_1 \approx \mathcal{C}; \mathcal{C}_2 & (a) \\ \mathcal{C}_1; \mathcal{C} \approx \mathcal{C}_2; \mathcal{C} & (b) \\ \mathcal{C} \parallel \mathcal{C}_1 \approx \mathcal{C} \parallel \mathcal{C}_2 & (c) \\ \mathcal{C} + \mathcal{C}_1 \approx \mathcal{C} + \mathcal{C}_2 & (d) \end{array}$$

Proof. Suppose the τ-bisimulation $\mathcal{S}$, $\mathcal{C}_1 \mathcal{S} \mathcal{C}_2$. To prove law (a), we construct a relation $\mathcal{S}_a = \{(\mathcal{C}'; \mathcal{C}_1, \mathcal{C}'; \mathcal{C}_2)|\mathcal{C}' \in \mathbf{R}(\mathcal{C})\} \cup \mathcal{S}$. It is easily seen to be a τ-bisimulation. Law (b) can be proved by same way.

To prove law (c), we suppose a relation $\mathcal{S}' = \{(\mathcal{C}' \parallel \mathcal{C}_1', \mathcal{C}' \parallel \mathcal{C}_2')|\mathcal{C}_1' \approx \mathcal{C}_2'\}$. In fact, $(\mathcal{C} \parallel \mathcal{C}_1, \mathcal{C} \parallel \mathcal{C}_2)$ is contained in $\mathcal{S}'$. All we are left to do is to show that $\mathcal{S}'$ is a τ-bisimulation. It is sufficient to argue that if $(\mathcal{C}' \parallel \mathcal{C}_1', \mathcal{C}' \parallel \mathcal{C}_2')$ is contained in $\mathcal{S}'$ and $\mathcal{C}' \parallel \mathcal{C}_1' \xrightarrow{a} \mathcal{P}$ for some activity a and choreography $\mathcal{P}$ then $\mathcal{C}' \parallel \mathcal{C}_2' \xrightarrow{a} \mathcal{Q}$ for some choreography $\mathcal{Q}$ such that $(\mathcal{P}, \mathcal{Q}) \in \mathcal{S}'$. According to SOS rules of parallel ordering structure, there are two possible forms that $\mathcal{C}' \parallel \mathcal{C}_1' \xrightarrow{a} \mathcal{P}$ may take:

(1).$\mathcal{C}' \xrightarrow{a} \mathcal{C}''$: it makes $\mathcal{C}' \parallel \mathcal{C}_1' \xrightarrow{a} \mathcal{P}$, so $\mathcal{P} = \mathcal{C}'' \parallel \mathcal{C}_1'$. Because $\mathcal{C}' \parallel \mathcal{C}_2' \xrightarrow{a} \mathcal{Q}$, $\mathcal{Q} = \mathcal{C}'' \parallel \mathcal{C}_2'$. We can see that $(\mathcal{C}'' \parallel \mathcal{C}_1', \mathcal{C}'' \parallel \mathcal{C}_2') \in \mathcal{S}'$, so $(\mathcal{P}, \mathcal{Q}) \in \mathcal{S}'$.

(2).$\mathcal{C}_1' \xrightarrow{a} \mathcal{C}_1''$: we can see $\mathcal{Q} = \mathcal{C}' \parallel \mathcal{C}_2''$ and $(\mathcal{P}, \mathcal{Q}) \in \mathcal{S}'$.

Therefore the relation $\mathcal{S}'$ is a τ-bisimulation.

For law(d), a τ-bisimulation relation $\mathcal{S}_d = \{(\mathcal{C} + \mathcal{C}_1, \mathcal{C} + \mathcal{C}_2)\} \cup \mathbf{Id}_{\mathcal{C}} \cup \mathcal{S}$ can be constructed. □

6 Hierarchical Models and Analysis

Refinement of web services choreography is the verifiable transformation of an abstract (high level) model into a concrete (low level) model. The whole model in high level can be refined to a more detailed model in low level. In this process, by reason of independent modeling for complex systems by different developers, one role in high level can either be refined to some roles, channels and their interactions in low level or kept unchanged. A correct refinement preserves the behavioural equivalence between high and low level models.

A choreography model consists of a static part that is the structure of roles and channels and a dynamic part that is the interactions among roles on channels.

Definition 4 (Choreography Model). *A choreography model is a tuple* $\langle RS, CS, \mathcal{C}\rangle$*.* RS *is the set of roles in a model,* $RS = \{r_1, r_2, ...\}$*.* CS *is the set of channels in a model,* $CS \subseteq \{\langle ch, r, r'\rangle | ch \text{ is name}, r, r' \in RS\}$*.* $\mathcal{C}$ *is choreography behaviour described by* **Chor** *language and roles and channels appear in this description must be defined in* RS *and* CS*.*

Refinement of choreography models maybe done by developers manually or supported by modeling tools partially. Roles in high level will be described as a sub choreography which consists roles, channels connected among them and interactions on channels. Functionalities must be preserved in refinements. It mean that external and observable behaviours are preserved equivalently. The refinement is defined as below.

Definition 5 (Refinement). *A refinement of choreography model is a tuple* $R = \langle chor_1, chor_2, m\rangle$*.* $chor_1 = \langle RS_1, CS_1, \mathcal{C}_1\rangle$ *is the original choreography model that is refined to* $chor_2 = \langle RS_2, CS_2, \mathcal{C}_2\rangle$*.* m *is the refining relation(role mapping) between* RS_1 *and* RS_2*.* $m = \{\langle r, R\rangle | r \in RS_1, R \subseteq RS_2\}$*, where* $\bigcup_{0<i\leqslant|m|}\{r_i\} = RS_1$*,* $\bigcup_{0<i\leqslant|m|} R_i = RS_2$ *and* $R_i \wedge R_j = \varnothing$ *(*$0 < i, j \leqslant |m|$*,* $i \neq j$*).*

We suppose that all of roles and channels in high level must be refined. It imply some roles will be unchanged or renamed if one developer only refines other roles. When refining a choreography model, the name of channels and data variables appear in interactions should be preserved in the detailed model. We use function $m(r)$ to denote the refined role set. It means that $m(r) = R$, if $\langle r, R\rangle \in m$.

The τ-bisimulation provides behavioural equivalence checking among general **Chor** documents. But for two choreography models that have refining relation, τ-bisimulation should be extended for their different roles contained and different abstract granularity. To check whether $chor_1$ and $chor_2$ are behavioural equivalent under mapping m, the τ-bisimulation should be extended by combing this mapping relation. Essentially, we can see that interactions among roles in R_i are internal activities in $chor_2$ and they will not affect the observable behaviour from pointview of $chor_1$ level. While control-flow activities among roles in R_i may affect observable behaviour. Interactions between roles in R_i and roles in R_j (where $i \neq j$ and $0 < i, j \leqslant |m|$) take place on channels in $chor_1$ and are not internal. Thus, for verifying behavioural equivalence, we can transform low level model $chor_2$ to high level model $chor'_2$ by abstracting internal activities at first, and then τ-bisimulation can be applied between $chor'_2$ and $chor_1$.

Based on effect of interactions for observable behaviour, the transform function $\mathbb{T}$ on role mapping m is denoted as $\mathbb{T}_m$, which is defined as below.

$$
\mathbb{T}_m(r_a \to r_b(c, x, y)) =
\begin{cases}
r_1 \to r_2(c, x, y) & \text{if } r_a \in m(r_1) \text{ and } r_b \in m(r_2) \\
 & \text{where } r_1 \neq r_2 \\
\tau & \text{if } r_a, r_b \in m(r_i) \text{ for some } r_i
\end{cases}
$$

$$\begin{aligned}
\mathbb{T}_m(\tau) &= \tau \\
\mathbb{T}_m(0) &= 0 \\
\mathbb{T}_m(r[\![x := y]\!]) &= r'[\![x := y]\!](\text{ where } r \in m(r')) \\
\mathbb{T}_m(\mathcal{C}_1; \mathcal{C}_2) &= \mathbb{T}_m(\mathcal{C}_1); \mathbb{T}_m(\mathcal{C}_2) \\
\mathbb{T}_m(\mathcal{C}_1 \parallel \mathcal{C}_2) &= \mathbb{T}_m(\mathcal{C}_1) \parallel \mathbb{T}_m(\mathcal{C}_2) \\
\mathbb{T}_m(\mathcal{C}_1 + \mathcal{C}_2) &= \mathbb{T}_m(\mathcal{C}_1) + \mathbb{T}_m(\mathcal{C}_2) \\
\mathbb{T}_m(\mathcal{A}(\tilde{y})) &= \mathbb{T}_m(\mathcal{C}\{\tilde{y}/\tilde{x}\}) \text{ (where } \mathcal{A}(\tilde{x}) \stackrel{\text{def}}{=} \mathcal{C})
\end{aligned}$$

To prove transitivity of transform function $\mathbb{T}$, we give the concatenation of two role mapping as $m_1 \circ m_2$, where $m_1 = \{\langle r, R\rangle | r \in RS_1, R \subseteq RS_2\}$ and $m_1 = \{\langle r, R\rangle | r \in RS_2, R \subseteq RS_3\}$. $m_1 \circ m_2 = \{\langle r, R\rangle | r \in RS_1, R = \bigcup_{s \in m_1(r)} m_2(s)\}$.

Lemma 1 (Transitivity of transform function). $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1}(\mathcal{C}) = \mathbb{T}_{m_1 \circ m_2}(\mathcal{C})$, *where* $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1} = \mathbb{T}_{m_1}(\mathbb{T}_{m_2}())$.

Proof. For interactions in $\mathcal{C}$, $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1}(r_a \rightarrow r_b(c, x, y))$ is equal to $r_1 \rightarrow r_2(c, x, y)$ by definition of $\mathbb{T}$, if $r_a \in m_1 \circ m_2(r_1)$, $r_b \in m_1 \circ m_2(r_2)$ and $r_1 \neq r_2$. Otherwise, $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1}(r_a \rightarrow r_b(c, x, y)) = \tau$. Thus, $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1}(r_a \rightarrow r_b(c, x, y)) = \mathbb{T}_{m_1 \circ m_2}(r_a \rightarrow r_b(c, x, y))$. By definition of $\mathbb{T}$, $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1}(\tau) = \mathbb{T}_{m_1 \circ m_2}(\tau)$ and $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1}(0) = \mathbb{T}_{m_1 \circ m_2}(0)$.

For sequence activity, $\mathbb{T}_{m_1}$ $(\mathbb{T}_{m_2}$ $(\mathcal{C}_1;$ $\mathcal{C}_2)) = \mathbb{T}_{m_1}$ $(\mathbb{T}_{m_2}$ $(\mathcal{C}_1);$ $\mathbb{T}_{m_2}$ $(\mathcal{C}_2)) = \mathbb{T}_{m_1}$ $(\mathbb{T}_{m_2}$ $(\mathcal{C}_1));$ $\mathbb{T}_{m_1}$ $(\mathbb{T}_{m_2}$ $(\mathcal{C}_2))$. Other control-flow activities have same equalities. The $\mathbb{T}$ function may be applied on control-flow activities until the parameters of $\mathbb{T}$ are basic activities. As proved above, $\mathbb{T}_{m_2} \circ \mathbb{T}_{m_1}(\mathcal{C}) = \mathbb{T}_{m_1 \circ m_2}(\mathcal{C})$ holds on basic activities. Thus, it also holds on control-flow activities. □

The transform function preserves bisimulation among choreography models as showed in Lemma 2.

Lemma 2 (Bisimilar preservation of transform function). *For two choreography models* $\langle RS, CS, \mathcal{C}_1\rangle$ *and* $\langle RS, CS, \mathcal{C}_2\rangle$ *on same roles and channels, if* $\mathcal{C}_1 \approx \mathcal{C}_2$*, then* $\mathbb{T}_m(\mathcal{C}_1) \approx \mathbb{T}_m(\mathcal{C}_2)$.

Proof. By definition of $\mathbb{T}$, we can see that there exists a bijection between $\mathbf{R}(\mathcal{C})$ and $\mathbf{R}(\mathbf{T}_m(\mathcal{C}))$, which is $\{\langle ce, cem\rangle | ce$ is an expression of $\mathbf{R}(\mathcal{C}), cem = \mathbb{T}(ce)\}$(Here, $\mathbb{T}(ce)$ is just a expression name). Let $\mathcal{C}_{1m} = \mathbb{T}_m(\mathcal{C}_1)$ and $\mathcal{C}_{2m} = \mathbb{T}_m(\mathcal{C}_2)$.

Because $\mathcal{C}_1 \approx \mathcal{C}_2$, there exists a τ-bisimulation $\mathcal{S}$, $\mathcal{C}_1\mathcal{S}\mathcal{C}_2$. So, we construct a relation $\mathcal{S}_m$ between $\mathcal{C}_{1m}$ and $\mathcal{C}_{2m}$. $\mathcal{S}_m = \{\langle ce_{m1}, ce_{m2}\rangle | ce_{m1} = \mathbb{T}(ce_1), ce_{m2} = \mathbb{T}(ce_2)$, and $ce_1\mathcal{S}ce_2\}$.

By the bijection between $\mathbf{R}(\mathcal{C}_1)$ and $\mathbf{R}(\mathcal{C}_{1m})$, if $ce_{m1} \xrightarrow{a} ce'_{m1}$, then there exist $ce_1, ce'_1 \in \mathbf{R}(\mathcal{C}_1)$ and $ce_1 \xrightarrow{a'} ce'_1$(where $\mathbb{T}_m(a') = a$).

Because $\mathcal{C}_1 \approx \mathcal{C}_2$, there exist $ce_2, ce'_2 \in \mathbf{R}(\mathcal{C}_2)$ such that $ce_1\mathcal{S}ce_2$, $ce'_1\mathcal{S}ce'_2$ and $ce_2 \stackrel{a'}{\Rightarrow} ce'_2$. By the bijection between $\mathbf{R}(\mathcal{C}_2)$ and $\mathbf{R}(\mathcal{C}_{2m})$, a τ-transition $ce_{m2} \stackrel{a'}{\Rightarrow} ce'_{m2}$ can be found in $\mathcal{C}_{2m}$.

Thus, If $ce_{m1} \xrightarrow{a} ce'_{m1}$, there exists $ce_{m2} \overset{a'}{\Rightarrow} ce'_{m2}$. Moreover, $ce_{m1}\mathcal{S}_m ce_{m2}$ and $ce'_{m1}\mathcal{S}_m ce'_{m2}$. $\mathcal{S}_m$ can be concluded as a τ-simulation and its inverse can be proved as a τ-simulation easily. □

Although a choreography model is refined correctly by its refined model, they are not τ-bisimilar. Therefore, a new simulation between models and their refined models is need to present this correct refinement. We introduce the refined simulation that is a relation between two choreography models under a role mapping.

Definition 6 (Refined Simulation). *A choreography $\mathcal{C}$ and its refined choreography $\mathcal{C}'$ on role mapping m, if $\mathcal{C} \approx \mathbb{T}_m(\mathcal{C}')$, we say that $\mathcal{C}'$ is refined similar to $\mathcal{C}$, denoted as $\mathcal{C} \approx^m \mathcal{C}'$.*

In hierarchical analysis of choreography, a refinement R is considered as sound if the two choreography models in R have a refined simulation.

Proposition 1 (Soundness of Refinement). *A refinement $R = \langle chor_1, chor_2, m\rangle$ (where $chor_1 = \langle RS_1, CS_1, \mathcal{C}_1\rangle$, $chor_2 = \langle RS_2, CS_2, \mathcal{C}_2\rangle$) is soundness preserving, if and only if $\mathcal{C}_1 \approx^m \mathcal{C}_2$.*

Now, we discuss choreography models in non-neighbouring levels. In development of a service-oriented system model, a choreography model is refined to detailed models step by step from top to bottom level. At last, the choreography model on bottom level can be projected into a local behavioural model (a orchestration model) for each role [4] and behavioural equivalence which is also know as conformance [18,19] between choreography model and orchestration models be verified. The transitivity of soundness of refinements will insure that the final refined model is equivalent with system specifications. To prove this property, we define catenation of refinements firstly.

Definition 7 (Refinement Catenation). *The catenation of two refinements $R_1 = \langle chor_1,\ chor_2,\ m_1\rangle$ and $R_2 = \langle chor_2,\ chor_3,\ m_2\rangle$, where $chor_i = \langle RS_i,\ CS_i,\ \mathcal{C}_i\rangle$ $(i = 1, 2, 3)$, is denoted as $R_1 \ltimes R_2 = \langle chor_c,\ chor'_c,\ m_c\rangle$, where $chor_c = \langle RS_1,\ CS_1,\ \mathcal{C}_1\rangle$, $chor'_c = \langle RS_3,\ CS_3,\ \mathcal{C}_3\rangle$ and $m_c = m_1 \circ m_2$.*

And then, The soundness preserving of refinement catenation is proven in Theorem 5.

Theorem 5 (Soundness of Refinement Catenation). *If refinements $R_1 = \langle chor_1,\ chor_2,\ m_1\rangle$ and $R_2 = \langle chor_2,\ chor_3,\ m_2\rangle$ are soundness preserving, then $R_1 \ltimes R_2$ are soundness preserving.*

Proof. When $\mathcal{C}_1 \approx^{m_1} \mathcal{C}_2$ and $\mathcal{C}_2 \approx^{m_2} \mathcal{C}_3$, this theorem is proven if $\mathcal{C}_1 \approx^{m_1 \circ m_2} \mathcal{C}_3$.

Because $\mathcal{C}_1 \approx^{m_1} \mathcal{C}_2$, $\mathcal{C}_{2m} = \mathbb{T}_{m_1}(\mathcal{C}_2) \approx \mathcal{C}_1$. In the same way, we can see that $\mathcal{C}_{3m} = \mathbb{T}_{m_2}(\mathcal{C}_3) \approx \mathcal{C}_2$. Let $\mathcal{C}'_{3m} = \mathbb{T}_{m_1}(\mathcal{C}_{3m})$, then $\mathcal{C}_{2m} \approx \mathcal{C}'_{3m}$ by Lemma 2. So $\mathcal{C}_1 \approx \mathcal{C}'_{3m}$ by the transitivity of τ-bisimulation. By Lemma 1, $\mathbb{T}_{m_1 \circ m_2}(\mathcal{C}_3) = \mathcal{C}'_{3m}$. Thus, $\mathbb{T}_{m_1 \circ m_2}(\mathcal{C}_3) \approx \mathcal{C}_1$. □

7 Conclusion

We have proposed a formal modeling and analysis approach for hierarchical web services choreographies. The structural hierarchy is presented by role mapping, while the behavioural hierarchy is described by compositional semantics of observable behaviours. The formal language **Chor** is used to describe dynamic behaviour of web services choreography and the τ-bisimulation of **Chor** constructs a general behavioural equivalence theory for choreography. The refinement of choreography models is discussed. We introduce the refined simulation between choreography models in neighbouring levels and hierarchical analysis approach for choreography models based on this simulation.

Some aspects of our approach are still being further investigated. Variables renaming that are important techniques in concurrent theory are not mentioned here. The restriction is that name of channels and data variables appear in interactions in high level choreography model should be preserved in detailed choreography model. The modelling and verification tools will be developed in the next step. Our approach will also be extended to formally analyze hierarchical and global interaction model for general concurrent systems.

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Spider Maps for Location-Based Services Improvement

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Abstract. Location-Based Services(LBS) are information services which are available through mobile devices inside a mobile network and can take advantage of the location of the mobile device. With the majority of the world population living in urban areas and using complex transportation systems, they can be used to assist people to use the public transportation systems more effectively and efficiently. This research aims to contribute to the improvement of LBS through the use of a new kind of a schematic map, called *spider map* that brings together geographic information in particular in its central location, or hub, with a schematic information of the overall transport network originating in the hub, including for instance relevant stops and their locations. These maps present an innovative layout that includes context information relevant for the users. They can be used to increase LBS user satisfaction and therefore increase the intention to use Public Transportation Services.

Keywords: Location-Based Services, Spider Maps, Schematic Maps, Public Transportation, User Satisfaction.

1 Introduction

At the late 18th century, the industrial revolution brought a wide set of scientific, economic and social changes which pushed new developments in the transportation field. The geographical world has already been discovered but the transportation systems (railways, roads, airways, underground systems, high speed trains) have been growing till today, and they are expected to continue to grow. Large urban areas appeared and needed complex transportation systems, combining different transportation types. Nowadays, about 80% of the world population [1] and 60% of the European population live in urban areas [2]. Public transportation is crucial to achieve sustainability and efficiency in mobility and high quality of urban life [3] However, people do not use Public Transportation to its full potential, due to two main factors: time and money [4]. Nevertheless, beyond economical profit maximization functions and rational choice paradigms there are other kind of improvements that can be studied. Trip planning in public transportation systems is currently offered to users through the use of paper maps at transportation network hubs and stops. People carry an increasing number of mobile devices (smartphones, etc) which could be used to access services

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such as trip planning in Public Transportation. Those maps are being manually designed by teams of expert designers. This process is expensive, time-consuming and it results in an inflexible map which may not reflect the spatial context and the needs of the user. Our research aims to develop a new kind of maps called spider maps, depicted in figure 5, which can be entirely produced by computer. These maps belong to the domain of schematic maps, and therefore they are an abstraction and simplification of the reality. In this paper we describe how those maps can be used to improve the dimensions of the theoretical information model [5] of the location-based services, leading to higher user satisfaction levels and consequently increasing public transportation ridership, as the empirical evidences of the literature state.

The structure of the paper is as follows. The main concepts and related work regarding location-based services, quality of information in mobile services and schematic maps are presented in section 2. In Section 3 we present the spider maps and discuss how to implement them in the location-based services. In section 4 we discuss the contribution of the spider maps to the enhancement of the location-based services and to the intention to use public transportation. Finally, some concluding remarks and clues about future work are provided in part 5.

2 Related Work

This section describes the research work carried away by researchers in the areas of LBS, quality of information in mobile services and schematic maps.

2.1 Location-Based Services

Location-Based Services are information services accessible with mobile devices through the mobile network which have the ability to make use of the location of the mobile device [6]. This definition is also accepted by the international OpenGeospatial Consortium [7]. Some authors state that LBS are an intersection of several technologies as internet, mobile devices and geographic information systems (GIS) [8] [9]. This model is shown at figure 1.

LBS allows the establishment of two way communication and interaction: user tells the system his actual context, intention and/or preferences (or the system may obtain them in a pervasive way) which can help the provider of such location services to deliver information tailored to the user needs [10]. As it is also possible to observe in figure 1, there is a relationship between GIS and LBS. Both of the concepts have common features, such as the handling of data with geographical reference and spatial analysis functions in order to answer the questions *"Where am I?"*, *"What surrounds me?"* and *"Where can i go to?"*. Nevertheless, their focus is completely different: while LBS recent appearance targets large non-professional user groups, GIS can be seen as traditional "professional" systems to be used by a restricted group of expert people.

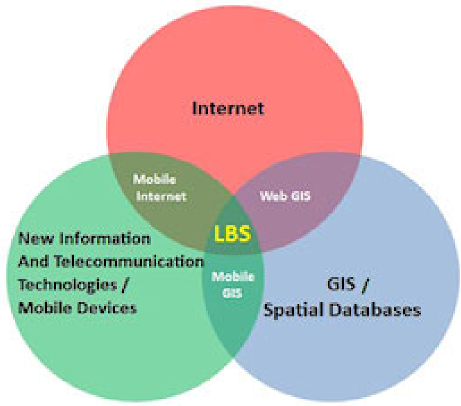

Fig. 1. LBS as an intersection of technologies [8]

According to Steiniger [10], LBS has the following components:

- **Mobile Devices:** The apparatus which serves as the physical interface for the user to access the service. It can be a PDA, Smartphone, mobile embedded systems or toll payment systems (ex: in automobiles).
- **Communication Network:** The network to transfer data between the service provider and the user mobile device.
- **Positioning component:** This is the component that determines the position of user. It can be a Global Positioning System (GPS) unit, or a triangularization technology that makes use of the wireless access points position (or GSM/CDMA antennas) to determine mobile device position, or any hybrid combination of both (as happens with assisted GPS (AGPS)). If this automation component is not present, the user has to specify its position by any mean.
- **Service and Application Provider:** The service provider offers a set of services to user.
- **Data and Content Provider:** Many times, the service and application provider need to obtain certain information it does not own, such as geographical information, event information, etc.

LBS applications need to be aware of a set of details, such as the type of mobile user, the context of the user, the user needs (can be gathered by questioning the user or by pervasive means, automatically), the search and spatial analysis, the user interface, the visualization properties of the device and a wide set of technological questions(how to transmit and store data, technical protocols and details). These details allow the user to effectively use the services.

Reichenbacher [11] enumerated five possible mobile actions users usually execute when using LBS:

- **Locating:** This is the most obvious action: user wants to know where he is.
- **Searching:** User may want to search for persons, objects or events

– **Navigating:** User may ask for the way to a location
– **Identifying:** Involves asking information about a location
– **Checking:** User may look for events near or nearby some location.

From this five possible actions it is easy to understand that all of them depend on the context. We can divide the context into three types of context [10]:

– **Spatial Context:** Where the user is,
– **Temporal Context:** When it is using the service,
– **User Context:** What is he using the service for.

Other authors [12] increase this list with other context types such as navigation history, orientation, purpose of use, social and cultural situation, physical surroundings and system properties. However, those context types can be viewed as subtypes of the three main context types proposed by Steiniger.

As it can bee seen, context is a main concept regarding LBS and as its importance is reflected in all the five kinds of mobile user actions, specially the spatial context.

2.2 Quality of Information in Mobile Services

Although mobile services are gaining popularity in contemporary life, there are some types of mobile services which are not effectively grasping their users. Public transportation services are among these services [13].

A comprehensive research [14] was made on how different dimensions of information quality affect consumers' satisfaction towards mobile information services and eventually the acceptance of these services. The fact that there are so many features which influence consumers' perceptions towards mobile services, called for a more precise theoretical framework. One promising way to consider the factors that affect the perceived quality of mobile information service from the consumers' point of view is the information quality framework of Chae et al. [5]. This framework identifies four dimension of information quality:

– **Context:** Although context was already mentioned in subsection 2.1, it is worth to mention a definition from Dey [15] adequate not only LBS but also generic mobile services context: *"any information that can be used to characterize the situation of an entity"*. Here an entity refers to a person, a place or an object that is considered important to the communication between the user and an application of the mobile service.
– **Content:** Content quality is the value and utility or usefulness of the information provided by mobile services [16]
– **Connection:** Connection refers to the link between the several components of the mobile service which allows the flow of information.
– **Interaction:** Interaction may be defined as the communication between a site and its users [17]. Mobile services achieve a high interaction quality if they are able to provide easy and efficient ways of interaction [14]. Being so, interaction is closely related to ease of use.

According to the framework, those qualities influence directly the user satisfaction. This influence has been proven by several studies [18] [19] [20] [21]. Based on the framework, Koivumaki *et al* [14] also show that all the four dimensions of quality in information services are positively related to user satisfaction. Another relevant conclusion of those studies is that user satisfaction is positively related to intention to use the service. The studies also state that although content quality is the most important factor, user satisfaction is affected by the set of the four factors, and consequently, the success of a mobile service depends on the form of all quality factors. Figure 2 shows the complete model.

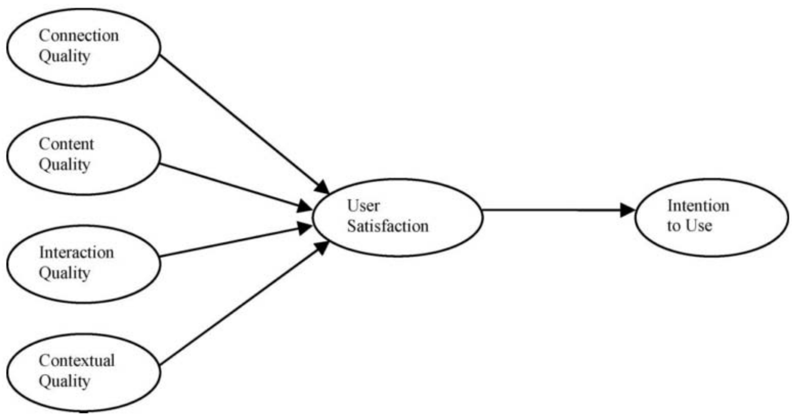

Fig. 2. The theoretical model of information quality, source: [5]

2.3 Schematic Maps

The onset of the industrial revolution brought a wide set of scientific, economic and social changes which required an increase of goods and people transportation. Large urban areas appeared and needed complex transportation systems, combining different transportation types. The need of highly efficient, easily understandable transportation maps pushed the evolution of the traditional maps, and new forms of cartographic representation have emerged. Among the new forms of cartographic representation that have emerged, the schematic maps were probably the most bold. One famous schematic map applied to a transportation network was the Harry Beck's London Underground diagram, depicted in figure 3.

Despite being bold and including some new and controversial features, this map was considered an innovation, as for the first time lines were drawn either horizontally, vertically or diagonally at 45. This map also uses a non-linear scale, so the central area of the diagram is shown at a larger scale than the extremities. It shall be noted that although it does not mimic the geography of London, this map gives the traveler some clues about the terrain features (ex: river) and his/her location. Avelar defines schematic maps as *"an easy-to-follow*

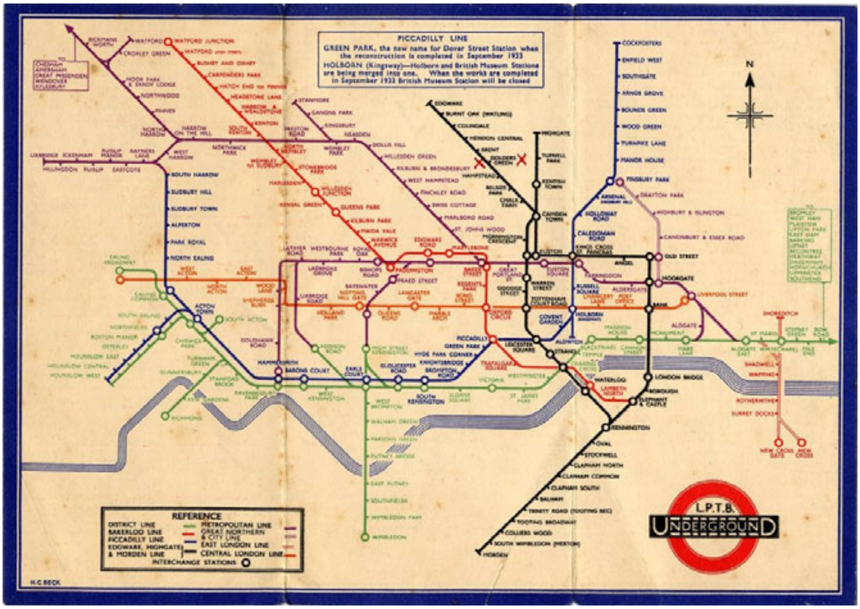

Fig. 3. London Underground Diagram by Harry Beck [22]

diagrammatic representation based on highly generalized lines which is in general used for showing routes of transportation systems, such as subways, trams and buses, or for any scenario in which streams of objects at nodes in a network play a role" [23]. The most important advantage of schematic maps is that they provide a quick view of the layout of the network by removing unimportant information like the detailed shape of the connections.

Schematic maps have been increasingly used in response to the need of better and simpler maps to describe complex transport networks. This apparent simplicity is achieved through a sequential process where choices are made regarding the level of detail and schematization choices. This process, called "schematization process", is still a manual process being carried away by teams of expert designers and cartographers, despite efforts in automating the process through the use of computers. The use of computers to execute the schematization process requires effective and efficient algorithms, to achieve in one hand high quality schematic maps which can be understood by people, and in the other hand a time efficient process. This process can also be used to produce schematic maps in soft real time, to support services such as transportation network load balancing through dynamic people routing across the network. Through schematization, certain map details are emphasized while others are deemphasized. It is fundamental, however, to present the smallest information amount the user needs to learn the map: the more information presented, the higher the learning time will be. Latto defends that information shall be reduced to its basic components to achieve that goal [24]. There are some studies regarding research the automated drawing of schematic maps [25] [26] [27] [28], nevertheless they do not analyze the schematic map generation a wide multidisciplinary problem as they tend to focus only in some areas of the problem. The automatic approaches for the generation of schematic maps mostly focus on the schematization process [29]. Nollenburg [30] [31] studies make an extensive research on the discrete mathematical foundations which are the basis of the algorithms used in the drawing of schematic maps and makes some brief considerations about their implementation. Nevertheless, his studies do not cover the human perception factors nor a concrete computer framework for drawing schematic maps. Silvana Avelar [23] presents a wider study, by including some human perception factors and makes a complete research on the schematic maps on demand, one of the components to be integrated in the new paradigm. She goes further on by presenting a framework for electronic schematic maps which can answer user queries and studies the automated generation of schematic maps. Nevertheless, the study of the human perception factors is limited to what she calls the aesthetic factors".

Most of the algorithms to design schematic maps retain a common structure [32]. They make use of a graph to model the transportation network, in which the vertices represent stops or turning points and the edges represent the paths between two turning points. Nevertheless, the automated generation of schematic maps is truly a multidisciplinary problem, which involves integrating knowledge from several science fields. Isolated studies of different areas of knowledge, such as cognitive psychology show that user centered maps have a better performance and allow users to commit less errors [33]. Hochmair, for example [34] studied the effectiveness in the context on route planning, more specifically, as a measure of how well the map information supports the map reader in planning the fastest route between trip origin and destination on a public transportation map.

As it is possible to see, the design of schematic maps is a complex problem. To solve it, there is the need to put together advanced optimization algorithms, transportation services knowledge, cognitive psychology and information systems engineering.

3 Spider Maps

Schematic maps are used nowadays as a vehicle for communicating transportation networks. The spider map, as a subtype of schematic map, can also be used for that purpose. But spider map features make it an enhanced tool for communicating transportation network information.

3.1 Definition

Schematic spider maps are a special type of schematic maps. As with traditional schematic maps, the stops and lines of the transportation network correspond to vertices and edges, respectively, in the spider map. However, they have enhanced features such a spider architecture, thus having a specific set of characteristics which sets them apart from the traditional schematic maps. Spider maps pay

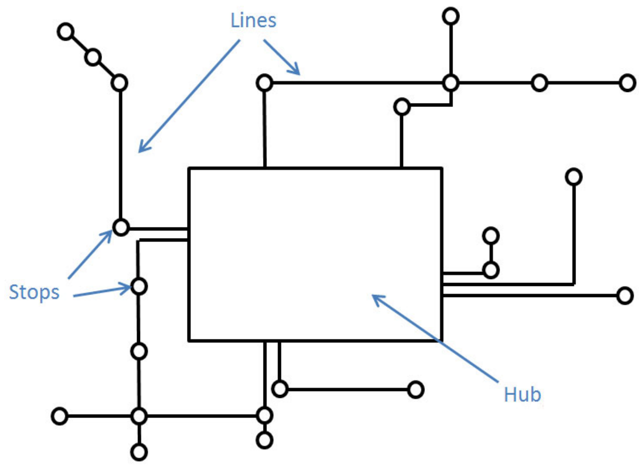

Fig. 4. Spider Map structure sketch

special attention to the context in order to enhance its learning by the users and it ease of use. The spider map architecture, depicted in figure 4, comprehends three main components []:

- **Hub:** The hub is the main part of the map. Describes the area in which the user is, as well as the surrounding area with a higher degree of detail (buildings, roads, etc). The hub, as it is the central part of the spider map, is the first component the user will look at, as it makes uses of *"focus and context"* [36] and detail focusing [24] techniques. The hub is the only part of the spider map which does not comply with the 0/45/90 degrees line orientation. It can also include landmarks to allow user to know important details about the place he currently is.
- **Lines:** The lines follow the orthogonal orientation of the traditional schematic maps, and describe the paths of the transport network where the user can go through while being at the zone depicted by the hub.
- **Stops:** The stops are the main destinations accessible to the user from the hub.

Figure 5 shows a Portugal real spider map of the the Sao Joao Hospital area for bus network service in Porto, produced with technology components developed by our investigation in the area in cooperation with OPT[1], FWT[2] and INEGI[3].

[1] OPT is an company based in Porto which develops IT infrastructures for Transportation Services. *http://www.opt.pt*

[2] FWT is a company based in London which produces maps for transportation networks. *http://www.fwt.co.uk*

[3] INEGI is a research institute based in Porto.

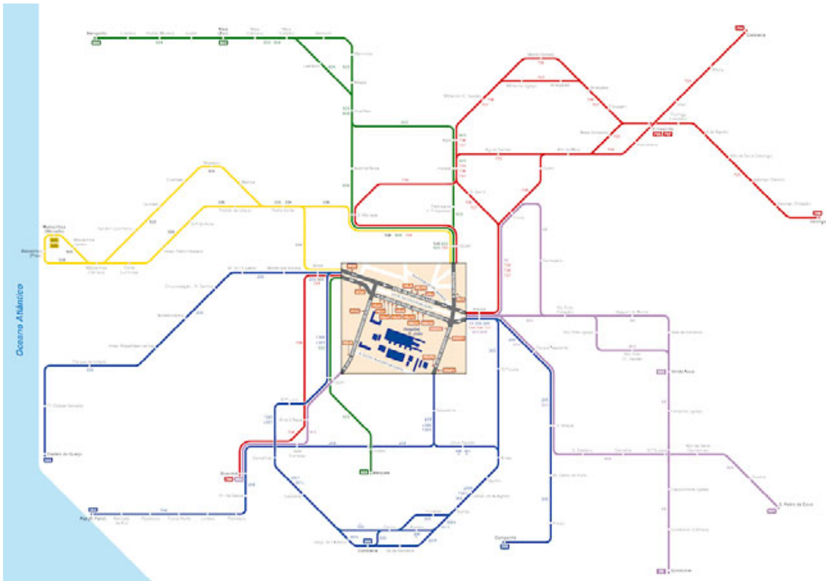

Fig. 5. Spider Map of the bus network service at Sao Joao Hospital Area in Porto, Portugal. For further detail on this figure please see http://paginas.fe.up.pt/˜ deg08005/index.html

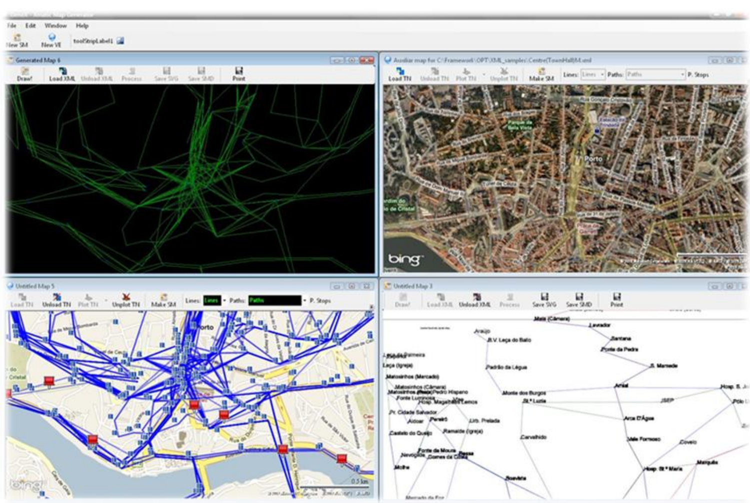

Fig. 6. The software framework, developed through our research. For further detail on this figure please see http://paginas.fe.up.pt/˜ deg08005/index.html

3.2 Electronic Spider Maps

Spider map advantages can only be fully materialized if automated means are used in their generation and use. This happens mainly in the communication of the user and time contexts: it is much faster to update an electronic map than a paper map, so an electronic map can be regenerated much faster than a paper map, enabling it to fit to a specific user context or time context. It is also better to generate user-centered maps through electronic maps [33]. The acquisition of context variables may be performed ubiquitously by seamless or autonomous sensors in pervasive systems which could directly affect in real time the production of spider maps. Space context could also be communicated more effectively and explored in many ways by using electronic spider maps. Our research has developed a software framework able to produce fully automated spider maps in soft real time [37]. This framework allows the visualization and generation of schematic (and spider) maps as shown on figure 6, serving as test lab for different schematization algorithms [38]. This is an excellent base to build user context-aware user centered spider maps in a bounded time frame, making them an ideal base for LBS.

4 How Spider Maps Can Enhance LBS and Public Transportation Ridership

If we look at the theoretical model presented in section 2.2 and depicted in figure 2, there are four dimensions of information quality which have a direct effect on the user satisfaction on mobile services. Regarding normal and schematic maps, spider maps present enhanced features to improve information quality in all the four dimensions.

4.1 Improving Context

Traditional schematic maps are not designed to pay special attention to the context of the communication act they are intended to support. Research on them has only approached syntax and semantics (ie. the symbols and their meanings in the layout of the map). Only recently the context (the third dimension of speech) [39] [40] has been given importance in the map design area. But as with any communication act, it also exists in the communication of spatial information. The spider map, due to its definition and features, is well suited to include context information. The map shall intuitively answer the user question *"where am I, and where can I go to?"*by providing him the correct space context to make the map more easily understood. The hub is a higher detail area which plays a fundamental role in communicating spatial context: when the user watches the map, intuitively it will look to the magnified area. This area shall depict the place where the user is at the present time, and the nearby stations, and all the relevant information for the user to understand that the hub represents the zone where he currently is. The zone can be only a point (a stop or station), an area (can have several stations, ex: city downtown), and shall be user-centered (the hub shall depict the geographical information accordingly to user's viewing perspective [33]). The lines flowing from the hub shall depict only the lines available from the station/stations inside the hub (not from the whole transportation network, thus reducing information amount and learning time and answering the question "where i can go to?"). The stations placed along the lines are the stations reachable from the station/stations/stops inside the hub. The hub also replaces the "you are here" statement, present at many maps, and allows the user to intuitively understand the spatial context where he is currently at. The spider map is also a good way to communicate user context. This is very important as there are different user types (at an extreme level, each user is inherently different from any other), with different intentions, needs and capabilities. Although there are many variables which could define the individual, when making transportation maps, the spider map shall be used to cope with different users, by changing its presentation (ex: high contrast schema for colorblind people, special hub and line definitions for children (ex: highlighting stations near schools and the lines which can take them there). Regarding time context, the spider map shall also change its presentation according to different times. For example, if at any instant, there is any problem in a line (obstruction, heavy load), the map shall regenerate itself in order to comply with that change. The same happens when special events that greatly affect transportation networks are taking place (ex: holidays, sport matches, celebrations). The challenge here is, this has to be achieved in near real time (which is already possible through the software framework we have been developing through our research).

4.2 Improving Content

Spider maps also provide enhanced content to allow the users to perform the five actions [11]. It allows the user to locate (through the hub), to search (as the spider map restricts the stops and lines presented to the ones the user can reach from its current location, it improves searching by eliminating superfluous information), to navigate (the user can easily know how to go to one destination through the schematized and simplified line layout). Identifying and checking are not the main objectives of the use of a public transportation network, but spider maps can be extended as other kind of maps to include content related to those actions.

4.3 Improving Interaction

Spider Maps have a higher degree of interaction quality. The use of the spider architecture is not a hit or miss matter. The spider map concept belongs to the domain of graphic organizers and mind maps. Spider architecture mimics the graphic organizers spider maps, which are proved to be improve learning and improve information recall as they represent knowledge in a similar way human brain does [41] [42] [43]. Being so, spider maps are easier to use and require less time for the user to learn them and therefore cause less errors and frustration, therefore increasing interaction quality.

4.4 Improving Connection

The use of Spider Maps cannot increase connection quality over a mobile service, as it can be easily understood. Nevertheless, the fact that spider maps can be produced in soft real time decreases waiting time for the user requesting the service.

4.5 Improving User Satisfaction and Public Transportation Ridership

As Koivumaki studies show, there is a positive relationship between the four information quality dimensions and user satisfaction, and between user satisfaction and the intention to use the service. [14]. Being so, if spider maps improve information quality in their dimensions, they will improve user satisfaction and consequently increase the intention to use the service. Dziekan [3] studies mention that one way to create high ridership in public transportation services is to strengthen their attractiveness by improving the quality of service. The author also presents the example of the city of Stockholm cooperation with the public transport authority in order to increase traveler numbers. This objective was also achieved by improving factors such orientation and information. Spider maps can play a fundamental role here in improving those factors, through their use in LBS.

5 Conclusions and Future Work

In this paper we have presented the theoretical foundations which support the assumption that the use of spider maps increases user satisfaction and intention to use LBS and therefore may increase public transportation services ridership. It is possible to conclude that the spider maps are a highly adequate vehicle to communicate transport network information in mobile services due to their higher information quality in comparison with normal or schematic maps. They improve the components of the information quality model presented by Chae [5] through the inherent advantages and innovations of their design. Their automated production through a soft real time makes them capable of responding in real time to changes in context, supporting what Steiniger calls *adaptative services* : services that dynamically respond to context [10]. Future work needs to be directed to test spider maps in real LBS of a public transportation service, to assess empirical evidence that spider maps increase user satisfaction, intention to use LBS and public transportation services ridership.

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On Viable Service Systems: Developing a Modeling Framework for Analysis of Viability in Service Systems

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Abstract. This paper explores the contribution of systems modeling to the design and analysis of viability in service systems. We apply a modeling framework called SEAM (Systemic Enterprise Architecture Method) to gain an understanding of how a service system maintains its identity and remains viable in its environment. SEAM embodies theoretical insights from systems science and organizational cybernetics, in particular the viable system model of Stafford Beer. We illustrate the applicability of the framework by modeling the design of viability in a service system.

Keywords: Viable Service Systems, Systems Science, SEAM, Viable System Model.

1 Introduction

The concept of "service system" is central to service science (SS) and service-dominant (SD) logic [1-3]. A service system is defined as "a configuration of people, technologies, organization and shared information, able to create value to providers, users and other interested entities, through service" [4]. Recently, service science researchers have shown an increasing interest in studying viable service systems (VSS) and discovering the factors that contribute to the viability of a service system.

From a systems perspective, a system is viable only when it maintains some aspects that enable the observer to identify it as different from other systems. The observer, in effect, invents the system by perceiving a purposive unity [5]. In other words, a system is defined only when an observer detects and identifies a set of entities standing in interrelations. Hence, when a system loses the aspects that help the observer distinguish it from other systems, it passes out of existence.

As the study of viable systems is a disciplined inquiry in systems science, exploration of the contributions of systems science to the study of VSS has emerged as a topic of relatively high importance among the researchers in the field. A recent issue (Spring/Summer 2010) of the Journal of Service Science is dedicated to the insights and the inferences of systems science upon research in the realm of service and in particular VSS. Understanding the building blocks of systems science can lead to a better insight into the nature of the contributions that systems science can make to the study of VSS.

M. Snene, J. Ralyté, and J.-H. Morin (Eds.): IESS 2011, LNBIP 82, pp. 30–41, 2011.

In [6], Banathy categorizes systems science into three domains of inquiry: systems theory, systems philosophy and systems methodology. Systems philosophy embodies the fundamental assumptions that provide the perspectives that give us insights into defining and categorizing the concepts and principles that are the building blocks of systems theory. Systems theory provides the theoretical insights that can be invoked to build an understanding of the complexities of some aspect of reality. Systems theory refers to the science of systems that resulted from Bertalanffy's General Systems Theory (GST). GST provides "models, principles and laws that can be generalized across various systems, their components and the relationship among them" [7]. GST is, in effect, a theory of universal principles that are common and apply to systems in general. Finally, systems methodology aims at the instrumentalization of systems theory and its application to a functional context [6]. It involves developing models and methods to make adequate predictions or retrodictions about some aspect of reality and to learn how to control a phenomenon of interest in a desirable way [8]".

A large and a growing body of literature in service science invokes theoretical insights from systems theory in particular GST and Cybernetics in order to examine various aspects of viability and gain an understanding of the factors that can contribute to the viability of a service system. (For instance see [9-10]).

Our research, however, involves a systems methodological approach to assist the design and analysis of the viability of a service system. Systems methodology provides a means for developing concrete applications and instantiations of the theoretical insights from systems science. In other words, systems methodology serves to connect the theoretical aspects of viability of a service system to an actual viable service system functioning in its context. It thereby sheds light on the preconditions necessary for a service system to meet the criterion of viability. This is achieved by means of applying models and methods that embody systems theory.

In this paper, we apply the Systemic Enterprise Architecture Method (SEAM) to represent and analyze a service system through the lens of viability. SEAM embodies theoretical insights from GST and the viable system model (VSM) developed by Stafford Beer [11-12]. SEAM is designed to analyze and assist in the design of business and engineering strategies. Developed at Ecole Polytechnique Fédérale de Lausanne (EPFL), SEAM has been used for teaching [13] and consulting [14] since 2001.

We illustrate the application of the modeling framework with an example inspired by a consulting project we undertook for a Swiss utility company called SIG (Services Industriels de Genève). The project we conducted at this utility company helped us gain important insights into various aspects of its service offering and implementation and thus makes the example concrete.

Our discussion is structured in the following way. In Section 2, we explain the key conceptualizations and the related theoretical principles that we employ in our modeling process. These conceptualizations are graphically represented in a "conceptual model". In Section 3, we model the utility company as a service system by applying the SEAM modeling framework. The theoretical insights embodied in our conceptualizations and thereby in our SEAM model will contribute to our understanding of the mechanisms by means of which the utility company maintains its viability. In Section 4, we discuss the related work and we present our conclusion and future work in Section 5. Throughout the paper we define a number of important terms from systems science that can contribute to a shared understanding of key systems terminologies and concepts used in this paper.

2 Conceptualizations

Central to systems methodology, is the practice of systems modeling. In systems modeling we construct systems that are adequate models of some aspects of reality [8]. The first step of systems modeling process is for the modeler to observe some aspect of reality referred to as the “universe of discourse” (UoD). Employing a set of conceptualizations, the modeler then tries to distinguish a set of entities that compose the universe of discourse and the relationships between them. In effect, the conceptualizations employed in a model form a lens through which the modeler observes phenomena of interest in a UoD. [15]. For instance, when a modeler looks at people who work in a building with a logo on the building, the modeler’s conceptualization of what is a “company” – if it matches what she sees – will help her realize that she is looking at a company. Without such conceptualization, the modeler would never be able to recognize the company.

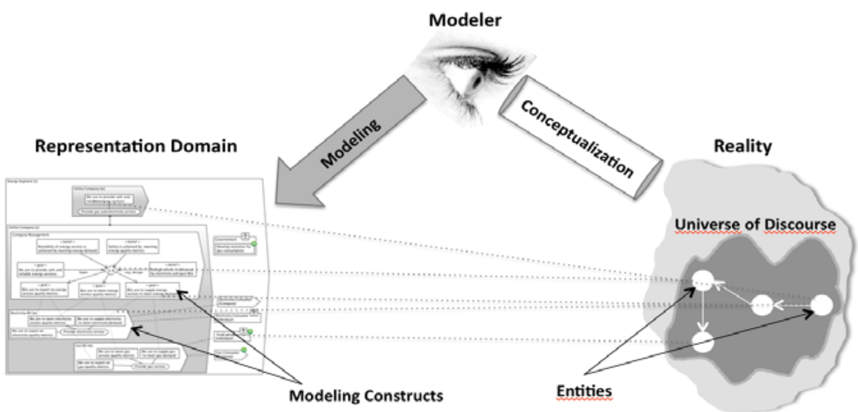

Fig. 1. The modeling process

Next, the modeler develops a model in the representation domain. The model is composed of modeling constructs that represent the observed entities in the UoD. The conceptualization explains the kinds of modeling constructs in the representation domain and allows a mapping between the modeling constructs in the representation domain and the entities observed in the universe of discourse. A conceptualization thereby gives the modeling constructs a real-world interpretation. Figure 1 represents the process of systems modeling.

In this paper we follow the modeling process illustrated in Figure1. SIG constitutes our universe of discourse and SEAM is the modeling framework we apply to build models of SIG in the representation domain. Our conceptualizations are based

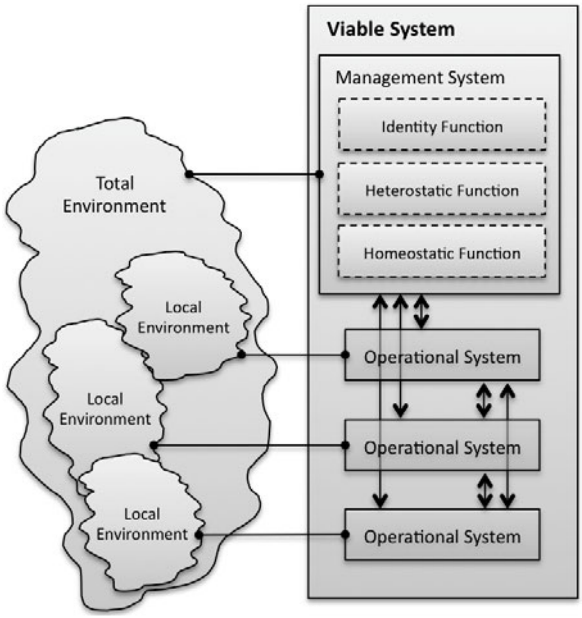

Fig. 2. The conceptual Model of a Viable System

upon GST and Cybernetics, in particular the work of Stafford Beer. Based on this understanding, we conceptualize the observed system in the UoD as a set of interacting systems and the channels that connect these to each other and to their environment.

Figure 2 is a graphical representation of the conceptualizations employed in our model building process. We call this graphical representation a "conceptual model". In the following sections we explain and interpret various parts, as well as the diagrammatic conventions of the conceptual model.

2.1 Systems

Our conceptualizations are inspired by the work of Stafford Beer and in particular the viable system model (VSM) [11-12]. We decompose a viable system into a set of operational systems that interact with a management system.

Operational Systems. Operational systems are the systems that perform the operations within a viable system. Operations create the outputs that justify the existence of the system from the observer's point-of-view. Hence, the functions of the operational systems are the reason that the system exists in the first place [12]. Recursively, an operational system is in turn a viable system. This means, an operational system contains smaller operational systems and is contained in a hierarchy of larger operational systems. Thus, an operational system can be decomposed to its constituent operational systems and its management system. In Figure 2, we illustrate a viable system with three operational systems. The operational systems in our conceptual model correspond to System 1 in VSM.

Management System. The management system performs a set of systemic functions necessary for the system to remain viable. In the following we discuss the main functions of the management system.

Homeostasic Function. The homeostatic function of the management system directs the "inside and now" operations (i.e. the current and internal operations). It develops a black-box view of the operational systems (i.e. viewing only their inputs and outputs without knowing their internal functions and constituent systems) and looks for ways to optimize the overall efficiency and improve the performance of the operational systems by overviewing their interactions. It also regulates the operational systems to keep the overall operations running smoothly, and to deal with and recover from any disruptions and oscillations. In order to achieve regulation, it communicates the desired bounds of certain variables of the operational systems and monitors compliance. Regulation of the interrelated operational systems creates synergy and makes the system more than the sum of its parts. Stability is an emergent property of the homeostatic function of the management system. The homeostatic function of the management system in our conceptualization maps onto System 2, 3 and 3* in VSM.

Heterostatic Function. The heterostasic function deals with "outside and future". It guarantees the adaptation of the system as a whole to a changing environment. In so doing, the heterostatic function requires an understanding of the total environment in which the system is embedded; which is beyond the capability of the operational systems, as they concern themselves with their local environment, which is only a sub-set of this total environment. As well as interacting with the environment, the heterostasic function needs to interact with the homeostatic function. This is because adaptation cannot be achieved without an understanding of the system as it currently exists. Evolution and adaptation are the emergent properties of the heterostatic function of the management system [16]. In Beer's VSM, System 4 performs the heterostatic function.

Identity Function. The identity function maintains the identity and ethos of the system by balancing the "inside and now" (i.e. homeostatic) and the "outside and future" (i.e. hetereostatic) functions. Identity is defined as the set of variables by means of which an observer identifies and distinguishes the system from other systems. Identity can be interpreted as invariance in some certain aspects of the system, in spite of all the changes that the system is going through. Hence, a system can sustain its identity only when a proper balance between stability and change is made. The identity function is performed by System 5 in VSM.

2.2 Channels

A system collapses if it does not interact with its environment. Thus, openness to environment is a precondition to viability. A system should interact and communicate with its environment in order to maintain its viability [17]. Channels enable the interaction and communication between the entities within the system and the entities with the environment. Two sets of channels can be distinguished in the conceptual model.

The inter-connecting channels within the system that are represented by arrows in Figure 2. These channels enable operational systems' interactions and, communication between the operational systems and the management system.

The channels connecting the system elements to the environment that are denoted by round tip lines in the conceptual model. These channels enable the operational systems' interactions with their local environments as well as the interaction between the management system and the total environment of the system.

2.3 Viability

The viability of a system is a function of the balance between homeostasis (i.e. stability) versus heterostasis (i.e. adaptability) [12]. A system achieves viability by maintaining the aspects of its operations that are linked to its identity (i.e. the aspects that enable the observer to identify the system). Maintenance of these aspects requires the management system to keep the state of some variables of the operational systems stable and/or precipitate change in the state of some operational systems' variables. Recursively, the states that an operational system is to maintain or achieve constitute its identity from the point of view of the management system. Hence, the management system within each operational system is to ensure the achievement or maintenance of those states, for the operational system to remain viable.

3 Modeling and Analysis of Viability in a Service System

In this section we develop SEAM models of SIG based on the conceptualizations explained in section 2. In the SEAM models, SIG is referred to as "Utility Company". Figure 3 is a SEAM model of the Utility Company in the Energy Segment.

In SEAM a system is denoted by a block arrow and can be represented as a whole (i.e. black box) or as a composite (i.e. white box). Modeling the Energy Segment as a composite we represent the Utility Company as the service system and its total environment. The environment of the service system comprises the Government as the *regulator* and Gas and Electricity Consumers (Individual and Company) as the s*ervice adopters.*

We conceptualize a service system as an operational system. Thereby, the service systems in our SEAM models correspond to the operational systems in the conceptual model. Therefore, considering the recursive nature of the operational systems, each operational system is composed of its constituent service systems and a management system.

A service system is characterized by its behavior and properties. In SEAM, behaviors and properties are represented by ovals and rectangles. Service systems as wholes and as composites have behaviors and properties.

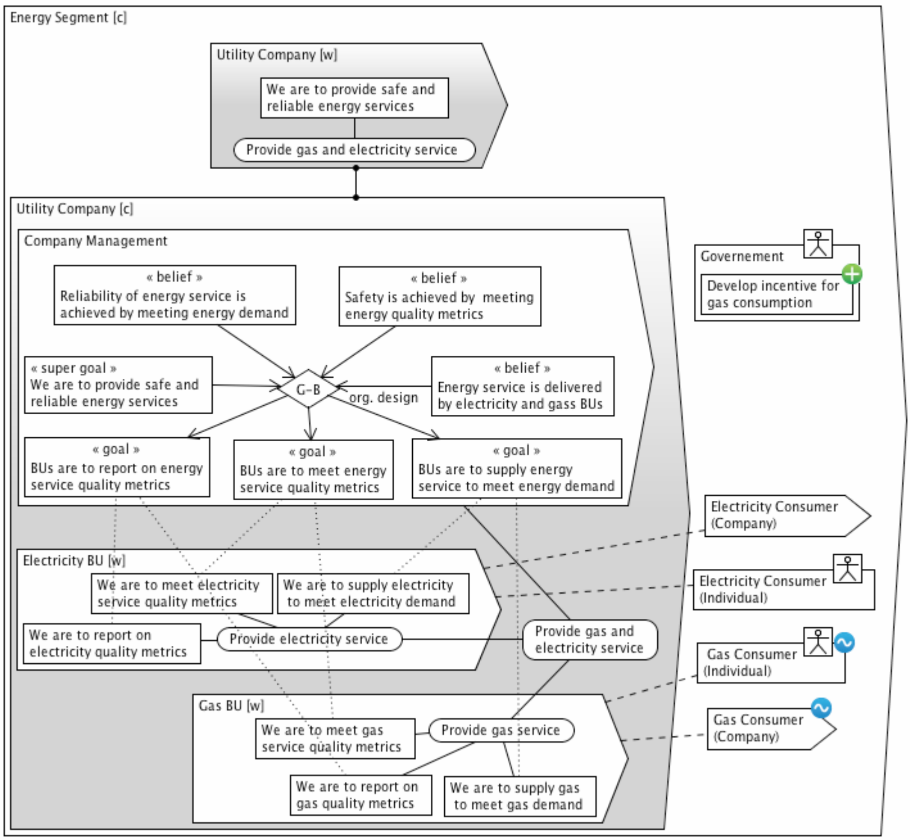

Fig. 3. Utility Company in Gas Segment

We call the behavior of a service system as a whole "service". The behavior of a service system as a composite is called "process". This process captures the implementation of the service. Representing a service system as a composite we model how its service systems and management system contribute to the service implementation process.

In Figure 3, "Provide gas and electricity service" is the service, the Utility Company as a whole, is offering to the adopters. Modeling the Utility Company as a composite, we represent the Company Management (i.e. the management system) and Electricity BU (Business Unit) and Gas BU (i.e. service systems) and their contribution to "Provide gas and electricity service".

The property of a service system as a whole captures the "identity" of the service system. The identity of a service system is expressed by a prescriptive statement that conveys what the service system *is to do* in order to sustain its viability.

We model the way a service system sustains its identity by considering maintenance of a particular identity property as a *super goal* and refining it to a set of (*sub)goals.* This refinement is a cognitive process carried out by the management system with the help of the *beliefs* it holds. Beliefs, in effect, represent the management system's interpretations of the state of service system and the systems with which the service system interacts.

Based on the explanations in Section 2.3, goals are grouped into two categories. The first category includes the goals that represent the changes that are to be made to some states of the service system. We refer to these goals as *achievement goals*. Goals in the second category specify the states of the service system that are to be kept the same and maintained. We call these goals *maintenance goals*. Achievement and maintenance goals respectively reflect the heterostatic and the homeostatic functions of the management system within a service system.

The management system of the service system then, assigns goals to the constituent service systems. These goals are to be considered by the service systems as the super goals and are thereby refined to a set of achievement and/or maintenance goals.

In Figure 3, "We are to provide safe and reliable energy services" is the identity property of the Utility Company as a whole, which is then perceived by the Company Management as a super goal. The Company Management believes that "Reliability of energy service is achieved by meeting energy demand" and the belief that "Energy service is delivered by electricity and gas BUs" is derived from the organization design of the Utility Company (in the SEAM models, such goals are annotated by "org. design"). Based on these beliefs, the goal "BUs are to supply energy service to meet energy demand" is developed by the Company Management as a refinement of the super goal. This goal is then communicated to the BUs by the management system as their identity properties. The Gas BU interprets this goal as "We are to supply gas service to meet gas demand". Other parts of the model can be interpreted the same way.

The pluses in the Figure 3 mark the emergence of new entities in the universe of discourse. As it can be seen the government develops incentives for gas consumption. The new incentives lead to an increase in the number of the Gas Consumers (private and company).

In Figure 4, we represent the Gas BU as a composite. The composite view of the Gas BU, provides us with insights into the beliefs and the goals the Gas BU Management holds. The increase in the number of gas consumers leads to the belief "Demand for gas is rising". The Gas BU management also believes that "Gas supply is adjusted by increasing or decreasing the pressure in pipes" and the organization design of the Gas BU derives the belief that "Gas supply dept. adjusts the pressure in pipes". As the identity of the Gas BU is geared to meeting the demand, the BU management formulates the achievement goal "Gas supply dept. is to increase the pressure in pipes".

The Gas BU, on the other hand, is to report on and meet the gas service quality service in order to sustain its identity. As illustrated in Figure 4, the Gas BU believes that "Gas quality metrics deal with incidents" and "preventative measures reduce the

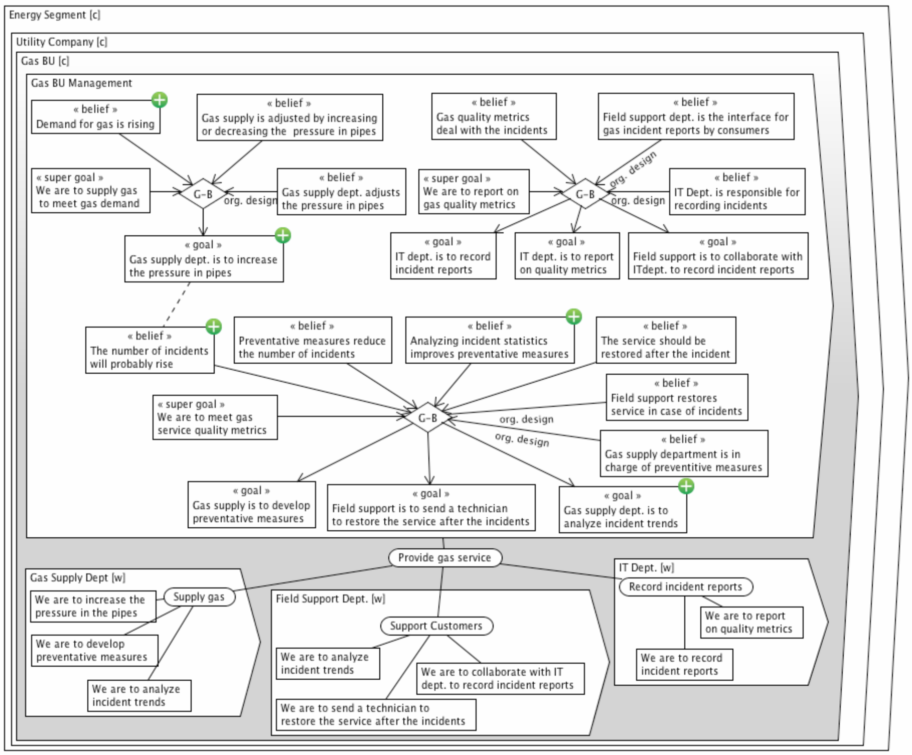

Fig. 4. Gas BU in the Utility Company

number of incidents". Increasing the pressure in pipes gives rise to the belief "The number of incidents will probably rise". The rise in the number of incidents leads to the inability of the Gas BU to meet the super goal "We are to meet the gas service quality metrics" and consequently puts the viability of the Gas BU and the Utility Company in threat.

The belief "Analyzing incident statistics improves preventative measures" reflects how the Gas BU management plans to counteract the effect of the increase in the pressure in pipes. Analysis of incident statistics results in the development of more effective preventative measures and therefore decreases the incidents. As "Gas supply dept. is in charge of preventative measures", a belief stemming from the organization design, the Gas BU Management formulates the maintenance goal "Gas supply dept. is to analyze incident trends".

Representing the Gas BU as a composite we also model the contribution of its departments to the implementation of the "Provide gas energy" service.

In Table 1, we present a mapping between the conceptualizations, SEAM modeling constructs and the entities in the universe of discourse in the modeling process of this paper.

Table 1. Mapping between the conceptualizations, modeling constructs and entities in the UoD

		Entities in the UoD	
Conceptualizations	**Modeling constructs**	**Utility Company [c]**	**Gas BU [c]**
Management system	Service system management	Company Management	BU Management
Operational system	Service system	Electricity BU, Gas BU	IT Dept., Field Support Dept., Gas Supply Dept.
Identity	Super goal	We are to provide safe and reliable services	• We are to supply gas service to meet gas demand …
Homeostatic function	Maintenance goal	• BUs are to supply energy service to meet energy demand …	• IT dept. is to report on quality metrics • Gas supply is to analyze incident trends …
Heterostatic function	Achievement goal	----	• Gas supply dept. is to increase the pressure in pipes

4 Related Work

We divide our related work into two categories of research activities: research aimed at gaining insights into viability in service systems by applying theoretical frameworks from systems science and the viable system model and, the attempts made in developing conceptual modeling techniques that can contribute to service management.

In the first stream of research, in [18], the authors compare the fundamental concepts of smart service systems and viable service systems, highlighting the potential mappings between the service science and systems science principles. In [19], the author explains the implications of the law of requisite variety within the service science and reasons about the mechanisms through which a system deals with the variety introduced by its environment. [20] provides an application of VSM to tourism services.

In the realm of conceptual modeling; e3Service [21] is a method for semi-automatically reasoning about matching service offerings with customer needs. In order to make this semi automatic reasoning possible, e3Service assumes that the customer and supplier share the same ontology, that the customer specifies her needs in the same vocabulary as the supplier specifies its offering. In SEAM, we precisely avoid to make this simplifying assumption. This comes at the cost of enormously complicating automatic or event semi-automatic reasoning with the benefit of models that more accurately reflect reality.

i* [22] is one of the leading modeling method used in the requirements engineering research community for reasoning about functional requirements (FR) and non-functional requirements (NFR). i* provides modeling artifacts for reasoning about alternative satisfactions of NFR. i* models describe relationships as actors dependencies. Hence, i* offers support for reasoning about alternatives. i* has been extended with value reasoning in [23] .

5 Conclusion and Future Work

This paper was an attempt to apply the viability theory developed in systems science and cybernetics to the service science. To do so, we applied a modeling technique called SEAM. The modeling constructs in the SEAM models enable us to map the theoretical conceptualizations of viability onto the mechanisms through with a service system remains viable. Our approach was illustrated by modeling and analysis of viability in a service system.

Our future work focuses on augmenting the modeling framework with variety concepts and applying it to a prospective case in order to develop prescriptions on a viability compatible design.

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An Approach to Extract the Business Value from SOA Services

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Abstract. Enterprises deploy SOA for the cost-effective flexibility and enhanced usage of legacy IT. But, the shift to SOA does not come easy and cheap. Building an effective SOA platform requires tight integration between new and existing product categories, and it may require large investments. Therefore, conventional investment valuation methods need to be combined with other modern techniques to reflect SOA's long-term strategic investment nature, the inherent uncertainty and the managerial discretion. Some emerging value-based analytical methodologies have started to be developed extensively under the umbrella concept of Business Value Analysis (BVA). However, BVA is not yet a wholly integrated and the theoretical foundation for it needs to be strengthened. Thus, in this paper, we apply modified CVP/BEP method developed under the BVA umbrella for the evaluation of SOA projects, in particular for the services reuse.

Keywords: Business Value Analysis (BVA), Information Technologies (IT), Return of Investments (ROI), Service-Oriented Architecture (SOA), Break-even Point (BEP), Cost-volume-profit (CVP).

1 Introduction

The enterprises are turning to SOA for the cost-effective flexibility and enhanced usage of legacy IT. But, building an effective SOA platform requires tight integration between new and existing product categories, and it may require large investments for new products such as SOA repositories. In the early stages of an SOA, limited ROI is achieved mainly from the creation of services from existing applications. It is not unusual for some organizations to experience negative ROI compared to conventional software development methods because additional investment may be required to achieve reusable services and to build an SOA infrastructure. IT flexibility becomes a reality once there are enough services in an SOA to stimulate extensive internal and external services reuse and consumption (Fig. 1). But, the largest business value of SOA, e.g., business agility and competitive advantage, is only gathered once the business starts to use services to orchestrate processes within the enterprise and choreograph processes between enterprises. Unlike traditional technology investments that tend to be implemented enterprise-wide in "big-bang" fashion, SOA is realized

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over a long time horizon through many distinct projects distributed throughout an organization (Fig. 2). And, in addition to the uncertainty associated with future service reuse, quantification of the soft benefits of SOA is often problematic [1 ÷ 4].

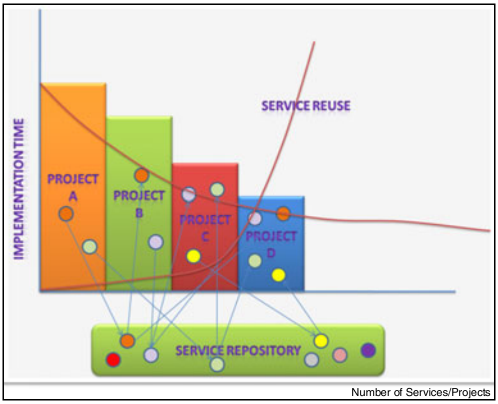

Fig. 1. Benefits from Components Reuse in SOA [5]

Therefore, the conventional valuation methods need to be combined with concepts modern techniques to reflect SOA's long-term strategic investment nature and the inherent uncertainty involved in SOA investment. These and some other emerging value-based analytical techniques, showing a promise, have started to be developed extensively under the umbrella concept of Business Value Analysis (BVA). BVA attempts to analyze the factors and forces that will shape the future instead of trying to forecast the future. It brings together methodologies that extend DCF (Discounted Cash Flow) and other traditional financial analysis techniques to include intangibles and other factors common to the digital economy. BVA includes the following techniques: Real-Options, Business Model Dynamics, Synthetic Markets, Multi-criteria analysis, Ratio methods, Break-even Point and Portfolio theory [6 ÷ 8].

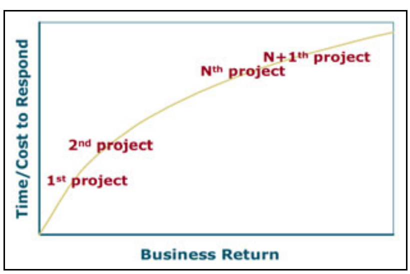

Fig. 2. Increase of SOA "Business Value" with Number of Projects [9]

However, BVA is not yet a wholly integrated analysis technique and the theoretical foundation for it needs to be strengthened. Further, more work needs to be done on the practical side. Properly implemented with supporting IT/SOA, BVA has the potential to lead to better investment decisions and business results (Fig. 3) [6, 10, 11]. Thus, in this paper, we apply modified CVP/BEP method, developed under the BVA umbrella, for the evaluation of SOA projects; in particular for the services reuse.

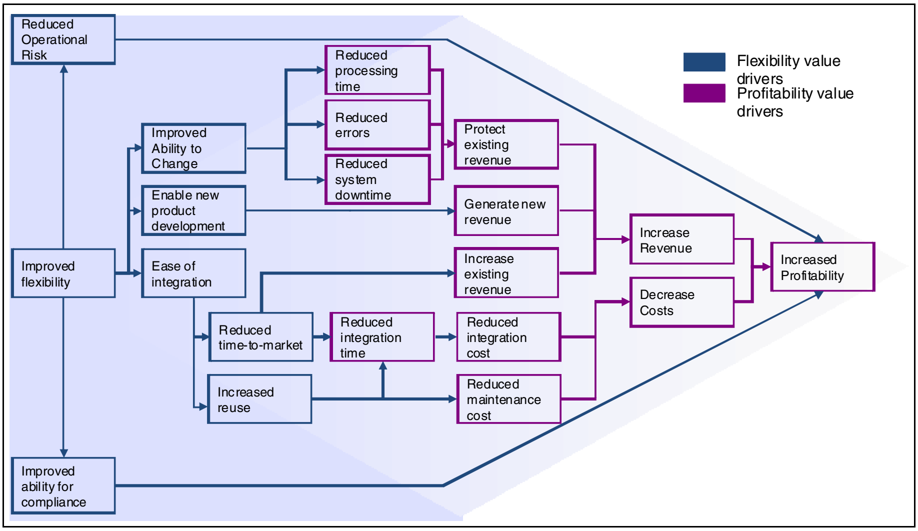

Fig. 3. SOA "Business Value" Features Tree [12]

2 SOA Concept and Its Importance for Enterprise Management

The Service-Oriented Architecture (SOA) is an architectural framework that takes business applications and breaks them down into *services* that can be made available for use *independent of the applications* and the computing platforms on which they run. These services can be integrated and used to build *new capabilities supporting new functionality from within current portfolio or from extended value chain* [12, 13].

Today's businesses depend on electronic processes at every level. An organization's ability to stay competitive relies heavily on being able to adapt its electronic processes in support of initiatives designed to improve productivity, reduce costs, deliver higher-quality information, and accelerate routine tasks. However, adapting business-critical processes requires evolving the systems they run on quickly and cost-effectively. This, in turn, is an extremely multifaceted task [4, 14, 15].

For these enterprise needs, SOA offers protocol independence, meaning that different consumers of computing services - such as an application, a server system, or a human end user can communicate with the same service in a different way to obtain the data or functionality desired. Services themselves function as discrete components, designed to aggregate underlying complex computing interactions into reusable "packages" that can be invoked whenever that particular piece of functionality is required (Fig. 3) [16, 17].

3 SOA Investments and Business Value Estimation Methodologies

Any methodology has to be designed to assess the business "competitive value assets" that are important to effectively implement a business strategies; assets such as those used to understand customer needs and turn them into knowledge, those used to create value, and those needed to deliver value. And, since an assessment process is in itself a strategic initiative, it has to be designed and implemented carefully to fit the goal that each benefit can provide. It may be possible to use the same evaluation to gain multiple benefits but it must be designed to do so [18].

As enterprises grow, it typically takes longer to see the impact of actions or investments. The effect also may be distributed throughout the enterprise, requiring more sophisticated techniques to capture the organizational impact of a particular action or investment. The distribution of effects may also make it more difficult to capture the right measures or collect data on measures in a timely or consistent way, since the effects are likely occurring outside the IT unit's domain. Thus, from an organizational perspective, it is difficult to place a concrete value on many decisions, actions, or investments because the effects are too distributed or too moderated by other factors to measure them easily or accurately [19 ÷ 23].

3.1 Problems with Measuring SOA Related Value

What is it about SOA that makes measuring its strategic value so difficult? A simple answer is that there are too many ways to measure it. Every consultant, practitioner, or faculty member has a unique method for capturing SOA value. Table 1 provides the list of sample measures [19]. Many of these models were designed for the private sector rather than for large enterprises, and some are more easily applicable than others to the goals and objectives found in the academic environment. Even if IT leaders can sift through these models and find an appropriate one to use, the unique challenges of IT valuation have only begun.

Table 1. List of Methods for Valuing IT in general and SOA in particular [20]

Accounting rate of return	Boundary value	Multi-objective methods
Analytic hierarchy process	Costs-benefits analysis	Profitability index
Application benchmarking	Costs-effectiveness analysis	Process quality management
Balanced scorecard	Costs-value techniques	Schumann's method
Bayesian analysis	Costs-revenue analysis	Real-options valuation
Bedell's method	Delphi evidence	System dynamics analysis
Buss's method	Information economics	Utility function assessment
Benefits-risks portfolio	Infrastructure analysis	Ward's portfolio analysis
Break-even analysis	Investments portfolio	Wissema's method

And, why is measuring the value of SOA so hard? As SOA has permeated organizations, measuring its direct contribution to the bottom line has become more difficult. This is because cost savings, primarily in the form of headcount reduction and productivity improvements, were gains that were achieved early on in a system's lifecycle.

In fact, as SOA is evolving over time, the difficulty of calculating the value of SOA investments is increasing, due in large part to refocusing application development away from clerical efficiency and toward a wider range of less well-defined outcomes such as competitive advantage, knowledge management, and improved organizational performance [20 ÷ 23].

3.2 Splitting the Variables of SOA "Business Value" into the Dimensions

We distinct and split here the SOA value variables into two dimensions: costs and benefits with 6 cost variables and 5 benefit variables. This splitting is needed for the definition of hypothesized relationships between the costs, benefits, and the "Business Value" (Fig. 4). The costs dimension is related to the efforts required for an enterprise-wide IT effort such as SOA, while the benefits are potential rewards of the SOA deployment.

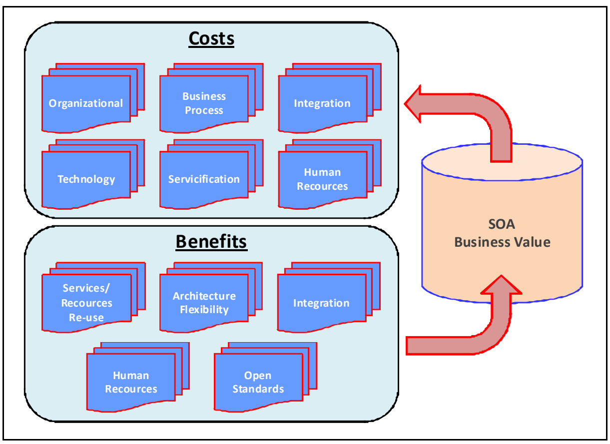

Fig. 4. Costs and Benefits Components of SOA "Business Value" [24]

The most important benefits are derived from low vendor lock-in, allowing enterprises to replace customized applications and products. This is followed by variables such as platform and technology independence leading to greater collaboration and integration, with less spending on middleware infrastructure, time to market, which enables enterprises to come out with products/services in a shorter timeframe, adaptability to emerging business scenarios. The benefits due to a reduction in application redundancy are emerging from rationalization of applications, and re-use of business processes, applications, and infrastructure through the potential reuse of services and infrastructure, standardized employee skill sets. As the SOA interfaces are abstracted from the implementation (loose coupling) it enables systems to be assembled and disassembled easily as they have less dependency on other systems. Finally, there are benefits from reduced cost and time of introducing new business processes, reduced cost and time of modifying existing business processes, reduced cost and time of introducing new applications, reduced cost and time of modifying existing applications, reduced cost and time of introducing new IT infrastructure, and reduced cost and time of modifying existing IT infrastructure.

To conclude, the IT investment decision makers need to have a comprehensive understanding of the cost and benefit variables to arrive at the business value measure to justify SOA-based IT architectures [20, 22, 24].

3.3 Risk Management Challenges within of IT/SOA Related Projects

Enterprises are investing capital into certain objects in order to generate cash inflows and subsequently to increase the return of the invested capital. Typically risk-averse management is making risky investments hoping to achieve an excess return over the risk-free rate. There is a general connection between risk and return of an investment object: higher return is systematically associated with higher risk [25].

Going further into the IT investments direction, we need to understand the context of these projects and the risks associated with them, since IT related investments are ones of the most profitable as well as the most challenging for modern enterprises. Thus, any IT investment project has to be embedded in an organization's technology infrastructure, relevant business processes, organizational environment, and external relationships. As an example, the risk factors that can impact investment decision process:

- *Organizational factors* - misalignment of internal goals, lack of leadership support;
- *Business process factors* - fear of changing work assignments;
- *Technology factors* - rapid changes in technology, interacting with parallel systems, scale and complexity [7].

Furthermore, project failures are the result of the multiplicity of risks inherent in software project environment. Software development projects are collections of larger programs with many interactions and dependencies. It involves a creation of something that has never been done before although the development processes are similar among other projects. As a result, these projects have a dismal track-record of cost and schedule overruns, and quality/usability problems [26, 27].

4 BEP/CVP Analysis with Emphasis on Services Re-use in SOA

Cost-volume-profit (CVP) analysis expands the use of information provided by breakeven analysis. A critical part of CVP analysis is the point where total revenues equal total costs (both fixed and variable costs). At this breakeven point (BEP), a company will experience no income or loss. This BEP can be an initial examination that precedes more detailed CVP analyses. The conventional Cost-volume-profit analysis (Fig. 5) employs the same basic assumptions as in breakeven analysis. Further, the breakeven point can be determined with a mathematical equation, using contribution margin, or from a CVP graph [28, 29].

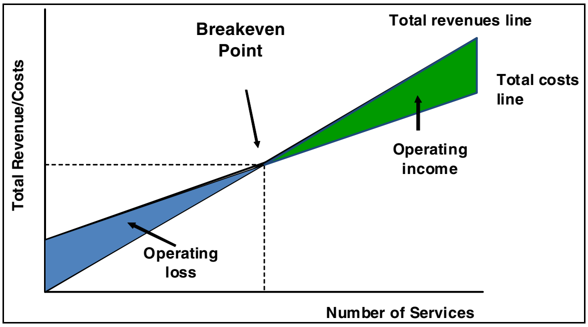

Fig. 5. Conventional CVP/BEP Approach [29]

4.1 Short Overview of Reference Resources

Since its development by Jaedicke and Robichek [30], the various CVP models have been proposed and studied: single-product versus multi-product, single production technology versus multiple technologies, single uncertainty source versus multiple uncertainty sources, uncertainty with respect to price versus uncertainty with respect to sales quantity, the assumption that production equals sales versus differentiation of the production quantity from the sales quantity, specification of the decision question simply as produce-not produce versus determination of a quantity to produce and/or a price to set, use of the fundamental CVP equation alone versus the addition of an "economic" demand function relating quantity sold to price charged, and so on and so forth [31].

Namely, the following researchers have contributed to the cost-volume-profit analysis under uncertainty: Dickinson [32]; Hilliard and Leitch [33]; Kottas and Lau [34]; Ismail and Lauderbeck [35]; Constantinides, Ijiri and Leitch [36]; Barry, Velez-Arocho and Welch [37]; Lau and Lau [38]; Kim, Abdolmohammadi and Klein [39]; and Yunker [31, 42].

4.2 Applying Modified CVP Approach to SOA Service Reuse Projects

The purpose of our work was to apply modified CVP/BEP method for the evaluation of SOA projects in general and for the services reuse in particular. We take as basis a diagram presented by [40] (Fig. 6), which reflects the specific of SOA investments in comparison with traditional IT software development approaches.

From the Fig. 6, we can see that the SOA-related service costs do not have linear nature, unlike IT traditional service implementation costs. This happens because the services developed within of SOA framework can be re-used further. Consequently, the number of (business, composite) services grows but the costs for their development – not or almost not, since they are just orchestrated/reconfigured from already existing ones.

Thus, according to what was discussed in the introduction, in order to find Break-Even Point (e.g., the point where SOA-based approach to the services development and deployment become economically feasible in comparison to the conventional software development methods), we perform here an analysis of BEP positioning depended on the following aspects: amount of services re-used, size of SOA projects and enterprises, specific implementation areas and industries.

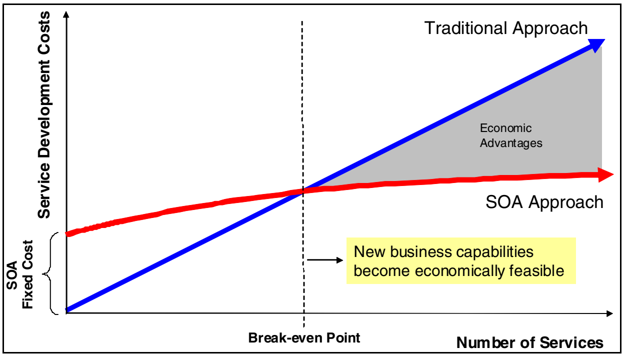

Fig. 6. Economic Value of SOA-oriented Development [40]

Besides, we apply combined/hybrid approach. Namely, for the conventional software/services development projects we apply conventional CVP/BEP analysis (Eq. 1) widely described in the mentioned above references as well as in [41] and [42]. But, for the SOA-based projects, we use modified cumulative distribution function (cdf) (Eq. 3 and 4) of the negative exponential distribution (Eq. 2). Why do we apply the modified cdf for the SOA costs? From the Fig. 6, we can see that SOA first project costs (e.g., SOA fixed costs) are not equal to zero. In comparison to the conventional IT "single application" approach – to build SOA framework considerable investments are needed, see details in the introduction. So, we set up the value "A" - SOA fixed costs, which is higher than "1".

$$\pi = pq - cq - f = (p - c)q - f \tag{1}$$

where: .. .. profits, p .. price, q .. quantity, c . . unit cost (average variable cost), f .. fixed costs [31, 41, 42].

$$f(x) = \begin{cases} \lambda e^{-\lambda x}, & x \ge 0 \\ 0, & x < 0 \end{cases} \quad \text{where } \lambda > 0 \tag{2}$$

$$F(x) = \begin{cases} 1 - e^{-\lambda x}, & x \ge 0 \\ 0, & x < 0 \end{cases} \tag{3}$$

$$F(x) = \begin{cases} A - e^{-\lambda x}, & x \ge 0 \\ 0, & x < 0 \end{cases} \tag{4}$$

5 Conclusions and Further Work

Because this paper is a research in progress and due to the space limitation, we present here a shortened picture of our working theme. We have already made extended recherché of the previous work and have collected data necessary to develop our approach. We perform currently a modeling of BEP placement fluctuation depending on influencing factors/variables. As the next step, we also plan to compute the variance and the standard deviation of gotten BEP values.

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An Enhanced Framework for Semantic Web Service Discovery

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Abstract. The paper describes an ontology-based framework for semantic Web services description and discovery. The proposed framework relies on a lightweight and minimal description model allowing to describe services in terms of a set of functional and non-functional properties. Functional properties describe services capabilities in terms of Inputs, Outputs, Preconditions and Effects (IOPE). Non-functional properties describe services in terms of Quality of Service (QoS) properties. We propose an enhanced discovery approach in which Web services are discovered based on their functional and non functional properties. The enhanced discovery approach proposed is twofold. First, the approach relies on deductive relaxation of discovery queries based on semantic service descriptions and domain knowledge (domain ontology) to select a set of services that match a discovery query with different matching degrees. Second, non-fonctional properties are incorporated into the Web service discovery mechanism to generate a partially ordered list of services that meet user functional and non-functional requirements.

Keywords: Semantic Web, Web service discovery, Ontologies, deductive reasoning, logical relaxation, Quality of Service.

1 Introduction

Due to the proliferation and ubiquity of the Internet network, information systems are becoming increasingly distributed in nature. This growing connectivity allows organisations to share different types of resources, to automate and outsource their business processes in order to offer their services to a worldwide audience [1]. The paradigm of service-oriented computing is gaining popularity as an appropriate system engineering approach for enabling distributed, heterogeneous software components to communicate and interoperate through Web services [2]. Existing Web service technologies such as the Web Service Description Language[1] (WSDL), the Simple Object Access Protocol[2] (SOAP), and the Universal Description, Discovery, and Integration[3] (UDDI) have concentrated

[1] http://www.w3.org/TR/wsdl
[2] http://www.w3.org/TR/soap/
[3] http://www.uddi.org/pubs/uddi_v3.htm

M. Snene, J. Ralyté, and J.-H. Morin (Eds.): IESS 2011, LNBIP 82, pp. 53–67, 2011.

on providing an interoperability infrastructure and syntactic service descriptions. Recently research on semantic Web has explored the use of ontologies to enhance service descriptions with formal semantic annotations, such services are namely known as Semantic Web Services (SWS) [3].

The overall aim of this effort is to enable semantic-based reasoning that exploit rich service descriptions to support smooth automation of service discovery and composition. However, due to the inherent complexity required to fully capture computational functionality, creating SWS descriptions has represented an important knowledge acquisition bottleneck and has required the use of rich languages and complex matchmaking algorithms. Semantic frameworks such as OWL-S [4], WSMO (Web service Modeling Ontology) [5] and SAWSDL (Semantic Annotations for WSDL) [6] propose rich semantic descriptions of Web services. On one side, OWL-S and WSMO frameworks offer domain-independent and structured representation of service semantics by means of upper (top-level) service ontologies and languages with formal logic groundings such as OWL and WSML. On the other side, SAWSDL provides a set of semantic annotations to enrich syntactic WSDL service descriptions and comes without any formal semantics. We may notice that these frameworks offer heterogeneous semantic descriptions of Web services because they support different service semantics facets, they use different languages to express service descriptions, and hence they allow different types of reasoning.

In this paper, in order to deal with semantic heterogeneity of semantic Web services descriptions, we propose an RDF-S *canonical description semantic model* comprised by a set of canonical primitives that captures service capabilities (functional properties) and Quality-Of-Service (QoS)-related properties (non-functional properties) of Web services. The proposed model can be seen as a *lightweight and minimal model* of semantic service descriptions that captures the core semantics of a Web service. Semantic frameworks presented above are linked to our canonical description model by a set of semantic mappings. Therefore, we propose an enhanced Web service discovery approach that relies on both functional and non-functional properties to select the most *appropriate* services. Thus, based on the canonical model, our approach allows to discover semantic Web services created under different frameworks.

The paper is structured as follows. Section 2 reviews existing frameworks for semantic Web service description and main approaches for service discovery. Section 3 presents an enhanced semantic Web service description and discovery framework. In section 4, we illustrate our contributions with a real-world case study from the bioinformatics domain. Finally, section 5 concludes and outlines our future work.

2 Related Work

Semantic service discovery is the process of locating existing Web services based on the description of their functional and non-functional semantics. Discovery scenarios typically occur when one is trying to reuse an existing piece of functionality (represented as a Web service) towards building new or enhanced business processes. In following, we review semantic service description frameworks considered as the most prominent ones in the field of SWS. Also, we briefly describe the two services description languages USDL [7] and BSDL [8] that offer service descriptions from a purely business perspective. We review only functional-aware Web services discovery approaches which consider only functional service profiles in terms of inputs, outputs, preconditions and effects or post-conditions.

2.1 Semantic Web Service (SWS)

Semantic service description refers to an abstract description that makes explicit functional and/or non-functional semantics of a Web service. Functional semantics are captured by a service profile and/or service process model. The service profile describes the service signature in terms of Input (I) and Output (O) parameters, Preconditions (P) and Effects (E) which are conditions supposed to hold before or after executing the service in a given world state. In contrast, non-functional properties allow the description of a Web service in terms of quality attributes, such as performance, reliability, or availability issues. The former parameters are observable at run time, while the latter are embodied in the static structure of the Web service. It is well known that functional and non-functional properties constrain each other, and therefore, they should be treated together.

In order to describe the semantics of a set of available services, different description frameworks have been proposed [6, 4, 5]. Each semantic service description framework can be characterised with respect to the scope and granularity of their conceptual models and also the language used to express service descriptions.

OWL-S is an OWL ontology comprised by three main components: the *service profile* which provide a concise service description required to its publication in a registry; the *service model* which establish how the service works as a set of processes; and the *service grounding* which specify how the service can be accessed. The OWL-S service profile describes a Web service in terms of a set of Inputs, Outputs, Preconditions and Effects (IOPE). Once a service has been selected the profile is useless; rather, the client will use the service model to control the interaction with the service. The OWL-S process model allows to describe services in terms three types of processes: atomic, simple and composite. Composite processes are decomposable into other (non-composite or composite) processes; their decomposition can be specified by using control constructs such as *sequence* and *split*. However, OWL-S does not dictate any constraint between the profile and process models, so the two descriptions may be inconsistent without affecting the validity of the OWL expressions. Moreover, OWL-S does not consider non functional properties of Web services related to the service quality.

On the other side, the Web Service Modeling Ontology (WSMO) [5] describes services from the requester (consumer) and provider point views. A WSMO instance describes a service in terms of the functional description of the service's capabilities, the ontologies used to describe the service, the mediators that can deal with protocol and process related mismatches between web services; and a set of non-functional properties. In addition, the model supports the definition of client goals that need to be satisfied when a Web Service is invoked and the specification of the mediators that can be used to handle heterogeneity between goals specifications and services descriptions. We notice that goals definition and mediation aspects are not considered in the OWL-S ontology.

Semantic annotations for WSDL (SAWSDL) defines mechanisms to annotate WSDL elements with a set of mappings that establish the meaning of WSDL element via semantic annotation. However, when a WSDL element is annotated with several concepts, it is not possible to differentiate which concept annotates the service category, which one annotates the behavior or which one annotates a precondition or an effect of a service.

The aforementioned frameworks propose rich semantic descriptions of Web services. Table 1 presents a comparison pointing to the syntactic and semantic heterogeneities of these descriptions. It is clear that besides the complexity introduced by these frameworks and the additional effort demanded of users to understand their conceptual foundations, they brought additional semantic heterogeneity to the actual Web.

Table 1. Comparison of OWLS, WSMO and SAWSDL

	OWL-S	**WSMO**	**SAWSDL**
Functionality Description	Service Profile	Capability	Operation
IOPE	hasInput, hasOutput, hasPrecondition, hasResult	Precondition, Postcondition, Assumption, Effect	Input, Output
Service behaviour	Process Model	Interface	Not supported
Non-functional Properties	Profile hierarchy	Quality Of Service	Not supported
(Supported) Ontology Languages	OWL	WSML	Any Ontology Language
Goal Specification	Not Supported	WSMO goal	Not supported

Other languages was proposed to describe services from a purely business perspective. The most prominent ones are the Universal Service Description Language (USDL) [7] and the Business Service Description Language (BSDL) [8]. Cardoso et al. [7] propose USDL as a language for describing business, operational and technical aspects of "*universal*" services, i.e., any type of services independently of their economic area. The business description includes the formal specification of legal, marketing and bundling aspects. The operational description includes functional and behavioral characteristics, and resource requirements. Finally, the technical description specifies how a service can be invoked and relies on references to Web services protocols. Although, the formal specification of USDL relies on a MOF-based meta-model to describe any type of services, authors do not present any case study to illustrate how USDL services may be discovered.

On the other side, BSDL [8] addresses the description of both functional and non fonctional properties of a business service. BSDL is similar to our canonical model; both of them provide formal semantics based on a logic formalism. Moreover, BSDL proposes to apply an hierarchical decomposition or refinement of business services in order to create a service network. In our opinion, such decomposition does not reflect reality of business, different patterns of service networks exist including hierachical pattern. Even if BSDL covers a wider range of non functional properties than our canonical model, it does not perform any domain based reasoning to exploit domain knowledge, reasoning in BSDL is only restricted to decomposition rules.

2.2 Service Matching and Discovery

Service matching and discovery algorithms can be classified according to their search and reasoning capabilities. On the one hand, Web service search engines such as seekda![4] provide access to a significantly higher number of WSDL files for a given keyword-based user request and relies on either keyword search or category browsing. However, Web service search engines are not well suitable for Web service discovery because services are selected in terms of keyword-based searches.

The majority of service discovery approaches use Request Functional Profiles that represent user requirements in terms of functional properties, and performs deductive-based semantic service matching. Paolucci et al. [9] propose a logic-based service discovery approach that relies on the information published in the OWL-S Service Profile to identify matches between the user's query and a service profile. In [10], authors describe an ontology-based framework for the discovery of semantically heterogeneous Web services. The approach relies on user-supplied, and context-specific mappings from user ontologies to relevant domain ontologies used to specify Web services. User-specified functional requirements are considered during the discovery process and a user-specified criteria is used to rank the discovered services. OWLS-MX [11] is a hybrid approach that complements logic-based reasoning with approximate matching based on syntactic-based similarity computations. OWLS-MX uses the OWL-DL description logic reasoner Pellet for logic based filtering, and the cosine, loss-of-information, extended Jacquard, and Jensen-Shannon information divergence based similarity metrics, for complementary approximate matching. However, existing approaches for semantic Web services discovery do not provide a generic solution; mostly, because

[4] http://webservices.seekda.com/

they consider one specific semantic description format. Therefore, user requirement are expressed in terms of functional OR non-functional constraints and not both of them. Moreover, reasoning tasks performed by existing approaches do not include domain constraints reasoning and are only based on hierarchy reasoning.

3 An Enhanced Semantic Service Discovery Approach

In this paper, we propose an enhanced discovery approach that combines deductive-based techniques and ranking techniques to select a set of candidate services with different degrees of matching and classify them in terms of their non-functional properties. The main contributions of this paper are summarized as follows:

- In order to deal with the heterogeneity of semantic Web services descriptions, we propose a canonical semantic description model of Web services as a *core model* for service semantics.
- A Logic-based reasoning approach that enables flexible matchmaking between Web services descriptions and discovery queries considering the background knowledge domain.
- An enhanced service discovery approach comprised by two steps. First, candidate services, those satisfying functional user requirements, are selected based on relaxation techniques. Second, candidate services are ranked with respect to their non-functional properties values in order to generate a partial ordered set of Web services.

3.1 Canonical Semantic Service Description Model

Figure 1 illustrates the canonical semantic service description model which is a simple RDF-S integration model conceived based on the principle of minimal ontological commitment [12] to capture the core semantics of a Web service. We notice that the canonical model does not aim to be yet another service model which bring further heterogeneity to the SWS landscape; rather the different semantic frameworks for Web services are mapped to the proposed model [13]. The semantic model offers a set of lightweight semantic annotations that describe functional and non functional properties.

A *Service* is declared as an RDF triple as follows (s, `rdf:type`, isService). Each service s has a possibly empty set of *inputs* declared by a set of RDF triples, (c, `hasInput`, $inputName$) and a non empty set of *outputs* defined by a set of RDF triples (c, `hasOutput`, $outputName$). Also, a service s has a possibly empty set of *preconditions* and *effects*, and an optional *Category*. The inputs and outputs of a service describe respectively the parameters required for the execution of the service and those generated after the execution of the service. A service is also characterized by its category, which is the description of the functionality provided. Each input, output and category is defined with a name (label) and is annotated in terms of a set of domain ontologies concepts.

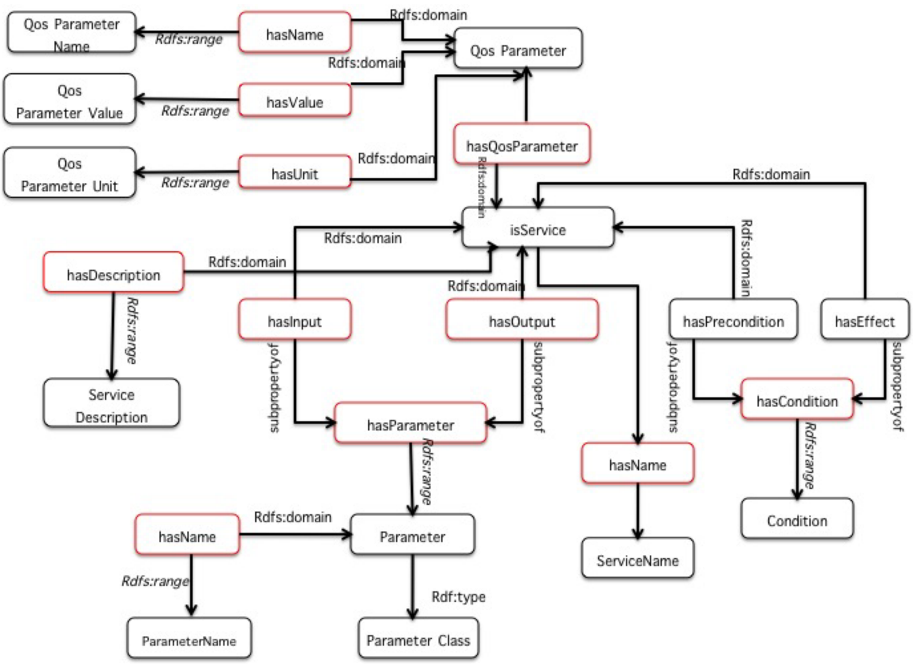

Fig. 1. Canonical Semantic Service Description Model

From the non-functional view, the concept of *service* is also described by a possibly empty set of non-functional properties, namely Quality-of-Service (QoS) properties. In our model, each QoS property is defined by a triple (p, v, u) where p is QoS parameter name, v is a value's parameter and u is the unit in which a value v is expressed. QoS properties are defined by a set of RDF triples as follows (s, `hasQoSproperty`, p). We adopt the non-functional properties set, proposed by [14], that includes metrics to evaluate the Web service *performance*, *dependability* and *reputation* reflecting the consumer perception towards the service. The performance of the Web service is measured by metrics such as *throughtput*, *response time*, *execution time* and *resource utilization*. The dependability of a web service integrates different attributes including *reliability*, *availibitity* and *security*.

Given a set of available services described as above, a discovery query is defined as a set of functional and non-functional requirements expressing constraints in terms capability descriptions and QoS parameters values. We formalize discovery queries as follows.

Definition 1. *An Extended Discovery Query Q is a tuple (F, NF), where F represents a set of functional requirements and NF represents a set of non-functional requirements.*

– *Functional requirements F are represented by a pair (I,O), where I is a set of inputs and O is a set of outputs that need to be produced as the result of the query Q.*
– *Non-functional requirements NF are represented by a set of 4-tuples (P, C, V, U), where, P is a QoS parameter, C is a comparator; V is a value and U is an unit; the evaluation of the query Q has to respect the conjunction of the conditions expressed in the set NF. If* (P, C_i, V_i, U_i) *and* $(P, C_j, V_j, U_j) \in NF$*, then* $C_i = C_j$, $V_i = V_j$ *and* $U_i = U_j$.

We adopt SPARQL query language [15] to express extended discovery queries as illustrated by the following example.

Example 1. Suppose that a client is looking for a shipping service to deliver goods from Geneve in Switzerland to Hannover in Germany. The following SPARQL discovery query specifies the properties of the package to deliver: package weight, expedition and delivery dates, expedition and delivery cities and a set of non-functional constraints as follows:

```
SELECT     ?service, ?capability
{
 WHERE
?service        hasCapability          ?capability;
                hasQoSProperty         QoS1;
                hasQoSProperty         QoS2.
?capability     hasInput               I1.
I1              rdfs:label             "PackageName1";
               _:hasPackageWeight      30;
               _:hasExpeditionCity     "Geneve";
               _:hasDeliveryCity       "Hannover";
               _:hasDeliveryDate       '02-02-2011'.
QoS1            rdfs:label             "Reputation";
QoS2            rdfs:label             "Price";
FILTER
(          QoS1 > 90    &&          QoS2 < 15)
}
```

In this paper, a two-fold approach is proposed to select the services satisfying an extended discovery query. The first phase allows to determine the most appropriate services that meet functional and non functional requirements of a discovery query. In this phase, a deductive-based approach is used; the search space of a discovery query is enlarged by relaxing the functional constraints of the query. In the second phase, a ranking process is performed to generate a partial ordered set of Web services based on QoS properties and user preferences. In the next two sections, we present relaxation techniques used in the selection phase and the ranking process of our enhanced discovery approach.

3.2 Discovery Query Relaxation

The query relaxation step corresponds to the rewriting process of a given discovery query Q based on a set of logical axioms. We define different types of relaxation depending on the types of knowledge used. Thus, we distinguish *type relaxation* which is an instance based reasoning, *hierarchy relaxation* that exploits concept taxonomy and *predicate relaxation* which exploits semantic relations between concepts in a domain ontology. We explain in following the different types of query relaxation.

– **Type relaxation** allows to infer a new triple (a, *rdfType*, c) from the triple (a, *rdfCollection*, c). Based on type relaxation, we define the following two axioms in order to relax some discovery query conditions:

$$\frac{(S,hasInput,I)(I,rdfCollection,C_1)}{(S,hasInput,C_1)} \quad (A_1)$$

$$\frac{(S,hasOutput,O)(O,rdfCollection,C_1)}{(S,hasOutput,C_1)} \quad (A_2)$$

– **Hierarchy relaxation** considers all classes belonging to the tansitive closure of a concept C in a domain ontology $\mathcal{O}$. We define two hierarchy relaxation axioms:

- **Input specialisation** asserts that if a concept A is declared as an input concept of a requested capability C then all sub-classes of A are asserted as relaxed functional constraints of the query Q. For example, given a query Q containing the triples (?*c*, *hasInput*, I_1) and (I_1, *rdftype*, `Book`); if the concept `Novel` is defined as a sub-concept of the concept `Book` in a domain ontology, then we infer a new triple (?*c*, *hasInput*, `Novel`).

$$\frac{(S,hasInput,I)(I,rdfType,A)(B,subClassOf,A)}{(S,hasInput,B)} \quad (A_3)$$

- **Output generalisation** asserts that if a concept A is declared as an output of a requested capability c then all super-classes of A may also asserted as relaxed functional constraints of the query Q. For example, given a query Q contains the triples (?*c*, *hasOutput*, O_1) and (O_1, *rdftype*, $ConferenceProceedings$) and the `ConferenceProceedings` is a sub-concept of the concept `Proceedings`, then we infer a new triple (?*c*, *hasOutput*, `Proceedings`).

$$\frac{(S,hasInput,I)(I,rdfType,A)(A,subClassOf,B)}{(S,hasInput,B)} \quad (A_4)$$

- **Predicate relaxation** relies on semantic relations defined between concepts in a domain ontology $\mathcal{O}$ defined by a triple (C_1, P, C_2) where C_1 and C_2 are concepts and P is the predicate that relates C_1 and C_2. We distinguish two types of axioms: the predicate to domain axiom and predicate to range relaxation axiom defined as follows:
  - **Predicate to domain** axiom allows to infer a new triple (c, *hasInput*, C_1) from the triples (c, *hasInput*, P), (C_1, P, C_2) and (P, *dom*, C_1).

$$\frac{(S,hasInput,I)(I,rdfType,P)(C_1,P,C_2)(P,dom,C_1)}{(S,hasInput,C_1)} \quad (A_5)$$

  - **Predicate to range** axiom allows to infer a new triple (c, *hasOutput*, C_2) from the triples (c, *hasOutput*, P), (C_1, P, C_2) and (P, *range*, C_2).

$$\frac{(S,hasOutput,O)(O,rdfType,P)(C_1,P,C_2)(P,range,C_2)}{(S,hasOutput,C_2)} \quad (A_6)$$

Example 2. Suppose that a scientist is looking for a bioinformatic service that takes as input a *nucleotide sequence*, an *organism identifier* and a *database name* and returns as output a collection of *nucleotide sequences* that are similar to a given input sequence. Sequence similarity is computed based on a given primary sequence structure in order to deduce homology between DNA or proteins sequences. Figure 3.3 illustrates the SPARQL query graph and the corresponding relaxed query based on the hierarchy relaxation. The query answers may include services that match exactly the query, if it exists, and relaxed matchs based on Input specialisation and output generalisation relaxation. Discovery query's answers will include services that take as input any type of sequences, i.e., DNA, RNA and mRNA and that return as output all types of genomic sequences.

3.3 Non-functional Matchmaking

Relaxation techniques enlarge the search space of a discovery query allowing to select new services with various matching degrees. Let $S = \{S_1, ..., S_n\}$ be a set of candidate services that meet functional and non-functional constraints of a discovery query Q. The QoS of a candidate service S_i is represented as a vector QoS_i=<$q_{i,1}$,...,$q_{i,n}$>, where $q_{i,j}$ is the value of QoS attribute j $(1 \leq j \leq n)$. The quality vectors of a set of candidate services S are used to derive a quality matrix Q.

Definition 2. *A quality matrix* $Q = \{QoS_{ij}\}$ *refers to a collection of quality attribute values of a set of candidate services, such that, each row of the matrix corresponds to the values of the* j *QoS attributes of a service* S_i

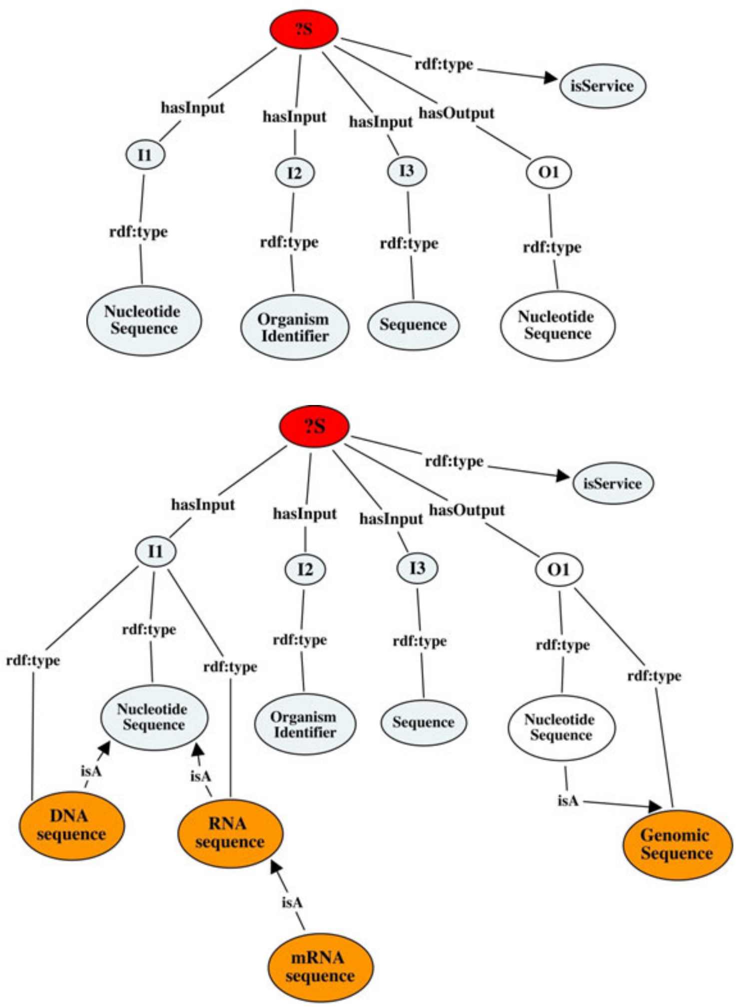

Fig. 2. Example of a Discovery Query Relaxation based on Hierarchy relaxation

QoS attribute values can be either negative or positive, thus some QoS values need to be minimized whereas other values have to be maximized. For example, availibity and reliability should be maximized while price should be minimized. To cope with this issue, the scaling phase normalizes every QoS attribute value by transforming it into a value between 0 and 1 with respect to the formulas below [16]:

– Negative attributes :

$$q'_{i,j} = \begin{cases} \frac{q_j^{max} - q_{i,j}}{q_j^{max} - q_j^{min}} & \text{if} \quad q_j^{max} - q_j^{min} \neq 0 \\ 1 & \text{else} \end{cases}$$

– Positive attributes :

$$q'_{i,j} = \begin{cases} \frac{q_{i,j} - q_j^{min}}{q_j^{max} - q_j^{min}} & \text{if} \quad q_j^{max} - q_j^{min} \neq 0 \\ 1 & \text{else} \end{cases}$$

where $q'_{i,j}$ denotes the normalized value of QoS attribute j associated with service candidate S_i; It is computed using the current value $q_{i,j}$ and also q_j^{max} and q_j^{min}, which refer respectively to the maximum and minimum values of QoS attribute j among all services candidates.

Example 3. Given the discovery query illustrated in example 3, we suppose that the quality matrix corresponding to the candidate services set is the following:

$$A = \begin{pmatrix} & Availibility & Throughput & Reputation \\ S_1 & 0.94 & 0.93 & 0.96 \\ S_2 & 0.92 & 0.97 & 0.93 \\ S_3 & 0.93 & 0.94 & 0.97 \end{pmatrix}$$

In order to rank a set of candidate services, we propose a user preference-based approach in which a user assigns a weight value for each QoS attribute. An additive value function is defined as follows:

$$f_{QoS}(service_i) = \sum_{ij}^{m}(QoS_{i,j} \times Weight_j)$$

For instance, a user may specify the following weights: $Weight_{Availibility} = 0.8$, $Weight_{throughput} = 0.6$ and $Weight_{reputation}$=0.9. A ranking function is defined as follows.

Definition 3. *Let S be the set of candidate services, R_a is a set of ranking attributes, and $R_O \in \{ascending, descending\}$ is the ranking order, then $f_{rank}(S,x,R_O) = S'$ is called the ranking function, which produces S', the ordered set of candidate services.*

4 Case Study

In this section, we describe a real-world case study conducted in the bioinformatic domain in order to illustrate the enhanced discovery approach proposed in this paper and the performance of relaxation techniques. As examples, we formulate the following queries that reprensent a set of functional requirements of a scientist:

(Q_1) *Which Web services return a set of nucleotides sequences corresponding to a gene identifier?*

(Q_2) *Which Web services return a set of protein sequences similar to a given protein sequence?*

(Q_3) *Which Web services predict the 3D-structure of a given protein sequence?*

(Q_4) *Is there a ressource that estimates phylogenies from protein sequences?*

We have generated a Web service catalog based on the BioMoby Web service catalog which is a bioinformatics Web service registry [17]. Services was described in terms of a set of inputs, outputs and a service category according to the canonical description model. The BioMoby catalog classifies Web services with respect to two hierarchies: a *service type ontology* that organizes services with respect to the task they implement and a *data type ontology* which focuses on the input/output classification. However, BioMoby does not integrates any reasoning tasks and service discovery is only performed through category navigation.

The discovery queries described above were evaluated against the Web service catalog without initiating any reasoning tasks and later with reasoning capabilities. The results obtained from this evaluation are summarized in Table 2. While, the services `runPhylipProtpars` and `runPhylipProtdist` match exactly the discovery query Q_4, no service matches exactly the discovery queries Q_1, Q_2 and Q_3.

Table 2. Discovery Query answers with and without relaxation techniques

Queries	Answers Set without Reasoning	Answers Set with Reasoning

Q_1	`No service`	`DDBJGetEntry`
		`eFetchSequence`
		`DBFetch`
		`retreive_ensembl_sequence`

Q_2	`No service`	`runNCBIblastp`
Q_3	`No Service`	`ShowPDBfromFASTA` `PDBWebService`

Q_4	`runPhylipProtPars`
	`runPhylipProtdist`
		`runClustalWService`
		
		`PhylipService`

The first query Q_1 requires a Web service that takes as input a gene identifier and a scientific organism name (i.e., homosapiens) and returns as output a nucleotide sequence. Output generalisation axiom is applied to infer that services returning sequences as output are included in the query answers set. As illustrated by the case study, reasoning tasks enable to enlarge the search space of a discovery query.

5 Conclusion and Future Work

In this paper, we propose a twofold enhanced semantic Web service discovery approach that not only select services based on the functional requirement of the user but also based on the non-functional requirement. First, in order to cope with semantic service description frameworks heterogeneity, we propose a canonical Web service model. In the proposed approach, flexible Matchmaking of services is based on deductive-based techniques that relax discovery queries constraints to enlarge the search space of candidate services to include services that meet functional and non functional requirement with different degrees of matching. A ranking process is performed in which users express their preferences by assigning weights to a set of ranking non-functional attributes. As future work, we aim to conduct a set of experiments to evaluate the efficiency of the discovery approach. Also, we intend to use clustering techniques to reduce the search space of a discovery query and generate services clusters based on QoS values. Clustering techniques allow to group services with respect to their QoS into a set of clusters which may improve the ranking process of services.

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A Model-Based Method for the Design of Services in Collaborative Business Environments

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Abstract. The uncertainty of collaborative environments in Architecture, Engineering and Construction (AEC) projects makes the design of services dedicated to professionals of the construction sector particularly challenging. Our work - still in an early stage - introduces a method enabling the design of such services, from business analysis to implementation, answering the needs of specific projects' situations. This method is supported by a toolset and based on Model-Driven Engineering (MDE) approach. We illustrate it by a case study scenario based on the particular requirements within sustainable building design projects.

Keywords: service design, business process, MDE, UML, BPEL, Architecture Engineering and Construction (AEC), Sustainable architecture projects.

1 Introduction

An architectural project seems to be a well-known process associated with an identified life-cycle. But the collaborative context varies with the type of a project, its objectives, and the nature of work or the composition of actors. In this way, we assume that business and IT services dedicated to project management have to follow these variations in order to be adapted to professionals use in each specific project case. Services developers should have methods to understand professionals' collaborative behaviors and to propose solutions directly derived from business analysis. From professionals' interest to services analysts and developers, our approach consists in conciliating an amount of viewpoints in a unified method to design adapted services for the construction sector. The development of our approach is actually in its early stages.

In the first part, we will present Dest2Co method based on three viewpoints declined in three views: the business requirement view, the business solution view and the technical solution view. In the second part, we will use two scenarios based on a case study to illustrate the method. In this part, we will focus on the particular case of design and construction of sustainable buildings. Then, we will see how we

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can identify collaborative practices related to sustainable goals to be achieved within the project. We will finally present how to propose adapted services for such practices. In the third part, we will present the suggested toolset which is composed of an editor and a repository. The paper concludes with the prospects of the approach.

2 A Method to Conciliate Viewpoints in Service Design Process

Our approach to the design of services considers it as a continuum from business service to technical service, as it is more and more considered in emerging service science community [7]. The approach is based on the notion of viewpoints from the different actors involved in this design. This notion of viewpoint follows the architectural framework ISO/IEC 4210, where each role involved corresponds to a viewpoint. We define a view for each viewpoint, corresponding to the related models. Regarding the design of services in highly collaborative business environments, we have identified three views: The business requirements view (BRV), the business solution view (BSV), and the technical solution view (TSV). For each of these views, services need to be designed in a complete manner. To do this, we have chosen to differentiate the aspects concerning the description of what the service does ("functional aspects") from the aspects of how the service interacts with other services and tasks ("transactional aspects") and the characteristics of the service ("non-functional aspects").

The next subsection will present the design method globally, while the following subsections will detail the three views and the models used in these views.

2.1 The Dest2Co Method

The goal of the Dest2Co method is to combine these three views. The objective is to allow different actors to model services from their own viewpoint, and according to functional, non-functional and transactional aspects. Initially, this should be a top-down process as the business requirements should be considered first, before continuing with a business solution and then technical solution(s). However, it must be possible to apply the method in a more bottom-up approach, by reusing existing services. For this, we suggest creating a services repository, containing the service models for the previously defined views of a service design project, and not only for technical descriptions. In addition, traceability will be modeled in order to enable to capitalize on the relations between technical services and business services but also to identify requirements fulfilled by a service. All these pieces of information will be stored in our services repository.

An overview of this process is shown in Fig. 1. As far as the models are concerned, all the activities described in the process contribute to the refinement of services and domain models. It is noteworthy that the process is mainly iterative, since the final activity of each step can lead to previous activities. The meta-models of each view are defined and enable modeling services from given viewpoints.

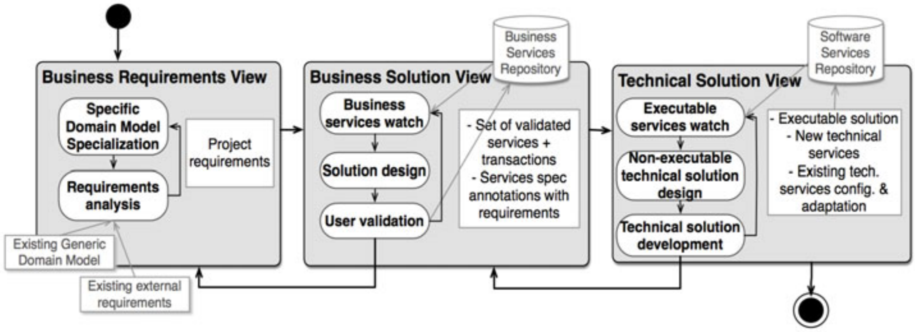

Fig. 1. Overview of the Dest2co method process

The integrative aspect of this methodology is based on Model Driven Engineering techniques [3]: we defined meta-models for each view and these meta-models are linked between each other. Then we can use these relations for model transformations, i.e. for passing from one viewpoint to another. However, it is not possible to fully automate these transformations and human operations are always necessary. It has to bring missing information in the models and to align these with user requirements. It is also necessary to have full traceability between the transformations and thus to annotate the concepts of one view with those of the previous one. For example, during the "business requirement view" design step, the user should be advised on the impact of her choices on the solution, and the requirements could be modified accordingly. This example covers notably the constraints that specific services or services' composition could generate [1].

The service repository will contain all the models for the design of services, for the technical view but also for the business viewpoints. Because of this, it will allow to reuse services on a business level as well as on a software level. For example, a business user could notice that an existing service fulfills some of his business needs, and choose to integrate it in his business service definition.

Finally, we have introduced a "user validation" step in this process: we propose here an innovative approach enabling business experts to validate the defined business services and models through an animator tool. We plan to reuse and adapt here an existing method and toolset called "Efficient" (see [8], or the Efficient website[1]). The goal of this toolset is to help to validate models of electronic transactions by proposing an animation tool. It allows business experts to "play" the model as if it was already implemented. Business experts send and receive messages through a web interface. That is how they can detect if the model contains errors, like information that is not asked at the right moment or with the right structure. Once the model has been corrected, the animation can be executed again. This is repeated until the business experts consider that the model corresponds to their needs, and is thus considered valid. This toolset is currently being adapted to UML models used for the design of services in the Business Solution View.

[1] http://efficient.citi.tudor.lu/

2.2 Business Requirements View

The Business Requirements View contains models describing global requirements from the business. At this step, business experts do not focus on a solution and neither speak in terms of services. They focus on high-level needs, expressed in the form of Collaborative practices. These business experts participate in the project and are implicated in several early choices regarding the setup of collaboration. This role can be assumed by the coordinator of the project who enables and supervises the cooperation between other business roles.

With the model of Collaborative practice, we characterize the cooperative context in the particular highly collaborative environment of a construction project. This context can be characterized by different recurrent concepts. An architecture project involves many different actors, with their own organizational role, who work together during the life-cycle of the project. It is based on the creation and use of documents and objects to build. These are characterized under the concept of artifact. This context finally concerns the management of various activities linked to the nature of the project, the phase of the project and the nature of the tasks performed. A major issue when characterizing cooperation context of a specific project situation is to identify the relations between these Actors, Artifacts and Activities. For example, the relations between actors are defined by the nature of the roles they play and the organizational structure of the considered project. The relations between actors and artifacts define how an artifact is produced, used or simply referred. Actors' roles and artifacts' properties are related to the context of activity in which they are involved. Moreover, such relations differ from one project situation to another, and could also evolve during a single project.

Dealing with the static description of a cooperation context is therefore not sufficient to define requirements for service design. We suggest introducing the concept of Collaborative Practice (CP) in order to represent the "process view" on collaboration activity. However, we consider CPs as "high-level" processes agreed by practitioners at the beginning of an AEC project. We could also consider them as "best collaborative practice". They have to guide the requirements for supporting the design of services that would fit the specific collaborative situation.

In the domain of automotive industry, other works [12] [13] introduce the concept of "task pattern". It is defined as "self-contained model template with well-defined connectors to application environments capturing knowledge about best practices for a clearly-defined task". This organizational knowledge is then used for analyzing information flow problems and developing organizational and technical improvements.

In the context of the construction sector, the concept of practices is notably developed in [10] where the authors analyze "team work practices" to manage sustainable construction knowledge. [4] suggests that "project management practices" are often linked to emerging information technology (IT) because IT impacts these work practices. Our approach consists, on the contrary, in identifying them as business requirements in order to align IT services.

The Fig. 2 shows a subset of the meta-model of the BRV, realized in Ecore[2]. The notion of *Collaborative Practice* has been defined in the Dest2Co service meta-model, as well as the *Requirement* class. This class could be further divided into functional, non-functional or transactional aspects of requirements (not on the figure). In addition, Collaborative Practices are linked to Actor, Artifact and Activity classes from the domain meta-model as described above.

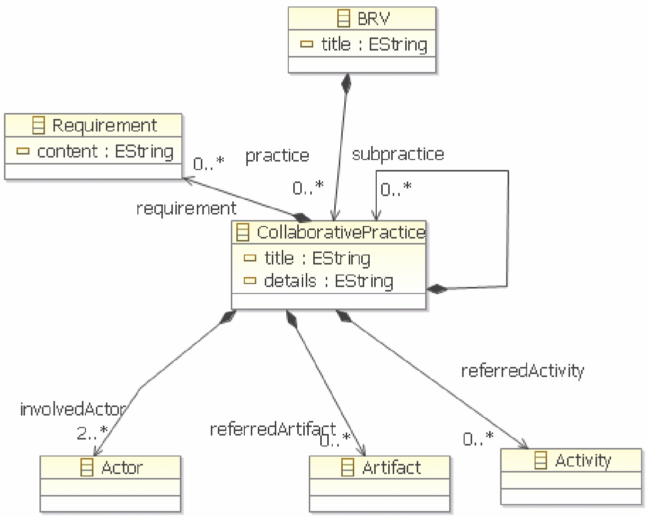

Fig. 2. Meta-Model of Business Requirements View

2.3 Business Solution View

The Business Solution Viewpoint is the viewpoint from services experts, closely working with domain experts: it deals with the solution in terms of business services, from a business point of view, without any technical consideration. These services experts should be aware of software services research and development, and also service implementation within a considered business domain. Their role is to fill in the gap between professionals of the construction and software designers. The models in this view correspond to the requirements expressed in the Business Requirements View.

Because UML is well adapted to business analysis, we have chosen to use it in this view for part of the design. We propose to use UML class diagrams to model information exchanged (business services input and output), and activity diagrams to model the business process realizing the service, including other services reused (see the case study diagram in Fig. 5.). In the Business Solution View, the activity diagram represents the decomposition of a collaborative practice into a set of individual practices performed by all involved partners, from a business point of view. The actor

[2] See `http://www.eclipse.org/modeling/emf/?project=emf#emf`

who calls the service is called “service consumer”. The “service provider” is responsible for the realization of the service and the information sharing between each actor when they perform these Individual Practices. At this stage, the swim lanes correspond to business actors that will provide or consume the business service. Actions can be other business services reused, or simple actions. Information exchanged is modeled through object flows and pins (see [11] for a more detailed description). In addition, the domain model is expressed in UML classes, which facilitates the links between the service model and the domain model.

We needed to describe the services according to the three aspects presented previously. That’s why, on top of this UML model, we have chosen to define our own meta-model for elements not covered by our use of UML. Indeed, we considered that at this step, technical interoperability was less important because the result of the business design will not be directly executable. We have thus chosen to define this meta-model using the Ecore meta-modeling language. It is flexible, close to OMG’s Meta-Object Facility[3] and can be used directly for tool support in the Eclipse platform. This meta-model covers the definition of functional aspects (packages, service, categories, inputs, outputs, preconditions, effects), as well as non-functional aspects, mainly by the use of external taxonomies for quality of service (QoS). In addition, links are created between this meta-model and the UML meta-model. As this article focuses on the UML models, this meta-model will not be presented here.

2.4 Technical Solution View

The technical solution view corresponds to a software analysis and conception phase, realized by software analysts and designers. It is a refinement of the business solution view that takes IT into account. Similarly to the classical analysis/design separation, we have decided to divide this view into two layers, realized one after the other. They are called the software service layer and the implemented service layer.

The Software Service Layer. This layer is the first “software” layer, obtained by deriving the business solution view to take software services into account. This mainly consists in deciding which business services or activities will be realized by software services, and which existing software services will be reused. To simplify the design of software services, we chose to keep nearly the same meta-model as for the BSV. UML class and activity diagrams are used similarly, the main differences are in the use of swim-lanes in activity diagrams that now represent systems instead of human roles, and actions that can be reused (“composed”) software services. The Ecore meta-model is also slightly modified.

The Implemented Service Layer. This layer not only considers software services, but also that these services will be implemented and executable. It should thus completely define the services’ interfaces, and take into account that they can be reused by other services. Because of this, we have chosen to use existing standards, as the services designed by our method can be usable and interoperable with existing

[3] `http://www.omg.org/mof`

services technologies. Processes for the realization of services are described using BPEL[4], services interfaces using WSDL[5], and messages using XML Schema[6]. Creating the models for this layer thus requires switching from a choreography point of view to an orchestration point of view. The other aspects of the services will be defined by other formats, or extensions to existing formats, that have not been selected yet.

The following chapter illustrates the above Dest2Co method through a case study.

3 Case Study: Service Design for Supporting Collaboration in Sustainable Construction Projects

Sustainable architecture projects differ from others by an amount of objectives to reach and criterion to respect. These have an impact on the actors involved and the tasks performed. We suggest evaluating how a collaborative practice can evolve in this case (alternative BRVs) on the basis of a case study. Then we will go ahead with the application of the Dest2co method, through the BSV and the TSV to design an adapted service.

3.1 Business Requirements View of the Case Study

The complex collaboration within an AEC project could be characterized through a set of collaborative practices (model Fig. 2) generic enough to cover the various collective situations in which actors perform their business tasks. Depending on the objective to reach, the relations between actors, activities and artifacts can also evolve during an ongoing project. The used methods of project management are specific because of the distribution of responsibilities between the actors, the complexity of the architectural "object" and the prototype character of each operation [6]. That's why methods usually used in other industrial sectors (such as workflow definition or reverse engineering) are not easily transposable in the AEC domain. In our approach, we firstly suggest analyzing the collaborative situations through a high level of abstraction. A first set of interviews with practitioners allowed us to identify basic Collaborative Practices. They are highly related to the specific collaborative tasks of professionals involved in the entire life-cycle of a sustainable architectural design project. We then enriched these practices through a review of sustainable design standards [5] [2], considering them through the collaboration viewpoint. We assume that eleven generic Collaborative Practices can be observed in most of construction projects situations:

CP1: site choice and assessment
CP2: designer determination
CP3: objectives determination

[4] `http://www.oasis-open.org/committees/wsbpel/`
[5] `http://www.w3.org/TR/wsdl`
[6] `http://www.w3.org/XML/Schema`

CP4: budget determination
CP5: design and reporting
CP6: construction enterprises (contractors) determination
CP7: design assessment and reporting
CP8: meetings organization and reporting
CP9: execution preparation and management
CP10: execution assessment
CP11: users' awareness

The Dest2co method aims at allowing designers to select and reuse services adapted to various collections of Collaborative Practices of construction projects. Indeed, in all new projects, new collaboration contexts are setup. Depending on the actors, the objectives, the needs, etc, the Collaborative Practices aren't performed in the same way. For example, in the particular cases of sustainable conception and construction projects, professionals have to respect rigorous guidelines (like [9]) to ensure the quality of the executed building according to assessment methods.

We suggest below two case studies scenarios in order to understand both how these Collaborative Practices set can vary, and how they impact the BRV of service design. The CP7 refers to the assessment of the designed architectural project which is notably a very important phase in this type of project.

First scenario (Fig. 3). Our first case corresponds to a housing project. We suppose that the owner is the future user of the building and isn't really implicated in the various assessments of the designed project. He gives his point of view about architectural aspects but delegates the responsibility to the architect for all others technical aspects. Then, the architect performs the design and usually refers to an external expert to assess various technical aspects of the project.

Second scenario (Fig. 4). In a second case, we make the hypothesis that the owner is more implicated in the objectives to reach within the design project. It is more and more the case of public owners of building projects. In this scenario, the owner wants to follow all the design phases and takes the responsibility to manage the assessments of design documents before validating them. That's why he asks the architect to send design documents to an expert before validating them, and he wants to be informed about evaluation results.

Through these two scenarios, based on the same collaborative practice, we show how a collaborative situation changes depending on several parameters (objectives, actors' roles, actors' preferences…). The following BSV viewpoint makes use of the concepts identified in this first BSV view decomposed in Collaborative Practices.

3.2 Business Solution View of the Case Study

As defined previously, the activity diagram of the Business Solution View represents a decomposition of a collaborative practice into an amount of actions. These actions - also called individual practices- are performed by all involved partners, from a business point of view.

<table>
<tr><td>CP 7</td><td colspan="2">Design assessment and reporting</td><td>Specification Case 1</td></tr>
<tr><td colspan="3">Description</td><td rowspan="2">The architect performs the design and when he needs to, refers to an expert to evaluate his work.</td></tr>
<tr><td colspan="3">When the design is over, we must perform some analyzes to check safety and security, hygiene, accessibility… and specialists of each domain are involved to give their evaluation. In a particular context of a sustainable architecture project, experts evaluate light properties, energetic and acoustic performances. Depending of the nature and the objectives of the project, evaluations are conditioning the execution of the project.</td></tr>
<tr><td colspan="2">Actors</td><td>Artefacts</td><td>Activities</td></tr>
<tr><td colspan="2">Architect (internal), expert (external)</td><td>Design documents (plans, prospects, sections…) from architect</td><td>Housing private project, conception phase, coordination and evaluation tasks</td></tr>
<tr><td colspan="4">Requirements</td></tr>
<tr><td colspan="4">A document can't be executed if an evaluation hasn't been performed after a request</td></tr>
</table>

Fig. 3. Specification of the collaborative practice n°7 in the first scenario

<table>
<tr><td>CP 7</td><td colspan="2">Design assessment and reporting</td><td>Specification Case 2</td></tr>
<tr><td colspan="3">Description</td><td rowspan="2">The owner asks to the architect to send design documents to expert before validating them and he wants to be informed about evaluation results.</td></tr>
<tr><td colspan="3">When the design is over, we must perform some analyzes to check safety and security, hygiene, accessibility… and specialists of each domain are involved to give their evaluation. In a particular context of a sustainable architecture project, experts evaluate light properties, energetic and acoustic performances. Depending of the nature and the objectives of the project, evaluations are conditioning the execution of the project.</td></tr>
<tr><td colspan="2">Actors</td><td>Artefacts</td><td>Activities</td></tr>
<tr><td colspan="2">Owner (internal), Architect (internal), expert (external)</td><td>Design documents (plans, prospects, sections…) from architect</td><td>Public building project, conception phase, coordination and evaluation</td></tr>
<tr><td colspan="4">Requirements</td></tr>
<tr><td colspan="4">A document can't be executed if an evaluation hasn't been performed after a request</td></tr>
</table>

Fig. 4. Specification of the collaborative practice n°7 in the second scenario

For example, the first specification scenario of our case study could be represented by the following diagram (Fig.5). It illustrates the collaborative practice performed by the architect and the expert when the architect (service consumer) requires an evaluation.

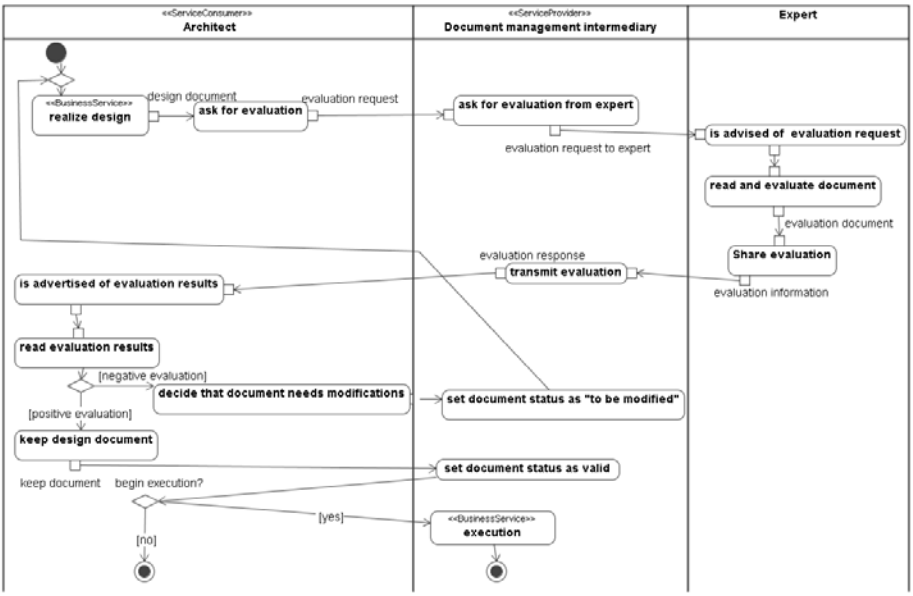

Fig. 5. BSV of the first specification scenario of the Collaborative Practice 7

In the second specification scenario, the service provider should become the owner who requires the evaluation phase from the architect. The process would contain one more partition and more steps from the beginning to the end. However, the relation between the architect and the expert should be the same, and from a business point of view, a part of the service could be reused for the 2 different situations.

To illustrate the last part of the Dest2Co method, we will focus on this first specification case. We will explain how to fill in the gap between a business view and a technical view. The second specification case could be developed in the same way (BSV, TSV) but we will not give the details here.

3.3 Technical Solution View of the Case Study

For this view, we transpose the business individual practices of each actor in service calls and human activities through IT interfaces. We also precise that the role of intermediary between actors is played by a document management service.

The Software Service Layer. In the software service layer of the TSV, individual practices related to notifications from the system ("is advised of") become software services (“getDocument”) because of the “passive” characteristic of the practice from an actor’s point of view. The software service layer of our first specification case could be represented by the following diagram (Fig. 6).

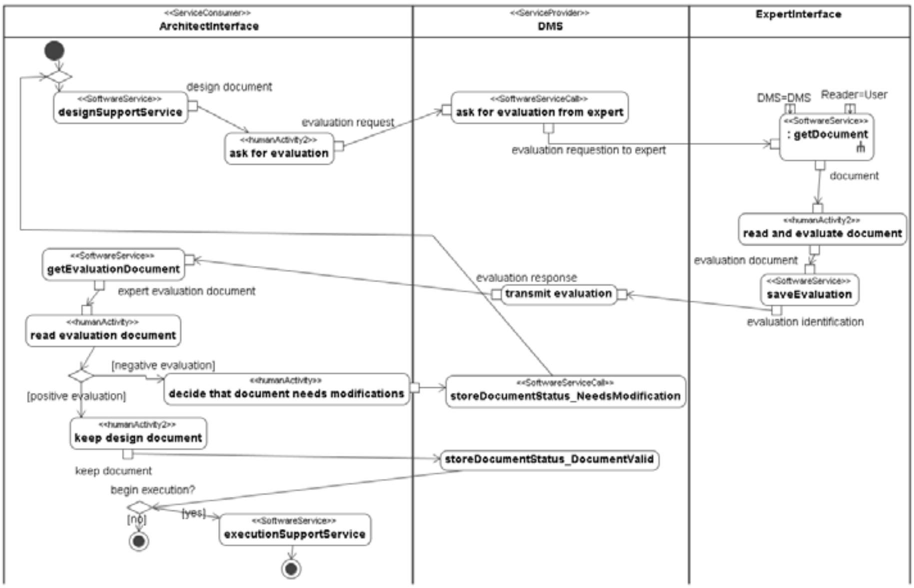

Fig. 6. Software Service Layer of the TSV

At this step, the variations of the TSV are directly issued from the variations of the BSV as the technology used doesn’t impact yet on the process.

Implemented Service Layer. For the implemented service layer, it is necessary to know which components will implement which parts of the system. For our example, we have chosen a centralized system for the DMS and its different user interfaces, thus resulting in a relatively simple business process in BPEL, illustrated in the Fig. 7. Another solution would have been to implement the different components separately (for example in case they would be parts of different systems), In this case, the process would have been divided into three separated processes. The external software services “designSupportService” and “executionSupportService” called in the software service layer are not present in this process, as they are in fact outside of this service. They should be called by a more global process depending on the evaluation result from of this process.

After this final step of the Dest2Co method, we have modeled implementable and executable services adapted to a specific collaborative pratice identified by a business analysis. The toolset supporting the method is described in the following parts.

Fig. 7. Implemented Service Layer of the TSV

4 The Supporting Toolset

The service design method presented in this paper is mainly supported by three tools:

- A service editor to support the creation of models of services following the design method
- A service repository, where services are published for direct use as well as for reuse during service design
- A validation toolset, to animate the service processes for validation (will not be detailed further here, see [4]).

4.1 The Service Editor

To support this method, we have chosen to focus our efforts on adapting and integrating existing open source software components. In addition, because of our meta-modeling approach, we have decided to use code generation from model-driven tools for the missing parts of this editor, and to limit specific developments. Because of this, we have chosen the Eclipse platform as a basis for this tool integration, thanks to:

- The existence of a number of editor plug-ins that can be used directly in our editor. Because of our approach based on different viewpoints, we need different editors to support the models for the different viewpoints. In particular, we have chosen to integrate a UML editor (Papyrus[7]), a BPEL editor[8], and a WSDL/XML Schema editor[9]

[7] http://www.eclipse.org/modeling/mdt/papyrus/
[8] http://www.eclipse.org/bpel/
[9] http://www.eclipse.org/webtools/ws/

- Its meta-modeling facilities: Eclipse provides a meta-modeling language called Ecore, with a serialization syntax based on XMI[10]. In addition, Eclipse provides different tools, part of the Eclipse Modeling Framework (EMF[11]) and Graphical Modeling Framework (GMF[12]), to generate or create editors based on Ecore meta-models.
- Its extensibility and open source licensing scheme, which is well adapted to the creation of our own plug-in and the integration of existing plug-ins.

These reasons made Eclipse the perfect choice for a plug-in that would support our method. In addition, Eclipse's user interface is very flexible, providing the notions of Eclipse views and perspectives, which allow us to adapt our user interface to the viewpoint currently edited.

Finally, in order to support the MDE approach, we plan to implement partially transformations between views. User interfaces dialogs ("wizards") could also be added to ask for additional information for transformation. A model traceability tool could also be used to keep the links between the different models, and, depending on the links, to send notifications in case linked elements are changed in another view.

4.2 The Service Repository

The main requirements regarding the service repository were to be able to save and load different kinds of service models, for the different viewpoints. However, we could not use a structured database as these models use different modeling languages, and because some of the meta-models may still evolve. The best and most flexible solution was thus to use an XML database[13]. Indeed, with an XML database, models serialized in an XML format can be saved directly, without transformations. In addition, XML databases offer search functionalities among the stored documents, for example using XQuery[14] or XPath[15].

In addition to the main repository, a "reuse module" will be integrated in the service editor [1], in order to allow users to easily reuse existing services in their design of services, whether these are business or software services. Lastly, a web interface for end-users will also be implemented, in order to access to the interfaces or descriptions of published services. It will also allow navigating in the list of services by using different criteria, like the viewpoint or the category.

5 Conclusion

The ongoing Dest2Co research project aims at defining a method for the design of services dedicated to highly collaborative environments as the construction sector. This method is based on 3 viewpoints. 1) An identification of collaborative practices

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[10] `http://www.omg.org/spec/XMI/`
[11] `http://www.eclipse.org/modeling/emf/`
[12] `http://www.eclipse.org/modeling/gmp/`
[13] `http://exist.sourceforge.net/`
[14] `http://www.w3.org/TR/xquery/`
[15] `http://www.w3.org/TR/xpath20/`

(Business Requirements View). 2) A first identification of the solution from a business point of view in an activity diagram (Business Solution View). 3) A transposition of these business services to software services taking into consideration technical aspects and existing services to reuse (Technical Solution view).

Based on two case studies scenarios, we showed how to design collaborative practices. These collaborative practices are used to help designers to identify the characteristics of various projects' situations, especially in sustainable architecture projects situations. Using this method, we suggest a guideline to propose adapted services to these specific Collaborative Practices.

In the next step of our work, a real project case study and the contact with practitioners will allow us to validate the collaborative practices in the entire life-cycle of a sustainable design project.

From a technical point of view, partial transformations between viewpoints still need to be defined. The objective is the future implementation and deployment of services designed in SOA tools, while full traceability is kept to track back the initial business requirements.

To validate this method, we are currently implementing the editor, and we will use it to model our case study. In continuity with the first step of evaluation, we could evaluate how the repository can be used to find services adapted to the collaborative practices identified by the practitioners themselves. Then we could propose design and re-use of services supporting the design of sustainable buildings.

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Mining Customer Loyalty Card Programs: The Improvement of Service Levels Enabled by Innovative Segmentation and Promotions Design

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Abstract. A good relationship between companies and customers is a crucial factor of competitiveness. The improvement of service levels has become a key issue to develop and maintain a loyal relationship with customers. This paper proposes a method for promotions design for retailing companies, based on knowledge extraction from transactions records of customer loyalty cards, aiming to improve service levels and increase sales. At first, customers are segmented using k-means and then the segments' profile is characterized according to the rules extracted from a decision tree. This is followed by the identification of product associations within segments, which can base the identification of the products most suitable for customized promotions. The research reported is done in collaboration with an European retailing company.

Keywords: Customer services, Clustering, Classification, Market Basket Analysis, Retailing.

1 Introduction

The economic and social changes that occurred in Europe in recent years modified the relationship between companies and customers. In the past, companies focused on selling products and services without searching detailed knowledge concerning the customers who bought the products and services. With the proliferation of competitors, it became more difficult to attract new customers, such that companies had to intensify efforts to keep current consumers. The evolution of social and economic conditions also changed lifestyles, and as a result customers are less inclined to absorb all the information they receive from the companies. This context led companies to evolve from product/service-centered strategies to customer-centered strategies. The establishment of loyalty relationships with customers also became a main strategic goal. Indeed, companies wishing to remain at the leading edge are trying to improve the service levels in order to ensure a good business relationship with customers.

Some companies invested in building databases that are able to collect a big amount of customer-related data. For each customer, millions of data objects are

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collected, allowing the analysis of the complete purchasing history. However, the information obtained is seldom integrated in the design of business functions such as marketing campaigns. In fact, in most companies the information available is not integrated in procedures to aid decision making. The overwhelming amounts of data have often resulted in the problem of information overload but knowledge starvation. Analysts are not being able to keep pace to study the data and turn it into useful knowledge for application purposes.

Data mining (DM) techniques are increasingly being used as tools to analyze data resulting from customers activity, stored in large databases. It can be applied in order to detect significant patterns and rules underlying customer behavior. However, the use of DM for marketing purposes is still incipient and most companies use mass strategies to instigate customers loyalty. The marketing segmentation of customers or the identification of customer groups with similar behavior patterns is done in an ad-hoc way, which often constitutes the basis to design customized promotions.

This paper proposes a method for promotions design, informed by product associations observed in homogeneous groups of customers. This method is based on clustering techniques to segment customers, and decision trees to characterize the segments profile. This analysis is followed by the identification of the products usually purchased together by customers from each segment.

The structure of the remainder of the paper is as follows. Section 2 includes a brief literature review to contextualize the research. Section 3 includes a presentation of the techniques used, corresponding to cluster analysis, classification and market basket analysis. Section 4 introduces the company used as case study and discusses the results. The paper finishes with the conclusion and some ideas for future work.

2 Literature Review

Customer loyalty in service industries has gained considerable prominence in marketing and management literature. According to Keaveney [1], customer loyalty often acts as a customer retention factor, so it has an important role in companies competitiveness.

Customer satisfaction and loyalty critically depend on service quality, which is a central element of customer relationship management. The marketing literature (e.g. [2,3,4]) identifies several aspects of customer service, such as: price, promotions, customer attention and additional services. Customized promotions address a few of these pillars of service quality, so it has good potential to enhance customer loyalty.

Contrary to traditional promotional policies, that treat all consumers alike, the design of customized promotions requires a deep understanding of customers behaviour to be able to recommend products or services that suit individual needs. In this context, according to Ngai et al. [5], customer characterization is usually achieved by means of market segmentation and products recommendation is possible by means of market basket analysis.

Market segmentation was firstly introduced by Smith [6], based on the economic theory of imperfect concurrency developed by Robinson [7]. Segmentation was developed taking into account that companies need rational adjustment of products or services as well as effective marketing strategies to meet customers' demand. Segmentation can be described as the process of transforming a large market into smaller clusters of customers. It represents an effort required to increase targeting precision. Segments' characterization leads to a better understanding of customers, which can assist in the design of more effective marketing programmes, products and services.

The first segmentation approaches were based on geographic criteria, such that companies would cluster customers according to their area of residence or work. This was followed by segmentation approaches based on demographic indicators, such that customers would be grouped according to age, gender, income or occupation. Marketing segmentation research gained momentum in the 1960s. Twedt [8] suggested the use of segmentation models based on volume of sales, meaning that marketing efforts should focus on customers engaged in a considerable number of transactions. This approached, called "heavy half theory", highlighted that one half of customers can account for up to 80% of total sales. Frank et al. [9] criticized this segmentation arguing that this assumes that the heavy purchasers have some socioeconomic characteristics that differentiate them from other purchasers, what was rejected by the regression analysis carried out. Subsequently Haley [10] introduced a segmentation model based on the perceived value that consumers receive from a good or service over alternatives. Thus, the market would be partitioned in terms of the quality, performance, image, service, special features, or other benefits prospective consumers seek. These models triggered further research that allowed to obtain sophisticated lifestyle-oriented approaches to segment customers. The lifestyle concept, introduced in the marketing field by Lazer [11], is based upon the fact that individuals have characteristic patterns of living, which may influence their motivation to purchase products and brands. During the 1970s, the validity of the multivariate approaches used to identify the variables that affect deal proneness was criticized (see Green and Wind [12]), which motivated the development of enhanced theoretical models of consumer behavior (e.g. [13]). One decade later, Mitchell [14] developed a generalizable psychographic segmentation model that divides the market into groups based on social class, lifestyle and personality characteristics. However, practical implementation difficulties of this complex segmentation model was widely noted during the 1990s in, for example, [15] and [16].

More recently, the marketing literature raised the concern that customers are abandoning predictable patterns of consumption. The diversity of customer needs and buying behavior, influenced by lifestyle, income levels or age, are making past segmentation approaches less effective. Therefore, current models for marketing segmentation are often based on customer behaviour inferred from transaction records or surveys. The resulting data is then explored with data mining techniques, such as cluster analysis. Examples of applications of data mining for segmentation purposes using survey results include [17]. In the context of long-distance communication services, the clients were segmented using psychographic variables, based on data of a survey composed by 68 attitude questions. Min and Han [18] clustered customers with similar interests in movies from data containing explicit rating information provided by each customer for several movies. The rating information allowed to infer the perceived value of each movie for each customer. Helsen and Green [19] also identified market segments for a new computer system based on the use of cluster analysis techniques with data from a customer survey. The segmentation was supported by the rate of importance given to the product attributes.

Concerning segmentation approaches informed by transaction records stored in databases, the "recency, frequency and monetary" (RFM) model introduced by Bult andWansbeek [20] is an example of a widespread approach for segmenting customers by means of clustering techniques. This model explores the information on the date of the last purchase (recency), on how often the customer makes purchases (frequency) and on the amount spent (monetary), extracted from the transactional database. Recent segmentation studies using the RFM model include [21], whose objective was to specify segments in the hardware retail market.

Having grouped customers with similar features into several segments, it is often necessary to infer their behaviour or lifestyle from purchasing records. In this phase, it may be interesting to find common trends in their purchases, such as sets of products often bought together. Market basket analysis is a data mining technique widely used for extracting product association rules. These rules can then be used by companies to propose potential purchases to customers, which are often associated to discounts as an incentive to buy. The use of market basket analysis to support customized promotional strategies is still incipient in the marketing literature. It is often used to support cross-sales for all company customers (e.g. [22]), or to support decisions of product assortment within stores (e.g. [23]). The literature on market basket analysis describes several developments of efficient association rule algorithms, but their application to real world case studies and integration with marketing policies is often disregarded.

In this context, this paper proposes the application of data mining techniques, including cluster analysis and market basket analysis, to enhance the design of customized promotions in an European retail company.

3 Methodology

The methodology followed in this paper aims to support the design of promotions to provide better perceived service levels. For this purpose, customers with similar purchasing behavior are first grouped by means of clustering techniques. This is followed by the characterization of the clusters' profile using a decision tree classifier. Finally, for each cluster, an association rules extractor is used to identify the products that are frequently bought together by the customers from each segment. Using this procedure, it is possible to send discount coupons to selected customers, based on their history of purchases and the product associations identified for customers of the same segment. Next, we describe the techniques underlying the application of the methodology described.

3.1 Clustering Analysis

Clustering analysis is a widely used data mining technique that maps data objects into unknown groups of objects with high similarity (i.e., clusters). There is a large variety of clustering algorithms (see Jain et al. [24] for an overview). Most clustering algorithms can be classified in partitional or hierarchical. A partitional clustering is a division of the data objects into non-overlapping groups, such that each object belongs to exactly one cluster. Partitional techniques require the prior specification of the number of clusters. Despite this limitation, partitional techniques have the advantage of allowing the optimization of a criterion related to similarity of objects within clusters or dissimilarity between clusters. Hierarchical algorithms can be classified as agglomerative or divisive. An agglomerative hierarchical clustering starts with clusters containing single objects and then merges them until all items are in the same cluster. In each iteration the two most similar clusters are merged. Divisive hierarchical clustering starts with one cluster and iteratively divides it into smaller clusters. Both agglomerative and divisive hierarchical algorithms produce a nested sequence of clusters, with a single all-inclusive cluster at the top, and single-object clusters at the bottom. The resulting structure of the nested clusters enables an easy visualization of the appropriate number of clusters. However, hierarchical techniques do not allow the relocation of objects that may have been "incorrectly" grouped or separated at an early stage.

The k-means algorithm, introduced by Aaker [25], is one of the clustering algorithms whose use is widespread. k-means, which belongs to the class of partitioning algorithms, has two main advantages: it is very easy to implement and it takes little time to run, which makes it suitable for large data sets. Therefore, in this paper we apply the k-means algorithm to segment customers based on transactions records. This algorithm aims to assign a set of n data objects to k clusters in order to achieve a high intracluster similarity and a low intercluster similarity. k-means has the disadvantages of requiring the prior specification of the number of groups (common to all partitioning techniques), and depending heavily on the initial seeds (initial objects defined as centroids of the clusters). In fact, it is necessary to define the initial seeds in the first iteration of the algorithm. Selecting different initial seeds may generate differences in clustering results, especially when the target sample contains many outliers. This algorithm does not have any mechanism for choosing appropriate initial seeds. However, it is a standard procedure to run k-means with different seeds and to choose the ones that have produced the lowest value of a criterion function, usually the square-error, which evaluates the distance from the objects to their cluster centroid. We used RapidMiner software for the empirical analysis reported in this paper, which uses an initial random sample as starting centroids for the clustering. After running the k-means algorithm with several seeds, we selected those with the lowest square-error.

After the selection of the initial seeds, each object is assigned to the closest cluster, according to the distance (typically the Euclidean distance) between the object and the cluster centroid. At the end of each iteration, the cluster centroids are updated, such that a new iteration can start. This process ends when the criterion function, e.g. the square-error, converges to a value close to the minimum.

Concerning the definition of the number of clusters, several heuristics are available, as it is not possible to theoretically determine the optimal value of the number of clusters (see Tibshirani et al. [26] for a revision). In this paper we used two criteria: the Davies-Bouldin index and "elbow" criterion. The Davies-Bouldin index, developed by Davies and Bouldin [27] is a function of the ratio of the sum of within-cluster (i.e. intra-cluster) scatter to between cluster (i.e. inter-cluster) scatter. A good value for the number of clusters is associated to lower values of this index. The elbow criterion, proposed by Aldenderfer and Blashfield [28] is based on a typical plot of an error measure (the within cluster dispersion defined typically as the sum of squares of the distances between all objects and the centroid of the correspondent cluster divided by the number of clusters) versus the number of clusters (k). As the number of clusters increases the error measure decreases monotonically and from some k onwards the decrease flattens significantly. Such "elbow" is commonly assumed to indicate the appropriate number of clusters.

3.2 Rules Extraction

Classification rules extraction is a process that can be used to identify the main features that distinguish the objects from different clusters. A well-known technique for classification is the decision tree developed by Quinlan [29], which easily allows to obtain rules that characterize groups. This is done by identifying the attributes, i.e. clustering variables, considered relevant to the groups' description. A decision tree has the structure of a tree with nodes and branches. The nodes can be of two types: leaf and decision node. A leaf represents a classification, i.e. the cluster name, while a decision node is a point where a choice must be done between two branches corresponding to different values of a certain attribute. The branches spanning from a node represent the possible alternatives between ranges of values of the attributes.

The algorithm used in this paper for the construction of the decision tree was C4.5, developed by Quinlan [29]. This algorithm is an enhancement of the ID3 algorithm [30]. In order to remove branches of the trees that provide little power to classify data objects, the decision trees are pruned. The main reason for pruning is to allow the definition of generic rules, easily interpreted, that classify most objects.

A decision tree can be used to classify a market segment. This requires starting at the root of the tree and moving through the branches, containing the mutually exclusive values of the attributes, until reaching a leaf (containing a cluster name). Therefore, to extract rules concerning a cluster, it is necessary to consider all paths from the root to the leafs with the cluster name.

3.3 Market Basket Analysis

Market basket analysis consists on the discovery of groups of products/services purchased together, using data mining association techniques. An association rule can be represented in the form $X \Rightarrow Y$, indicating that when product X is purchased, product Y is also purchased. X is known as the antecedent and Y is the consequent, such that the antecedent triggers the purchase of the consequent. The algorithms that can be used for market basket analysis are the ones used for a generic problem of association: the Apriori algorithm [31], Frequent-pattern growth algorithm [32] and Eclat algorithm [33]. These algorithms involve two stages. The first stage concerns the discovery of the products more frequently purchased. The frequent set mining problem algorithm used in this paper was the Apriori algorithm. The second stage relates to the association rule generating process, defining which products are the antecedents (X) and which are the consequents (Y).

Algorithms for discovering frequent products involve several steps. In the first step, it is defined which products have a minimum percentage of occurrences in all market baskets. The support, represented by $s(X)$, measures the percentage of transactions in all shopping baskets that correspond to sales of product X. Next, the products with a support higher than the limits specified are combined two by two, and the percentage of occurrences for these candidate product sets is computed, i.e., it is estimated the value of $s(X, Y)$. The groups of two products with a support greater than the minimum defined by the analyst are taken into account in the next step, where the set is added one more product, selected from the group of frequent products identified in the first step. This iterative process continues until no more product sets with a support above the minimum specified are found.

Once the discovery of the products more frequently purchased is finished, it is necessary to identify within the frequent product sets, the antecedent and consequent products. This requires the estimation of confidence and lift measures. Considering the association rule $X \Rightarrow Y$, confidence is the ratio between the number of market baskets which contain both products X and Y and the number of baskets which contain X. Lift is a measure that evaluates the level of dependency between the products of an association rule. It is obtained by dividing the support of X and Y, $s(X, Y)$, representing the percentage of occurrences of X and Y in the same basket in relation to all baskets, by the product of the support of X and Y considered separately, as shows the expression (1).

$$lift(X, Y) = s(X, Y)/(s(X).s(Y)) \tag{1}$$

The lift represents the tendency to buy the products X and Y together. If the lift is equal to 1, there is independence between the occurrence of sales of products X and Y. If the lift is greater than 1, the products tend to be bought together, and if it is lower than 1, they tend to be bought separately. Rules presenting a lift less than 1 are usually disregarded, as only the rules with lift higher than 1 are interesting to guide the design of marketing programmes.

4 Customized Promotions Design

4.1 Introduction to the Company Used as Case Study

This paper develops a method to design retail promotions, informed by product associations observed in homogeneous groups of customers. An European retailing company is used as case study. This retailing company has a chain of hypermarkets and two chains of supermarkets (large and small stores). These formats differ essentially by the range and price of products offered, by the sales area and by the size of the city where they are located.

The establishment of loyalty relationships with customers became a main strategic goal for this company. The development of the company's information system and the implementation of a loyalty program have enabled collecting data on each customer profile (e.g. customer name, address, date of birth, gender, number of people in the household, the telephone number and the number of one identification document) and on their transactions (date, time, store, products and prices). This programm is supported essentially by a loyalty card, and currently approximately 80% of the total number of transactions is done by customers using the loyalty card.

At present, the company customers are segmented in two ways. One of them consists on grouping customers based on their shopping habits. This segmentation model is a simplified version of the RFM model proposed by Bult and Wansbeek [20], and is called internally: "frequency and monetary value" (FM) model. According to the values of these two variables, the company specifies 8 groups of customers. Each client integrates one of these groups, according to the average number of purchases done in a 8 week period and the average amount of money spent per purchase. The changes in the percentage of customers belonging to each group are used to sinal actions required in customer relationship management. For example, if the number of customers in the clusters with more visits to the store decreases, the company is alerted to launch marketing campaigns in order to motivate customers to go to the stores more often. The other method of segmentation is based on customer necessities and preferences. In this case, customers are grouped into 7 segments according to the mix of categories and products they purchase. Each segment is distinguished by the high relative weight of the purchases of certain products category compared with others segments. This type of segmentation is used to optimize the price and range of products sold in certain stores.

Concerning the promotional strategy of the company, there are mainly 3 types of policies:

1. discounts on specific products advertised in the store shelves and leaflets, that are applicable to all customer with a loyalty card;
2. discounts on purchases done on selected days (percentual discount or absolute discount on the total value of purchases). These are applicable to customers that present at the point of sale (PoS) the discount coupon sent by mail;
3. discounts for specific products on selected days. These can be sent by mail or issued at PoS.

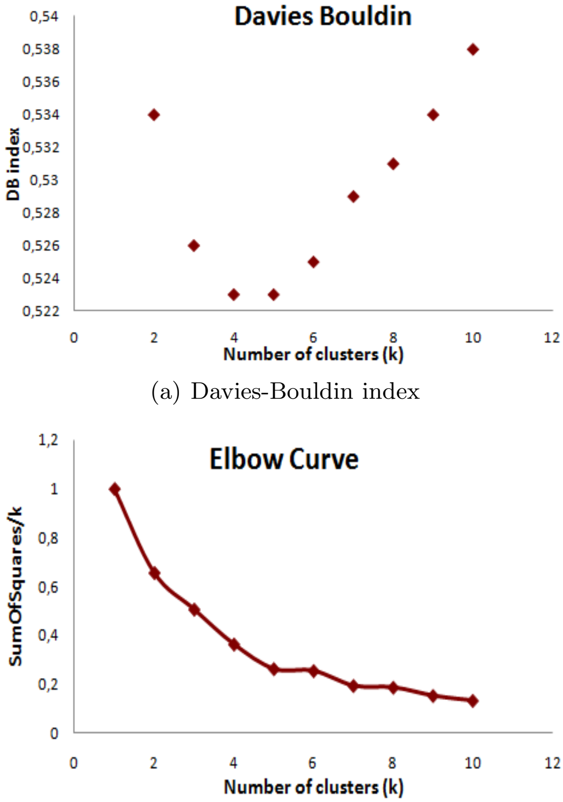
The first two types of promotions do not differentiate between customers of different segments. The third type, instead of using the segmentation models previously described, uses a model based on the historical purchases of the product included in the promotion. The discounts are only issued to the most frequent buyers of the product, or to those customers who do not normally buy the product, to encourage new buyers.

The analysis reported in this paper is based on transactional data of customers with a loyalty card. The database used includes the records from the last trimester of 2009. Each transaction includes: the client identity number, the date and time of the transaction, the product transacted and the price of the product. In addition to the transactions information, the company provided demographic information for each customer: residence postcode, city, date of birth, gender, number of persons in the household. The preparation of the database for the exploratory analysis involved the integration of the data from different sources, and the elimination of the outliers. Customers whose average amount of money spent per purchase or the average number of purchases per month is out of the range of the mean plus three standard deviations were excluded from the analysis. As we are interested in the design of promotions for households it was also decided to remove from the database all customers whose average amount of money spent per purchase was greater than €500. These represented 0.75% of the customers included in the original database. Usually, purchases exceeding this value are done by small retailers that resell the products in competing stores, so these customers are not intended to be included in promotional programmes. After the selection process, the database contained 2.142.439 customers.

4.2 Segmentation

In our analysis, the customer segmentation was based on the concept of frequency and monetary value of customer transactions. These indicators represent proxies of customers' shopping habits, and are also the basis for the company FM segmentation model. Therefore, we defined as exploratory variables for clustering the following: the average number of purchases made per month and the average amount of money spent per purchase. Although the literature suggest the use of the RFM variables, we did not include the recency variable, since we consider that the period of analysis is not large enough to enable the differentiation of customers in this dimension.

Clustering customers by means of the k-means algorithm requires the a priori definition of the number of clusters (k). In order to support the choice of the number of clusters, it was computed an elbow curve and the Davies-Bouldin index for different values of the number of clusters, as depicted in Figure 1. According to the Davies-Bouldin index, the most appropriate number of clusters would be four or five, as these correspond to the lowest value of the index. From the Elbow curve, we can conclude that five clusters seems to be the most appropriate option. Therefore, we proceeded with customers' segmentation into five clusters.



(a) Davies-Bouldin index

(b) Elbow curve

Fig. 1. Error measures for different numbers of clusters

The percentage of customers included in each cluster specified by the k-means algorithm was as follows: 37% in Cluster 4, 27% in Cluster 2, 20% in Cluster 3, 8% in Cluster 0 and 8% in Cluster 1.

In order to characterize the profile of customers belonging to each cluster, the rules underlying this classification were extracted using a decision tree. The segments' profile resulting from the decision tree are illustrated in Figure 2, and can be detailed as follows. Cluster 0 includes customers that go shopping more than 6.2 times per month. Cluster 3 corresponds to customers that go shopping between 3.2 and 6.2 times per month. Cluster 1 includes customers that go shopping less than 3.2 times per month and spend more than €135.9 per visit. Cluster 2 includes customers that go shopping between 1.5 and 3.2 times per month and spend less than €135.9 per visit. Cluster 4 corresponds to customers that go shopping less than 1.5 times per month and spend less than €135.9 per visit.

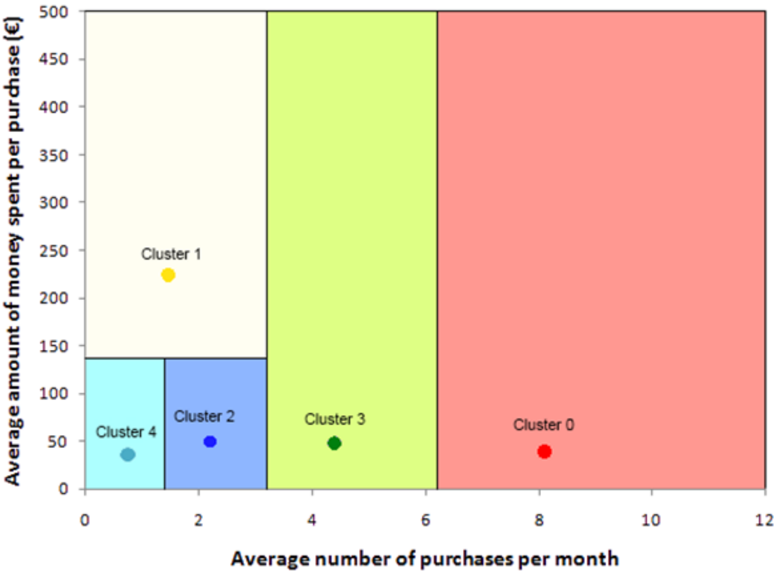


Fig. 2. Cluster characterization

4.3 Design of Customised Promotions Using Market Basket Analysis

The market basket analysis intended to identify relevant product associations within clusters, which can support the design of customized promotions. Customized promotions can contribute to improve customer loyalty as they represent an effort from the company to communicate with the clients, intended to reward the customer relationship with the company and suggest the acquisition of products that are likely to be of interest to each customer.

For the purpose of this analysis, a basket is the set of all products that have been bought by a customer in the past three months. Note that this information is collected without taking into account the products that were bought together in the same transaction. In this study, the market basket analysis was done at the subcategory level, instead of product level, since we were only interested in uncovering the type of products that may be potentially interesting for the customers of a given segment.

Let as assume, for illustrative purposes, that the company is interested in targeting customers with low frequency of visits to the store and low value of purchases. These clients are likely to make most of their purchases in stores from competitors, so the company may be interested in motivating them to visit the stores more often and enlarge the diversity of products purchased. The target segment that fits this profile corresponds to customers from Cluster 4. Thus, we developed a market basket analysis considering the shopping baskets of this cluster (785.679 baskets).

The subcategories were considered associated if they met the following conditions: a lift greater than or equal to 1, a confidence greater than or equal to 50% and a support greater than or equal to 2%. This means that there must be at least 15.713 baskets in which the subcategories considered to be associated were bought by the same customer. This resulted in the identification of 29 associations rules.

Most rules contain products from the same subcategory, such as hair conditioner and shampoo. A large number of rules include the products more frequently purchased, such as rice or milk, as could be anticipated. Nevertheless, some relationships between products from different sections were also identified. For illustration purposes, Table 1 shows the first ten product associations identified ordered by the lift.

Table 1. Association rules for Cluster 4

Antecedent (x)	**Consequent (y)**	Lift	Conf.	Supp(x,y)	Supp(x)	Supp(y)
Hair conditioner	Shampoo	5.50	64%	3%	5%	12%
Tomatoes	Vegetables for salad	4.55	60%	5%	9%	14%
Sliced ham	Flemish cheese	3.89	57%	7%	12%	15%
Cabbage	Vegetables for soup	3.68	58%	6%	10%	16%
Pears	Apples	3.68	51%	6%	12%	14%
Processed meat	Pork offal	3.52	51%	4%	8%	15%
Salt	Rice	3.40	53%	4%	8%	16%
Oil	Rice	3.26	51%	6%	12%	16%
Packaged vegetables	Vegetables for soup	3.22	51%	3%	6%	16%
Rice	Pasta	3.08	58%	9%	16%	19%

Let us assume that the company wants to motivate customers to buy products that may be of interest to them, but that were left out of their shopping lists in recent purchases (i.e. not registered in the customer transactions in the last three months). For this purpose, the company may issue a discount voucher at the PoS that advertises a consequent product of the association rule, which was not recently bought by the customer who bought the corresponding antecedent product. For example, the company shall suggest a discounted purchase of shampoo to customers that have bought conditioner but did not buy shampoo in the last trimester, or issue a voucher of vegetables for salad to customers that have bought tomatoes. The first of these promotional policies could motivate approximately 15 thousand customers to go shopping to buy a product that has not been recently included in their shopping list, despite its potential interest to the client. For the second promotion mentioned, the number of target customers would be about 27 thousand. Therefore, these promotions can not only motivate customers to visit the store more often, but also enhance the diversity of products bought in the company stores by each client.

In order to verify if the promotional actions would be different if the company targeted, for example, the most frequent customers, we developed a market basket analysis for customers of Cluster 0. Imposing a similar criteria for lift (≥ 1), confidence (≥ 50%) and support (≥ 2%), the total number of rules identified was 1000. The first 10 rules, ordered by lift, are shown in Table 2. It is interesting to observe that for small clusters, such as Cluster 0, using the same criteria, it is possible to obtain more subcategory association rules than for the bigger clusters such as Cluster 4. Most of these rules also present higher confidence and support. However, the high values of support for each subcategory resulted in the reduction of lift for the association rules. The values obtained for confidence, support and lift reveal high similarity in the purchasing behaviour of customers belonging to smaller clusters, such as Cluster 0. Conversely, in Cluster 4 whose customers make sporadic purchases, it is more difficult to find common buying patterns.

Table 2. Association rules for Cluster 0

Antecedent (x)	**Consequent (y)**	Lift	Conf.	Supp(x,y)	Supp(x)	Supp(y)
Vegetables for salad	Tomatoes	1.27	67%	45%	68%	53%
Tomatoes	Vegetables for salad	1.27	86%	45%	53%	68%
Flemish cheese	Sliced ham	1.26	67%	42%	63%	54%
Sliced ham	Flemish cheese	1.26	79%	42%	54%	63%
Sugar	Flour	1.22	62%	41%	67%	51%
Flour	Sugar	1.22	81%	41%	51%	67%
Apples	Pears	1.21	73%	50%	70%	61%
Pears	Apples	1.21	84%	50%	61%	70%
Napkins	Toilet paper	1.20	72%	43%	61%	60%
Toilet paper	Napkins	1.20	73%	43%	60%	61%

Although some of the rules discovered for Cluster 0 and Cluster 4 are identical, such as the purchase of sliced ham triggers the purchase of flemish cheese, we can verify from the comparison of Table 1 and Table 2 that clients from these clusters have different shopping habits. Therefore, we believe that the procedure suggested in this paper, consisting of segmentation prior to the use of market basket analysis to propose customised promotions, is a contribution to the enhancement of service levels by retailing companies.

5 Conclusion

This paper segmented customers of an European retailing company and proposed promotional policies tailored to customers of each segment, aiming to reinforce loyal relationships.

Data mining allowed to find natural clusters based on transactional records stored in the company loyalty card database. The segmentation was based on a frequency (average number of purchases made per month) and monetary value (average amount of money spent per purchase) criteria, and used data from the last trimester of 2009. Using a partitioning cluster analysis technique, customers were grouped into five clusters according to their shopping habits. The analysis also involved the construction of a decision tree in order to extract the rules underlying customer segmentation. Indeed, it was possible to draw a profile for each segment that can be used for customers classification with high precision.

The research described in this paper also identified significant product association rules within each segment, taking into account customers' market baskets. These rules enabled the design of customized promotions and consequently the provision of better services to customers. Indeed, product association rules can be crucial to motivate customers to increase their purchases and keep loyal to the company.

As future work, it would be important to interview panel customers belonging to each cluster, in order to verify if they are satisfied with the promotions that are issued to them and to know if they consider that the service levels have improved. It would be also interesting to monitor the evolution of the results of the satisfaction surveys currently done by the company, in respect of the promotions' offerings, in order to evaluate the impact on service levels following the changes in promotions allowed by the current work.

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The Dual Perspective of Sustainable Development in Service Innovation: A Conceptual Model Proposition for Research and Technology Organizations

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Abstract. The work presented in this paper aims to elaborate a model of sustainable development of service innovation dedicated to Research and Technology Organizations (RTOs). This model considers two aspects of sustainability, namely the one that supports the sustainability of the innovation process within the organization ensuring its continuous improvement, and the one that respects the environmental, social and economical constraints of traditional sustainability theory. The purpose of this model is to provide a complete and relevant vision of the multiple dimensions and organizational tensions that challenge the current issues of sustainable service innovation management within RTOs.

Keywords: Innovation, Services, Organizational Capabilities, Sustainability, Research and Technology Organizations.

1 Introduction

It is undeniable that we are in the midst of a service-driven business revolution [1]. Most economies have been basing increasingly their development on services. Moreover, innovation is critical for sustaining a competitive advantage towards rivals; pursuing the next great idea has become an end in itself as competition grows, technology advances and markets shift. As a result service innovation seems to be critical in order to keep up with the dynamic contemporary business environment.

However, as obvious as innovation in services may seem today, its specific attributes still represent a great challenge for both researchers and organizations. Considering research, this can be partly attributed to the fact that the majority of service innovation studies, rely on theories of innovation rooted in a time where manufacturing was still the major economic activity and they need therefore new conceptual insights and developments [2]. Considering organizations, a similar assessment can be made. Since most organizational forms and models, that support service innovation, rely on "traditional" perspectives of New Product Development (NPD) instead of focusing on New Service Development (NSD), consequently this makes them most of the time unsuitable [3].Thus the need for research on service innovation contributing to the relevant emerging literature is undeniable, as we

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manifestly lack of well-established theoretical contributions and practical experiences able to support service innovation in a sustainable way. This demand, therefore, raises issues of sustainability regarding innovation in services.

Studying sustainable innovation represents a challenge as there is no precise or established definition for it, reflecting the more general difficulty in defining the concept of sustainable development [4]. The literature has either been concentrated on the sustainable development of innovation in terms of its environmental, economical and social responsibility aspects [5; 6] or on the sustainability of the innovation process [7; 8]. However, beyond the consideration of the environmental, social and economical impact of service innovation, sustainability issues within organizations address also their own ability to ensure long term performance and business effectiveness. We argue in this contribution that it is the combination of these two aspects that permits us to gain a complete understanding of sustainable innovation.

We propose therefore to tackle such sustainability issues in the context of Research and Technology Organizations (RTOs), which are extremely sensitive to both aspects of sustainability. Indeed, RTOs are according to the European Association of Research and Technology Organizations (EARTO) organizations *"which as their predominant activity provide research and development, technology and innovation services to enterprises, governments and other clients…"* [9:1]. They can be public or semi-public research institutes benefiting from both public and commercial funding, and that provide a combination of academic and applied research [10:134].

So RTOs need, on the one hand, to sustainably support their own service innovation processes as they are knowledge-intensive organizations which have as a premium aim to provide innovative services and on the other hand they have to consider the environmental, economical and social impacts of their services as due to their dependence on government's support they are liable towards society. Moreover they can contribute towards sustainable innovation systems as they have strong links with policy makers, industry and academia.

As a result the purpose of this paper is to build a model that will explain the sustainable development of innovations in RTOs building on a resource based view of organizations. In this model we are assuming a representation of the RTO with internal and external aspects and we are taking into account the two aspects of sustainability. The model presented in this paper is conceptual and it is constructed out of the synthesis of several elements that result from a review in the literature of service innovation and sustainability.

2 The New Service Development (NSD) Process

Innovation may seem an abstract concept, however in order to achieve the development of an initial idea to real service a well-defined process is needed [11; 12]. Thus there has been a lot of discussion on the NSD process and the relevant models that would lead to the greatest efficiency. However, historically the bulk of research has been concentrated on the relevant NPD models.

Booz, Allen and Hamilton (BAH) proposed one of the first NPD models [13]; the famous BAH model on which many researchers have built. This model identifies six stages: idea generation, screening, commercial evaluation, development, testing, and market launch. Moreover, Kline and Rosenberg [14] with their chain linked model, presented for the first time an iterative model in NPD. However the validity of such NPD models in the context of services remains to be demonstrated [15].

But there have been also some attempts to model the NSD process separately. Shostack [16] developed one of the earliest linear models comprising of ten discrete steps. Scheuing and Johnson [17] based on the BAH model, created their fifteen stages model where they emphasized the importance of the concept development phase. Moreover, Edgett and Jones [18] presented their own sequential model as they identified 16 stages (observing a NSD project) including market research, business plan, IT development, agreement and post-launching evaluation.

As it was expected scholars quickly identified the weaknesses of linear models. Tax and Stuart [19] created an iterative model of NSD which shows that new services can be born in or out of existing service systems. De Jong et al. [20] see the NSD process as a process comprising two stages each with three activities; the search stage (idea generation, screening and commercial evaluation) and the implementation stage (development testing and launch). Furthermore, Johnson et al. [21] have created a general highly iterative model involving four phases; namely design, analysis, development and full launch. Froehle and Roth [22] propose their non sequential resource based conception of NSD where they emphasized the interdependence of design and development phases in NSD. Finally, more recently Zhou and Wei [23] after reviewing various NSD processes proposed a generic three stage model comprising the idea phase, the development phase and the introduction phase.

But the NSD process is not an isolated process. Service design requires an understanding of the customer outcome and customer process, the way the customer experience unfolds over time through interactions at many different touch points [24]. Gallouj and Weinstein [25] argue that the participation of the client in the NSD process is one of the fundamental characteristics of service activities, particularly 'knowledge-intensive' ones. The benefits of collaborating with customers have been praised by many scholars [26; 27]. However the integration of customers in the innovation process can bring also notable challenges that need to be addressed in order to make the most out of this valuable collaboration [26].

Based on all the above we conclude that structuring the NSD process is beneficial for the efficiency of the innovation activities and the sustainability of the innovation process within an organization. We argue that the iterative models are more likely to describe effectively the NSD process as they combine the necessary, for the NSD process, structure and flexibility. Finally, the outcome of the NSD can benefit significantly from proper client collaboration in various steps of the NSD process.

3 The NSD Process through the Resource Based View Lens

According to the Resource Based View (RBV) of the firm [28], the competitive advantage comes from a bundle of organizational resources which have four distinctive attributes; namely they are rare, valuable, imperfectly imitable and without equivalent substitute [29]. From this perspective, capabilities are considered as a repository of historical experience in organizational resources deployment and organizational learning [30]. But capabilities are not only the result of tacit accumulation of knowledge and learning by doing, they can also result from firm's deliberate actions to continuously learn and capture the lessons from previous experience [31]. Especially for the development of innovations the ability of the firm to exploit this knowledge in a way that permits to generate new application is what Kogut and Zander [32] named combinative capabilities, i.e. the firm's capacity to deploy their available resources [28].

Resources themselves though cannot be a source of competitive advantage; they need to be exploited in order to create innovation capabilities that will drive the NSD process effectively and efficiently. The same resources can result in different capabilities if they are deployed in a different way and in different combinations [33]. So it is the management choice how to use the available resources to create the capabilities for innovation. This is in line with Penrose [28] who argues that resources are a bundle of potential services and while these resources are available to all firms the 'capability' to deploy them effectively is not always present [33]. Thus *" a capability does not represent a single resource in the concert of other resources […] but rather a distinctive and superior way of allocating resources*" [34:914].

However challenges also exist with organizational capabilities; according to Schreyögg and Kliesch-Eberl [34] path-dependency and lock-in, structural inertia and commitment are the main challenges. In other words, organizational capabilities are prone to become fixed to the constellations in which they proved to be successful. In the face of a changing environment, organizations are bound to their stabilized structures and action patterns [34]. So it is vital to overcome the inherent inertia of capabilities in order to adapt to the dynamic environment.

Hence, organizational capabilities have become highly valued attributes of firm as the competent organization has become a new ideal [34]. Thus the "raison d'être" of innovative organizations is to develop such innovation capabilities in order to successfully achieve their innovation processes.

4 The RTO's Assets Structure

There have been some significant attempts to relate this RBV with the NSD process. Gadrey et al. [35] argue that performing a service involves setting a bundle of capabilities and human, technological, and organizational competencies. According to Froehle and Roth [22],we consider three main elements that are identified as key enablers for service innovation: namely the available information technology, the human skills, the organizational processes and structures. Nevertheless, according to recent literature developments, we complement their vision in adding the competencies of collaborating. Moreover, the experience base of the organization and the service portfolio are also taken into account. We gather all these elements in an extended asset structure, and for the sake of clarity, we separate them analytically though they are empirically entangled.

4.1 The Resource Base

We consider the resource base to comprise the following elements:

(i) *The Importance of Human Skills*. Organizational knowledge comes fundamentally from individuals and the transfer of know-how implies socialization processes, the connection of employees daily work experiences with opportunities for improvement and innovation [36]. Human skills and intellectual resources constitute the organization's human capital [29]. RTOs are knowledge-intensive organizations and so are the NSD processes and as a result the human capital plays a crucial role in the development of their business services.

But it is not only the technical skills and the specialized knowledge that counts. Froehle and Roth [22] bring forward also the cultural and experiential knowledge and skills contained within the firm's employees. Soft skills like the ability to collaborate, the open mind set and creativity are also skills that should not be neglected. Herzog [37] identifies that employees' personalities are important in the open innovation mentality. People should fight feelings of resistance which according to Kuschel [38] mainly comes from the technical staff and the middle managers.

(ii) *The Role of Organizational Structure*. The importance of the organizational structure on the innovation process is outlined by Miller [39] who argues that the most innovative firms are characterized by adaptive, organic organizational structures that foster collaboration and open and informal communication systems. These flexible organizational structures bring benefits from cross-functional teamwork and enhance knowledge combination perspectives which are far more important than improved efficiency or reduced development time [40].

Furthermore, what cannot be disregarded when discussing the organizational structure is its informal aspect. At the heart of this aspect lies the organizational culture; a system of informal rules that spells out how people are to behave [20]. Cultural change is essential to innovation activities [41] and such a culture, which fosters creativity, collaboration and knowledge transfer, is as important (and often more) as formal processes.

(iii) *Information Technologies (IT) as NSD Enabler*. IT plays a critical role for services, and has quickly become a crucial element of service firms [42]. Tools of advanced IT benefit firms as they allow for the regeneration of knowledge that lies within the organization and as a result the creation of better processes and service products [40]. We consider the benefits of IT for NSD to be twofold: (i) IT can raise organizational effectiveness in generating information efficiencies [43], by improving the initial base of knowledge to draw from when employees engage in problem-solving and decision-making; (ii) IT can foster collaboration and creativity in creating boundary-spanning information synergies.

(iv) *Relational Competencies.* The classical RBV according to which internal resources are among the firm's biggest competitive advantage has been challenged [44]. Möller et al. [1] discuss the limitations of the RBV view and extend it by analyzing the ways of value co-creation with customers in the innovation process. On top of that firms decided to open up their boundaries in the context of the open innovation paradigm [45] and create alliances with other firms and collaborations with suppliers or academia using distributed co-creation practices. Schilke and Goerzen [46] argue that alliances constitute an important asset of the organization which should be embedded in the overall strategy of the organization. They cannot merely be perceived as an *ad hoc* activity they need to be managed efficiently and their management constitutes a dynamic organizational capability. Previous relevant experience and organizational structures seem to be determinants of alliance success.

As a result the relational competencies of the firm constitute one of its significant assets since the value created from these relations has a significant effect on all the stages of the innovation process [1].

4.2 The Experience Base

In the theory of organizational capabilities the notion of previous experience often comes up as an important asset to be exploited. We consider the experience base to be a bundle of experiences and accumulated knowledge regarding previous NSD processes deployment that can be reused for the development of new services.

The experience base represents therefore the "organizational memory" [47] where both tacit and explicit knowledge of previous NSD experience are capitalized and managed. With tacit knowledge we mean all the knowledge that resides in employees in the form of un-codified knowledge such as learning by doing or best practice. The concept of best practice was defined by O'Dell and Grayson [48] as: "*Any practice, knowledge, know-how, or experience that has proven to be valuable or effective within one organization that may have applicability to other organizations*". However issues of rigidity should be considered as often best practices can lock employees and management in old practices and hinder the exploration of new knowledge.

Organizational devices that support the collective memory can adopt various forms, from individuals to organizational procedures and systems (e.g., quality and knowledge capitalization systems) [47]. However, the efficiency of the reuse of past experience is directly linked with the efficiency of the existing information retrieval systems implemented within the organization. Walsh and Ungson [47] notice also that this can lead to political issues and/or collective rigidity and inertia that can have negative effects for the organization.

4.3 The Service Portfolio (SP)

The SP is a concept that we do not often take into account when talking about RTOs however we consider it also an important asset in the development of innovation capabilities [3]. A SP is a consolidation of selected services developed by the organization and contains functional as well as non functional requirements of the service. SP is impacted by the business vision and objectives and also by how and when business wants to achieve its objectives [49].

Although the importance of the experience base is indisputable, it is not enough to maintain previous developed services merely in the experience base of the organization; neither in a tacit (e.g. in employees skills) nor in a codified manner (e.g. in KM solutions). SP represents something different as it allows for the capitalization of the previous experiences of the RTO in terms of developed services and can be directly applied to attract new customers and support the position of the organization within the market. As a result the efficient management of service portfolio is important for sustaining a competitive advantage.

Even though the benefits of portfolio management are clear few companies actually use it, as there are several difficulties related to its management [39; 50]. On a study of IT portfolio management Jefferry and Leliveld [50] identified ten benefits of effective portfolio management: improved business-strategy alignment, centralized control, cost reduction, improved customer service, improved decision making, competitive advantage, and communication with business executives, improved ROI, professional respect and IT integration during mergers and acquisitions. These benefits may also be applied to service portfolios as well.

Moreover in the specific context of RTOs Barlatier et al. [3] have identified two additional benefits of the SP management: (i) it increases services' visibility for the clients as it fosters interaction between the organization and the markets and (ii) it involves customers in the co-design process.

5 The Sustainable Development of Innovation in Services

We consider the sustainable development of innovation in services, which reflects the RTO's innovation strategy, to be double fold. On the one hand it raises issues of governance as far as the assets and the capabilities of the RTO are concerned and indicate the way innovative organizations need to manage efficiently their service innovation process. On the other hand, as far as the environmental, economical and social impacts of innovations, are concerned it reflects the organizational strategy of innovation and the way the latter is influenced by its external environment.

5.1 How the Efficient Governance of Resources and Capabilities Ensures the Sustainability of the Innovation Process

The difference between the NSD process and the innovation process is not always obvious in the literature. Merely structuring the NSD is not enough for assuring the sustainability of the innovation process. Thus a model is needed that structures the innovation process in a higher level than the NSD but that is directly linked to it.

Towards this perspective Hallenga- Brink and Brezet [8] present their sustainable innovation design diamond model. The diamond model has two parts: the first part is chaotic and describes the process of idea generation and screening while the second part is more structured and deals with the design and production process. The model places in its heart the concept phase and takes into account both internal (vision, learning and management) and external (consumers, government) actors. Finally, the model includes internal and external evaluation processes.

A similar noteworthy attempt was made by Absil et al. [7] and Bernacconi et al. [51] based on a service innovative RTO. In their framework the innovation process is structured in five steps (not necessarily sequential); namely the service value related with the opportunity identification activities, the service design, meaning the definition of the services functional characteristics, the service exposition which is related to the promotion activities, the service management which provides tools for monitoring and measuring the performance of the service and finally, the service capitalization which covers the activities related with the collection and analysis of assessment data.

Merely identifying such frameworks though is not enough. There is a need for adopting an integrated innovation strategy according to which resources and capabilities are managed accordingly. In fact organizational capabilities management has attracted a lot of interest primarily in the field of strategic management, in particular RBV theorists have put concepts of resources and capabilities as core elements of the generation and development of sustainable competitive advantage [29; 52]. However, a closer look at capability-based practices in service innovation management reveals the practical difficulties to manage resources and capabilities efficiently. Indeed, researchers points out lacks of effective management and governance practices in service-innovative organizations in terms of learning environments and continuous learning [53; 54] or even strategic and resource fit [55].

Recent research development on innovation capabilities and resources monitoring in RTOs focus on the necessary integration of indicators about intellectual capital (i.e. human resources), value-added processes and results of the organizational knowledge-production processes. Leitner [56] has observed two RTOs that have tried to implement such a governance system during four years. The author has concluded that one of the main benefits of intellectual resources measurement and reporting is that the organizations learn about their knowledge-production processes. However it is also alleged that frequent managerial guidance rather than constant monitoring provides innovation leaders with the autonomy and the effectiveness they need for the innovation development [57].

Towards this direction the need for an innovation and creativity culture is therefore evident. Indeed corporate culture and subsequently leadership have attracted interest in other theories of sustainable innovation development. An innovation culture which supports creativity, continuous learning and knowledge transfer through motivation and encouragement of new ideas by inspired leaders can be the most fertile environment for the birth and development of innovation [37]. Brennan and Dooley [58] in line with this opinion argue that it is important to foster the creativity of employees. They identify the available information technology, the motivation of employees, the reward system towards creativity, the training and the organizational support as essential levers for the innovation process.

5.2 Environmental, Economical and Social Responsibility in Service Innovation

Sustainable innovation, in contrast to market-driven innovation, considers the added constraints of social and environmental pressures. Thus it is more complex, as there is a wider range of stakeholders, and more ambiguous, as many of the parties have contradictory demands [6]. Therefore sustainable innovation represents a challenge for managers as often it proves their strategies to be inadequate [6].

Sartorius [5] argues that innovation is an answer to improved sustainability nevertheless it is often hard to shift from one technological trajectory to another one more sustainable and that is why this change is often induced by governmental regulations. This applies especially for RTOs who, due to their dependence on government's financial support, are obliged to be more sensitive in sustainability issues than other organizations, as their responsibility towards society is higher.

But it is not only the government regulations that require sustainability constraints. The customers also have started to show sensitivity towards sustainability issues and show actively their preferences towards more sustainable product and services. This is more relevant for service innovation for particular which, as we already elaborated before, is very much dependant on customer collaboration.

However being sustainable is neither an obligation nor a one-way interaction. RTOs contribute either directly or indirectly to systems of innovation [10] and their evolution. They support public innovation policy by facilitating technology transfer from science to industry [59] due to their strong relations with industry and academia. Potts [60] suggests that it is important to strengthen these links between academia, government, industry and research organizations because such a network would encourage collaboration and knowledge transfer between the actors driving the social change which is necessary for pushing the sustainable development into the society.

For instance some governments are promoting the concept of eco-innovation as a way to meet sustainable development targets while keeping industry and the economy competitive. Indeed much attention has been paid to innovation as a way for industry and policy-makers to work towards more radical and systemic improvements in environmental performance [61]. The challenge of a *sustainable innovation policy* is to develop enabling policy frameworks, strategies and processes that support technological and institutional innovation in ways that encompass the economic, environmental and social dimensions of sustainability. Hence this may lead to the development of better mixes of policy instruments that promote sustainable innovation [61; 62:2]. However, merely the political system cannot be a source of sustainable innovations a fertile environment is needed [5], and RTOs can provide it.

On the same reasoning Foxon et al. [62] propose to promote public-private institutional structures to implement sustainable innovation for specific environmental challenges. However, while the promotion of eco-innovation by industry and government involves the pursuit of both economic and environmental sustainability, the scope and application of the concept tend to differ [61]. Here the role of an RTO can be very beneficial as it offers the interface between government and industry, due to its public private character, which can bridge these gaps of incentives.

Furthermore, Dzisah and Etzkowitz [63:102] argue that: *"Interaction among university, industry and government as relatively independent, yet inter-dependent, institutional spheres is the key to improve the conditions for innovation and sustainable development in a knowledge-based society."* With the emergence of the concept of open innovation, RTOs may operate in the context of collaboration among other RTOs, suppliers and customers. Apparently this has an effect on the way the innovation process is performed or even the way innovation capabilities are mobilized. This open paradigm promoting the essence of collaboration is a lever to a sustainable (in its both aspects) innovation process.

Finally, we can consider RTOs as specific organization that may play an essential role in interfacing industry, academia and government. According to their particular mission, RTOs are expected to act under the sustainability constraints and thus positively and sustainably impact their service-delivery environment (e.g. their customers). But they may also influence their service innovation stakeholder's policies (industry, government and academia) through their service providing. As a consequence, RTOs co-evolve with their external environment and contribute positively to the development of sustainable service innovation systems.

6 Towards an Integrated Model

Building on these aspects, we propose the following model (Fig. 1) as synthesis of the above presented elements and their interactions.

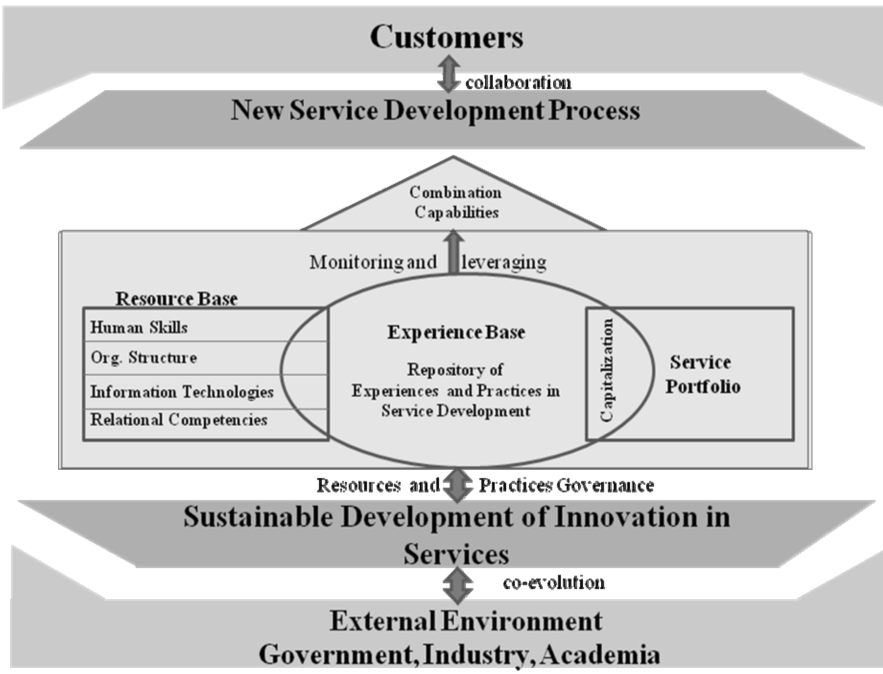

Fig. 1. Sustainable Innovation in Services Model

The model shows the two aspects of sustainability that the RTO needs to balance. On the one hand the innovation process has to be supported in a sustainable way within the organization. Thus there is a need for an innovation strategy that will lead the management of the assets of the organization. This implies the combination of the organization's critical assets; namely the resource base, the experience base and service portfolio that should be leveraged in order to develop innovation capabilities that will efficiently drive NSD processes.

On the other hand there are the environmental, social and economical constraints of the traditional sustainability theory that the RTO needs to respect. Due to its strong dependence to government's support the RTO is concerned about its impacts on the society. Furthermore, its strong relations with government, industry and academia make the RTO an important actor in the promotion of sustainable innovation systems that would lead the way towards a more sustainable society.

7 By Way of Discussion: A Glance into Existing Models

Our model illustrated the need for a complete perspective of sustainable service innovation that addresses both aspects of sustainability; the internal aspect that supports a sustainable innovation process but also the traditional sustainability aspect that takes into consideration environmental, economical and social impacts. An important notice here is that we examined traditional sustainability only on the level of policies and innovation systems. Of course the adoption of a sustainable strategy for the RTO has implications for its internal innovation process as well.

Concerning sustainability in NSD, many organizations, are now considering the environmental impact throughout the product's lifecycle and are integrating environmental strategies and practices into their management systems [4]. Different aspects have been taken into account such as the proposal of Brezet et al. [64] who specifically for the development of eco-efficient services have proposed a development process that is not much different from the traditional product or service development models but takes into account environmental aspects in various steps.

But it is not merely enough to consider sustainability as another parameter in the development process. There is a need for an integrated sustainability model that takes into account multiple aspects of the organization. For instance, Flores et al. [65] present a framework for sustainable innovation validated in two case studies. The model reveals four key enablers to sustainable innovation; (i) mass customization, (ii) sustainable development, (iii) the value network, and (iv) the complete product and service life cycle, where the three sustainable elements (economic, environmental and social) are identified inside each single process of the products' lifecycle. Accordingly, Maxwell et al. [66] have proposed the Sustainable Product and Service Development (SPSD) model. This model addresses issues of sustainable innovation in three levels: the service supply chain, the organization and the service and product development.

Although these two models present a complete proposal as far as sustainable services are concerned (taking into consideration internal and external factors) they do not entail issues of internal support to the innovation process. Towards this direction we consider promising the proposal of Hallenga-Brink and Brezet [8] to adapt their diamond model, in the future, to consider environmental constraints as well.

Despite their respective contributions, none of these models succeeds in capturing both aspects of sustainability in an integrated way taking into account the internal innovation processes of the RTO and its relations with the environment. We argue that both these aspects are extremely important for the development of sustainable innovation capabilities especially for RTOs. In line with Van Kleef and Roome [67] who distinguish innovation in two categories: innovation for competitiveness and innovation for sustainability and argue that the relative innovation capabilities for each of these innovation types seem to overlap, we argue that the two aspects of sustainability are not contradicting and should not be met as an extra burden for organizations. The right balance should be found so as to define strategy and organizational settings that support the innovation process while the environmental, social and economical impacts are taken into account in an integrated way.

8 Conclusions and Implications for Further Research

The model presented above provides a theoretical contribution on the different dimensions of the study of sustainable development of service innovation in RTOs. Through this articulation of theoretical elements we have highlighted key processes and organizational tensions of service innovation management, gathering internal and external insights, balancing with openness and sustainability. Of course it remains to be seen how this model will be altered, enriched and improved after its empirical testing within RTOs.

Thus next steps of this research consist in conducting qualitative, multiple case-studies of European RTOs in order to test empirically this framework. Expected benefits are multiple: first, we will have the opportunity to validate and/or refine the model through the empirical confrontation, second, such study will provide valuable insights of sustainable service innovation current practices within RTOs through cross-cases analysis, and third, the interpretation of the results may be a source of inspiration for every RTO's innovation and/or R&D managers.

Finally we are well aware of the fact that RTOs are not the only organizations dealing with the challenges of service innovation. We believe that other service innovative knowledge intensive organizations address similar issues of internal and external sustainability in service innovation. However profit based organizations, such as private companies, are fundamentally less sensitive regarding issues of environmental and social sustainability than RTOs. It would therefore be interesting, in terms of future research, to see such comparative studies between profit and non-profit or between public and private organizations and their attitude towards sustainability concerns.

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Implementing a Request Fulfillment Process

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Abstract. Request Fulfillment, as the name implies, deals with service requests, defining the roles and activities needed to deliver services. Typically, this process delivers the goods and services that customers request through the service catalogue. Although the Request Fulfillment process is perfectly described in the ITIL books, these do not explain how to implement this process. In this research we propose some solutions to mitigate the risks of a Request Fulfillment process implementation. The proposed solutions include a service request definition, its components, the roles involved in its management, a lifecycle process and their relations with others concepts. The proposal was implemented in two private companies, including a software factory that provides services to several clients. In order to evaluate the solution effectiveness, we monitored 8 metrics proposed by the ITIL framework.

Keywords: Request Definition, Request Lifecycle Process, Service Catalogue, Service Level Agreements.

1 Introduction

The work described in this paper is based on our previous research that proposed a service definition and a service identification process [1]. This process allowed us to identify the services of a service provider and to build a service catalogue. Having a service catalogue, the service provider can motivate their customers to request the services through it. However, this step is far from being trivial and some questions must be clarified from the beginning. Although the Request Fulfillment process is described in the ITIL books, these do not explain how to implement this process.

In this paper we propose a solution to manage the requests made over an existing service catalogue, including a definition of a service request, the components that a service request should have, the relations between service, service request, incident, change and SLA and a lifecycle process that describes the states that a service request can have and the activities that can change these states. The main contribution of this paper is to present practical solutions on how to implement the request fulfillment process and on how to integrate it with some other processes.

We evaluated our solution in two private companies in which we implemented a prototype that recorded all the service requests (before these implementations the companies had no idea which services were most requested and costly).

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In order to evaluate the solution effectiveness, we monitored 8 metrics proposed by the ITIL framework: number of Service Requests processed, request Fulfillment cost, hours worked against budget, time of day Requests have been submitted, number of presently unanswered Requests, number of Requests that have stopped dead in the process, number of bypasses to the process and percentage of Service Requests through the Request Fulfillment Management process.

As investigation methodology has been chosen the Action Research, because this is based on changes in the actual process and in the study of the results of those changes.

2 Problem

Although the Request Fulfillment process is described in the ITIL books, these do not explain on how to implement this process. For example, the request lifecycle process and the relations between requests and other concepts are not clear defined. Although ITIL addresses each concept (requests, incidents, changes, SLAs) individually, this library does not explain how these concepts should interact.

After having a service catalogue, a service provider must find a solution to link the clients' requests to the available services of the catalogue, otherwise it would be impossible to increase the operational efficiency by standardizing services and optimizing the delivery process. On the other hand, the service catalogue would become obsolete because the clients' requests would naturally evolve and not match the services described in the catalogue. The Request Fulfillment is a crucial IT management process because some of the other processes are based on these. So, if this process is poorly implemented, many other processes will suffer.

If IT does not have an articulated IT Service Catalogue used to request services, then IT managers cannot establish relations between the service results and the elements that work together to achieve those results. When this happens, IT has no frame of reference for knowing what matters to its customers, how well IT is performing in relation to expectations, or what needs to change to meet or improve expected results.

3 Related Work

The service concept is fundamental to understand the main principles of the best practices that the IT industry tries to follow. In order to comprehend this concept, a new way of thinking is necessary and it contrasts with the traditional instincts of the IT experts (that normally consists in components, such as software and hardware) [2]. This mindset requires instead an alternative outlook to be maintained, with the focus being the service-oriented view of what their organizations actually provide to customers. In other words, this mindset is focused in the results/value that IT can provide [3].

3.1 IT Services

Where the term "services" comes from? The modern usage arose out of the 1930s U.S. Department of Commerce's Standard Industrial Classification (SIC) codes. In these codes, the major economic sectors were agriculture, manufacturing, and services. At that time, services was a residual category for other activities that did not fit into agriculture or manufacturing [4]. Today, stretched beyond the point of being meaningful, that residual is the bulk of economic activity, and by far the fastest growing part of economic activity in the U.S.

How is the term "services" defined today? Ted Hill suggested that [5]:

"*A service is a change in the condition of a person, or a good belonging to some economic entity, brought about as the result of the activity of some other economic entity, with the approval of the first person or economic entity*."

Importantly, the U.S. government has accepted this definition as the basis for defining service products in the new North American Product Classification System (NAPCS) [6]. Other definitions of services can be found that emphasize an exchange between two or more parties and a transformation (potentially intangible) received by a customer [4][7][8].

According to ITIL, a service is *"a means of delivering value to customers by facilitating outcomes customers want to achieve without the ownership of specific costs or risks"*[9].

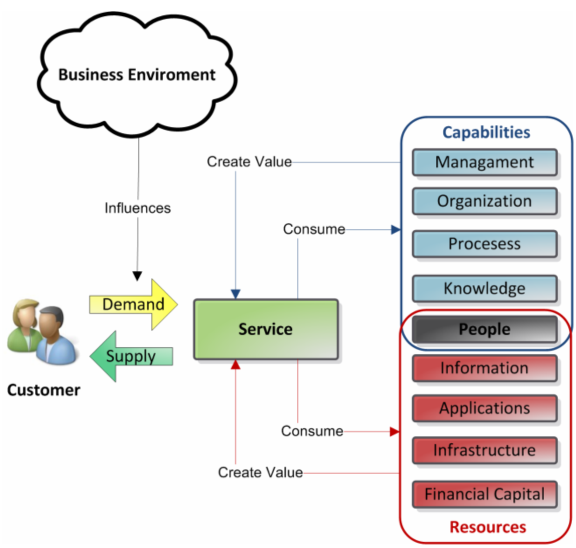

Fig. 1. Service Context [9]

Although this definition represents a good start to comprehend the general lines of what a service is, it is an abstract definition and does not identify all the service features, components and relations with the IT assets.

In the majority of the dictionaries the "service" concept is associated with intangibility, being defined as an action, not a thing, which cannot be stored or reused. A service responds to user needs by adding benefits to their operations.

To explain the key features of a service, we can use an analogy with the food industry. When we cook at home, we need to go to a grocery store, buy the ingredients, take these ingredients home, prepare and cook the meal, set the table and clean up the kitchen afterwards. As an alternative, we can go to a restaurant that delivers a *service* that provides us with the same outcome (a nice meal) without the time, effort and general fuss if we were to cook ourselves. However, the quality of a restaurant is not only influenced by the value of the food, but also by:

- The cleanliness of the restaurant;
- The friendliness and customer service skills of the waiters and other staff;
- The environment of the restaurant (lighting, music, decorations etc.);
- The variety of meal and drinks;
- The time taken to receive the meal (and was it what we asked for?).

If just one of these factors does not meet the clients' expectations then ultimately the perceived quality and value being delivered are negatively impacted. If IT staff focus on the application or hardware elements being provided and forget or ignore the importance of the surrounding elements that make up the service, just like in the example of the restaurant, the customer experience and perceived quality and value will be also negatively impacted [3].

The service definition used in this research is that every service [1]:

- Is an action not a thing and is intangible;
- Is simultaneously produced and consumed, so it cannot be stored or reused;
- Responds to identified needs;
- Can be sold to external companies;
- Uses capabilities and resources (people, tools, information, etc);
- Follows a delivery process;
- Adds value to buyers (this value may be valid for an agreed period);
- May contain tangible results;
- Is described with user terms.

According to this definition, as service examples may be considered: access and support to computer, application, printer or phone, and project or formation assistance. There are some examples of things that should not be classified as services: software XPTO, send email, change password or server.

3.2 Service Quality

Regarding the quality of services, there are two dimensions that determine it [10]:

- **The technical quality of the outcome** – This dimension is formed by the result of the service, *what* the customer is left with when the service has been delivered;
- **The functional quality of the process** – This dimension is determined by the way in which the customer receives the service, in other words *how* the service is delivered.

Service marketers often use the gap model to illustrate how differences between perceived service delivery and expected service can come about. The net difference between the perceived quality of the services and the expected quality (Gap 5) is caused by four other gaps [11]:

- **Gap 1** – The expected service as perceived by the service provider differs from the service as expected by the customer;
- **Gap 2** – The service specification as used by the service provider differs from the expected service as perceived by the service provider;
- **Gap 3** – The actual service delivery differs from the specified services;
- **Gap 4** – Communication about the service does not match the actual service delivery.

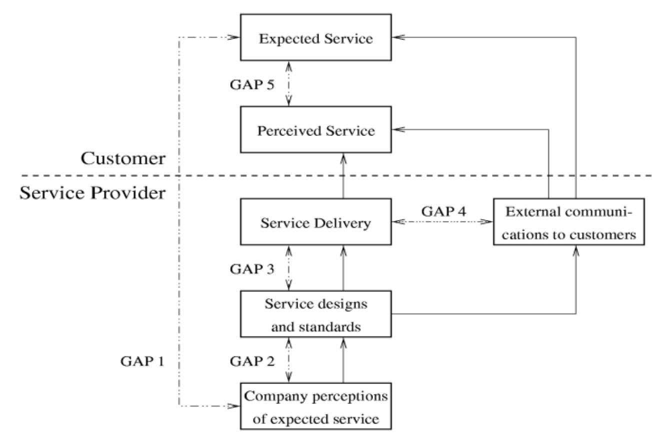

Fig. 2. The Gaps model of service quality [12]

Although the gaps model was produced in the marketing literature, it identifies 5 gaps that in our point of view are present in IT service providers. The difference between the customer's expected service and the service provider's perception of expected service is a classical gap in the IT industry (gap 1). The client normally does not know how to express his intentions and frequently the IT service providers do not understand these intentions.

3.3 Service Catalogue Management Process

The Service Catalogue Management process provides a unique information source of the agreed services and it ensures that the catalogue is available for users to consult [9].

The service catalogue is formed by the active services and by the ones that will be active in short term. In some cases it can be very detailed and describe besides services, politics, prices, service level agreements and sourcing conditions [13][14].

The service catalogue has two levels:

- Business Service Catalogue:
  - Contains details regarding the available services, relations with business processes and represents the customer view of the catalogue;

- Technical Service Catalogue:
  - Contains information about available services, relations with the support processes and the respective Configurations Items;
  - It is not visible by the customers.

Although ITIL and CMMI identify the principal aspects of what a service catalogue is, they both fail to explain how to implement this concept. For example, in the case of the service identification process, ITIL only says that the integration between the business needs and the IT capabilities must be done. CMMI defends that, when identifying the services, it is necessary to respect the organizational politics, standards and models. Neither explains how to identify the services of an organization.

This lack led us to propose solutions that allow a service provider to build its own service catalogue [1]. These solutions allow a service provider to close the Gap 1 because they translate the customer's service expectations into clear service agreements and also Gap 2 because they use the service agreements as a basis for planning and implementing the service delivery [1].

3.4 Request Management Process

According to ITIL, a service request can be defined as a "*request from a user for information, or advice, or for a standard change or for access to an IT Service*" [15]. From the customer point of view this definition makes sense, because all the requests made by him to the IT are service requests, although some may correspond to incidents or changes. But the same is not applicable to the IT employees, because they mostly understand what represents each request. ITIL starts to address it, but does not explain how to manage each concept. Some key questions remain unanswered: What is the difference between incident, change and service request? How and where should those concepts be recorded? When a standard change is made, should it be recorded as a service request? Although ITIL addresses each concept individually, this library does not explain how these concepts should interact.

3.5 Service Level Management

Service Level Management intends to define, to document, to agree, to monitor, to measure, to report and to review the quality level of the services (Service Level Agreements or SLAs). In its context it should be defined a Service Level Manager (SLM) employee, who acts as the IT representative inside the business and vice-versa. SLM has the responsibility to manage the business expectations and to ensure that the services are delivered according to these expectations [16].

4 Proposal

In this section we describe our solutions to solve the addressed problem.

4.1 Service Request Definition

We propose that a service request is only a solicitation of a documented service, therefore the distinction between documented services and standard changes must be very clear. IT managers might have the temptation to lists these two concepts in the service catalogue, which could make it too much extensive and not usable. For example, changes such as “Change Password” or “Give New Permission” should not be documented as services, they should be saved as standard changes that could and shall be associated with a support service.

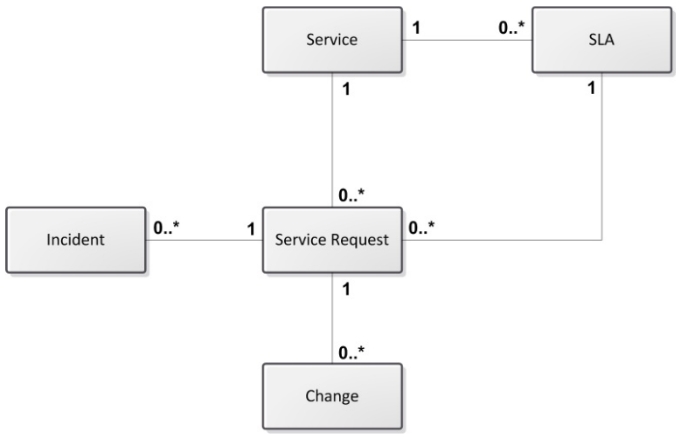

Fig. 3. Relations between service, service request, incident, change and SLA (proposal)

Figure 3 illustrates the proposed logic that shows the relations between services, service requests, SLAs, incidents and changes. All the services may have associated zero or more requests and SLAs. This allows to create several SLAs for the same service, giving opportunity for the users to choose the best for them in the service requests. These requests may have multiples incidents and changes associated that shall respect the respective SLA. Thereby, in the act of subscribing a service, the users know the maximum expected time to solve an incident related to that service.

4.2 Service Request Components

We propose that service requests contain the following components:

- Service – Service to be subscribed;
- User – User that subscribes the service;
- Receiver – Employee that will receive the service;
- Way of Request – How the service is requested (Service Desk, Web Portal, other);
- Request Date – Date of the request;
- Approval Date – Date in which the approver validates the request;
- Delivery Date – Date in which the service is delivered;
- Validity Date – Date in which the value of the service expires;
- Optional – List of the optional features chosen by the user;
- Service Level Agreement – SLA chosen by the User;

- Total Cost – Total cost of the service request. Sum of service base cost, optional features cost, SLA cost and validity cost;
- State – Identifies the state of the request.

We believe these attributes are sufficient to manage the requests effectively.

4.3 Roles

In the following sections are mentioned some roles that we propose to intervene in the requests management:

- User –Employee that requests services;
- Receiver – Employee that needs the service (may be the same that the user);
- Approver – Chief of the user's department. The employees with this role are accountable to approve/reject the users' service requests. This role represents the IT customer (pays for the services);
- IT Technician – IT employee that delivers the services;
- Service Owner – IT employee accountable for one or more services provisioning;
- Service Provider – Principal accountable for the service provisioning. Has the responsibility to approve or reject the publication of services in the catalogue. Normally the Chief Information Officer (CIO).

These roles are part of the previous research published in [1].

4.4 Service Request Lifecycle Process

The definition of a Service Request Lifecycle Process is essential to an efficient service provisioning (Figure 4).

This process starts when a user consults the service catalogue and chooses the optional features, the SLA and the validity. Then the user may save the requisition as a "Draft" or may send it to be executed. If the request has some feature that requires budget approval then it is redirected to the respective Service Owner that introduces the request budget, which sends the request for approval step and changes its state to "Submitted". However if the service has no features that require budget approval, it goes directly to approval. It may occur that a service does not need approval and when it is solicited goes directly to execution (state "In Execution").

The approver has the possibility to approve the request, which changes its state to "In Execution" and continues the process, or he can reject the request, which changes the state of it to "Rejected" and ends the process.

The requests that are in the state "In Execution" must be delivered by the respective Service Owner, who may change its states to "Complete OK" or "Complete NOT OK" according to the success of the request fulfillment.

At last, the user that received the service should classify the request as "Closed OK" or "Closed NOT OK" according to his satisfaction.

An important practice that should be taken on the entire process is to inform the users of the requests' updates.

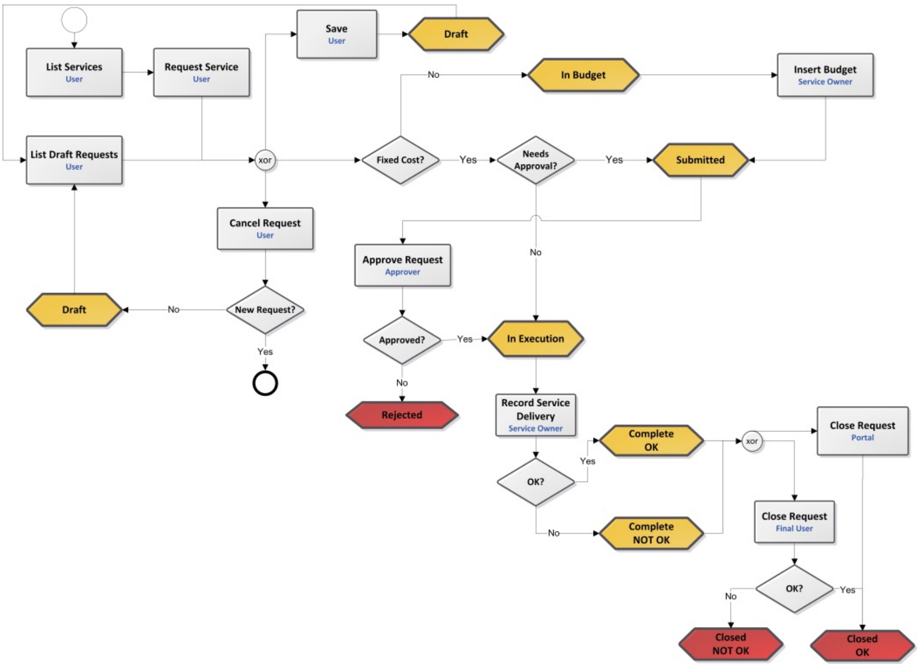

Fig. 4. Service Request Lifecycle Process (proposal)

5 Action

The service request management action was based in two practical implementations. We implemented a prototype that automates the proposed solutions and enables its users to manage the services lifecycle, the requests lifecycle, the tasks and impediments associated with requests, and the projects in which the requests are grouped.

The action took place in two organizations. The first one is a software factory (with 12 employees) that provides services to several clients (the services are "Change Existing Features", "Implement New Features", "Corrections to Existing Features" and "Management"). The second organization is a private company with around 100 employees, in which we used a running project to test some of the proposal ideas. This project still resumes to three services "Change Existing Features", "Implement New Features" and "Management", and the developers' team is composed by only one person.

One could argue that the development and maintenance of software cannot be seen as a service, but these activities are more comparable to services than to products (at least in the studied organizations). The difference between products and services is not clear-cut. Often, services are augmented with physical products to make them more tangible, for example, luggage tags provided with a travel insurance. In the same way, products are augmented with add-on services, for example a guarantee, to improve the quality perception of the buyer. In the service marketing literature a product-service continuum is used to show that there is no clear boundary between products and services[17]. This product-service continuum is a spectrum with pure products on one end and pure services on the other end, and product-service mixtures in between (Figure 5).

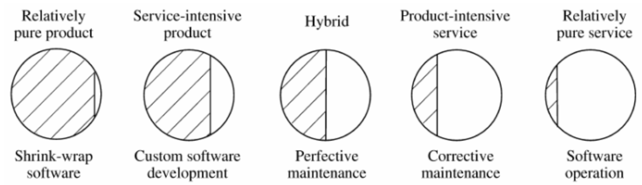

Fig. 5. The product-service continuum for software development and maintenance [18]

We argue that the described services are valid because they satisfy the characteristics of the used service definition and the software is highly customized in both the studied organizations.

In these organizations we registered the service requests and the tasks that were created to fulfill these requests. Before the proposals implementations there was no idea of which service was more requested, how the effort to fulfill the requests evolved or in which state the requests were.

6 Evaluation

In order to evaluate the proposal, we registered some metrics proposed by the ITIL framework regarding the Request Fulfillment Process [15]:

1. Number of Service Requests processed;
2. Request Fulfillment cost;
3. Hours worked against budget;
4. Time of day Requests have been submitted;
5. Number of presently unanswered Requests;
6. Number of Requests that have stopped dead in the process;
7. Number of bypasses to the process;
8. Percentage of Service Requests through the Request Fulfillment Management process.

Tables 1 and 2 show the results of the first three metrics of the software factory and of the other organization. The results are discriminated by service.

From Table 1 we can conclude that 46.17% of the requests were for new features, 22.96% regarding changes in the features, 11.87% were about the correction of bugs and 19% of the requests were for management issues. In the other organization (Table 2) 45.13% of the requests were for new features, 54.32% for changes and only 0.56% for management. These numbers shows that, in these two organizations, about half of the service requests are for changing existent features.

Table 1. Requests from the 1º organization (software factory)

	Implement New Features	*Change Existent Features*	*Corrections to Existent Features*	*Manag.*	***Total***
Requests	175	87	45	72	**379**
Requests (%)	46,17	22,96	11,87	19	**100**
Total Effort (h)	5191,8	1378,6	1015,05	1571,05	**9156,5**
Effort (%)	56,7	15,06	11,09	17,16	**100**
Effort/Request(h)	29,67	15,85	22,56	21,82	**24,16**
Effort/Budget(%)	100,5	109,24	104,17	97,57	**101,6**

Table 2. Requests from the 2º organization

	Implement New Features	*Change Existent Features*	*Management*	***Total***
Requests	162	195	2	**359**
Requests (%)	45,13	54,32	0,56	**100**
Total Effort (h)	381	208,05	1,25	**590,3**
Effort (%)	64,54	35,24	0,21	**100**
Effort/Request (h)	2,35	1,07	0,63	**1,64**
Effort/Budget (%)	100,59	100,53	100	**100,57**

Concerning the metric 2 (Request Fulfillment cost) these tables also indicate that in both organizations the requests to implement new features usually take longer than the ones for changes. In both organizations the cost of implementing new features is approximately two times the cost of changing existing ones.

The difference between the average effort by request of the software factory (24.16 hours per request) and the other organization (1.64 hours per request) is explained by the different development approaches that are implemented in the organizations. In the software factory the requests are grouped in sprints and the Fulfillment process is integrated with SCRUM Agile methodology. Therefore, the requests need a larger effort than in the other organization, in which the requests are continually fulfilled.

The difference between the average costs of the management requests from the two organizations is explained by the number of developers in the organizations. As in the second organization there was only one developer there was no need of many management requests.

Concerning the metric 3 (hours worked against budget), in the software factory we can conclude that the requests of changing the existing features and corrections of bugs were respectively in average 9% and 4% above the estimative. Contrariwise, the management requests were 3% below budget and the implement new features requests were fulfilled on budget. In average, the requests of this company were 1.6% above the budget. In the second organization the difference between real cost and budget is residual (0.57%).

Regarding the metric 4 (time of day requests have been submitted), it was also possible to understand the timings of the requests by recording the date and time that each request was made. In the Figure 6 is illustrated the number of requests by the hours of the day.

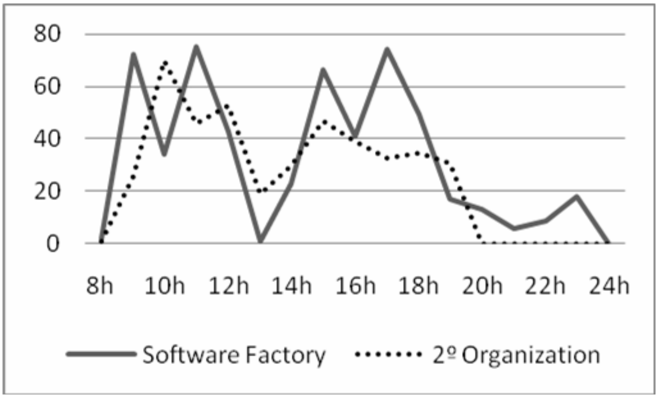

Fig. 6. Service Requests Timing

In both organizations the results matches the expectations, because they show that there was two main periods of activity: between 9h00 and 13h00, and from 14h00 to 18h00.

Regarding the metric 5(the number of presently unanswered requests) in the software factory there are 116 and in the second organization there are 16. These requests were identified as non-priority by the customers therefore these requests are only fulfilled when there are no important requests to solve.

Metric 6 (number of requests that have stopped dead in the process) and 7 (number of bypasses to the process) were 0 in both organizations.

The percentage of service requests through the Request Fulfillment Management process (metric 8) was 100% in both organizations.

7 Conclusion

The implementation of this proposal revealed to be very useful to the request Fulfillment process in both organizations. The solution did ensure that service delivery was done according to planning and procedures defined in the service catalogue, which helped in the closure of the Gap 3 (the service delivery differs from the specified services) from the gap model illustrated in Figure 2. Another important achievement was the management of the communication about the services delivered, which contributed to decrease the Gap 4 (communication about the service does not match the service delivery). This achievement was enabled by the implemented prototype, because it did replaced the e-mail as the main mean communication between customer and service provider. The results of the metric 4 (time of day requests have been submitted) proved that the prototype was being used frequently and not only sometimes. In both organizations, the customers used it to request the services and to check the requests' status. In other hand, the developers used it to fulfill the customers' requests by executing all the required tasks. This way it was easier to communicate about the requests.

Registering the service requests helped to find which (metric 1) and when (metric 3) services were requested and by whom, which gave both organizations an opportunity to predict the demand. Knowing the demand patterns service providers can manage its resources in a more flexible way [19]. In addition, the recording of the service requests allowed to know who in the business makes the requests and how often. This way these organizations found which business units were more dependent on IT services. This information and the results of the metric 2 (Request Fulfillment cost) could be used to apply techniques of chargeback. IT may have different charge rates according to the period of the day and the service requested. This way the service providers can discourage their customers to request services in a usually busy period.

The results of the metric 6 (number of requests that have stopped dead in the process), metric 7 (number of bypasses to the process), which were 0 in both organizations, and metric 8 (percentage of service requests through the Request Fulfillment Management process) that was 100% in both organizations show that the proposed Service Request Lifecycle Process was mature enough to deal with the requests of both organizations. For these organizations there is no need to improve the Service Request Lifecycle Process.

The main obstacle to the implementation of this proposal was the resistance to change that some users caused. Nowadays, we are working in a solution to motivate the users to the advantages of using this proposal.

In the future we plan to research the service role in the organizational engineering, by defining the relations between services and the other organizational concepts (agents, actions and artifacts). We believe we can use the normalized system theory ideas in this research, because as in the software engineering (the area from which this theory emerged) there are basic components and atomic actions made over these components, the same can be observed in organizational engineering. In every organization there are agents (humans or computers) that use some actions, which change the state of some artifacts. These three concepts (agents, actions and artifacts) are the basic components of the organizational engineering and everything else is somehow a view of these concepts, including the services.

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The Paradox of Service Industrialization

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Paradox: an argument that apparently derives self-contradictory conclusions by valid deduction from acceptable premises.

(Merriam-Webster Dictionary).

Abstract. The emergent interdisciplinary area Service Science Management & Engineering (SSME) considers the study of people, technology and shared information as prime components in service systems. Quite frequently, however, the area regarding people is the one that draws less attention. In this theoretical paper we analyse how the knowledge and application of recent discoveries on the way in which the human mind perceives and stores concepts and events has important implications regarding service design. The paradox of service industrialization arises when defining a continuum between maximum industrialization of the service on one end and complete personalization on the other. The contribution of this work lies in pointing out research lines for Service Science (SSME).

Keywords: Service science, industrialization, customization.

1 Introduction

The emergent interdisciplinary area *Service Science Management & Engineering* (SSME) considers the study of people, technology and shared information as prime components in service systems [11]. However, by observing the breakthrough in this research field, it seems that, quite frequently, the area involved in the study of people is less considered than the rest. Perhaps this is a reflection of the need that companies have for great doses of technology nowadays in order to design and deliver services. Furthermore, it may also reflect that this discipline is closer to Engineering schools than to other faculties within the University. This theoretical paper is intended as an analysis of the reflection on how people perceive the experiences that are a consequence of their own use of services and the subsequent implications this has on the way in which they should be designed.

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2 The Human Mind: How We Perceive Experiences

Recent research has drawn science to the study of how the human mind perceives the environment and how it interprets and stores the events and concepts it processes. It has been pointed out, for instance, that there is a difference between the logical and the psychological meaning of concepts. The latter refers to each person's idiosyncratic and individual experience [1], so that each concept has a unique value within each cognitive structure and every cognitive structure is different. Moreover, each cognitive structure is different since it has been built by each person within a different story. A concept such as *democracy* may evoke different states in heterogeneous cognitive structures, even when their owners have shared similar educational contexts. Nevertheless, in the majority of cases the meanings that emerge are similar enough to allow communication and understanding [2].

On the other hand, the set of internal representations a person has and their model of the world do not constitute a mere addition of isolated concepts but are linked creating relationships [7, 15]. In this world model, language plays a key role since it contributes to cognitive development by providing the setting of analogies and relationships and representations that allow abstraction [8]. Consequently, analysing how the individual understands the messages it receives and how s/he connects them with their previous mental structure, since each person has their own, is not trivial or irrelevant.

Accordingly, each person holds a unique way of seeing the world, which has been developed from their own previous experiences and which conditions their behavior to a great extent [3]. Moreover, a person's assessment of an event has a consequence that may not only be behavioral but emotional [5].

It has been recently discovered, that when the human being performs an action, observes it or imagines it, the areas of the brain involved in it are the same and the same is being ascertained in regard to emotions [12]. Therefore, a person's internal world (conceptual and emotional) is of prime importance in their life. What is more, in many occasions the memories people store in their memories do not exactly correspond to what actually happened. These errors happen because the memory is a constructive process in which information is stored so that it can be retrieved to make simulations of the future [20]. The processes that allow us to imagine or simulate the future depend on the same neural processes involved in episodic memory [21]. Nowadays, it is therefore assumed that people's memory does not register reality as it is, but a personal biography of an individual takes the shape of a story that is greatly influenced by the person's environment, their values, social class, gender, religion and culture, but above all, by their objectives [14].

From all these considerations it is easy to conclude that human beings do not perceive reality as it actually is, as stated by Plato [17] and that they live within the context of their own subjectivity. Thus, when considering the way in which people interact with services we must take into account that human beings perceive and stores events in a peculiar way that is strongly influenced by symbolic representations which are different and unique for each person and therefore moves away from reality, if that actually exists.

3 The Industrialization of Services

These considerations are very important regarding the design of services, as they are considered nowadays. The article by Levitt [13] broke new ground in regard to the industrialization of services. He highlighted that if a service is regarded as an action in which one person produces a service for another directly and personally, this service will be limited in terms of efficiency, reliability and quality, and will be less predictable and very expensive. Levitt suggested that more reliable, fast and less expensive services could be available by means of large amounts of capital and the industrial way of understanding production, where mass production is the key. Evidently, as well as having some advantages for the customer, this will turn into return on investment and, consequently, into value for shareholders.

Spohrer and Maglio [22] have described the evolution of what we might consider the industrialization of a service: in the first stage, the service is solely provided by human beings; in the second one, technology augmented systems are used; in the third, the service outsourcing takes place; and finally, the service is provided in a wholly automatized way. The key lies in understanding or predicting when or how the transitions should be dealt with.

Anyhow, according to Pine and Gilmore [16], the market evolves towards what these authors call experience economy, which differs from service delivery in that experiences are personal and involve physical, emotional, intellectual and even spiritual implications. Experiences, unlike services, are memorable events defined by the customer's degree of participation and their immersion. These authors stress that whereas goods or services are external to the customer, experiences are inherently personal: they only exist in the mind of the person and, consequently, two people can never have the same experience, since this is the result from the interaction between event and mind. On the other hand, but in line with this approach, Treacy and Wiersema [24] have defined the concept of customer intimacy, which supports the high degree of personalization as one of the ways of leadership in the market.

If we consider a continuum between one pole in which the service is wholly industrialized and another where it is completely craft work, from a simple perspective, it seems clear that if the company is willing to capture the same value along the continuum, in the pole where the service is purely craft work, the cost for the customer will be high. However, this is also the point in which the maximum level of personalization takes place, due to a high interaction between the company and the customer, and the point in which few customers can acquire the service. On the other hand, if the level of industrialization is high, the service is produced at a very low price and the company captures the same value, being able to sell it to the customer at a low price. This fact entails that a greater number of customers can enjoy this service, resulting in the potential increase of the company's income in a significant way. Nevertheless, in the majority of cases the service is identical for all the customers, involving consequently a low level of personalization.

And therein lies the origin of the paradox: the interesting issue for discussion is that in this scenario the industrialized service is, by definition, replicable and therefore similar to itself, being thus little personalized: broadly speaking, all the customers have the same experience with the same company. Moreover, due to consultancy processes and benchmarking, competitive advantage is moved from one company another, so in the end many companies from the same sector end up offering essentially the same service to millions of customers that, as we have just seen, perceive the world in a clearly different way and, as a result, try to have different experiences. A brief review of several services, such as flights, communications or restaurants reveals that, in most cases, they are essentially the same.

It is easy to find some side effects of industrialization: let's take, for instance, the way in which economy class in planes frequently has an almost identical way of providing the catering and entertaining services. The passengers cannot eat when they want, buy when they want and cannot often watch a film when they want either, but have to adapt to the rhythm imposed by the cabin crew. In the hotel industry, there is a similar phenomenon: millions of passengers come and leave hotels at different times because their flights land and depart at different times. However, the hotel industry insists, quite surprisingly, in the concept of room occupancy from noon till noon the following day. The effect of industrialization can also be seen in call centers: in many cases, the customer is forced to repeat their problem incessantly to different operators as they each cover a very small area in the value chain; there is nobody at the other end who can understand the customer's situation and problems globally. This frequently leads to the situation where a customer who has placed a complaint is startled when some days later, another department from the same company, unaware of an upset customer, offers him a new product. The most extreme case of call centers are the phone calls that many people get at ungodly hours offering them services they have neither requested nor need. Almost thirty years after the above mentioned article by Levitt [13], critical voices have been raised on the industrialization of sales calls. They stress that in many cases they left no room for initiative and that what was before a conversation between two people, has become a dialogue between one person and machine simulating a person [19].

The paradox takes place when the service is industrialized so that it is replicable, predictable and can also be provided with a high quality level and at a low production cost. At this juncture, there is a risk of destroying what lies at the very essence of service delivery: clients seeking diverse experiences because they themselves are different and, as stated above, they perceive the world in different ways. In sum, theoretically industrialization increases service value, but as service value is based on subjectivity, industrialization can also destroy it.

It can also be drawn from that that if all companies from a sector include the ways in which service delivery was exclusively offered by one of them at the beginning, because they have put themselves in the same level through consulting processes and benchmarking, what happens then is that, as we have seen, the whole sector essentially offers the same service with slight alterations. It can be deduced from Porter's ideas [18] that if the service is the same (and if it is not the case of a market niche), the companies will be forced to compete in cost since they cannot compete in differentiation. The tourism sector is a good example of this phenomenon: if holidays are reduced to the mere addition of a flight and a hotel, it is clear that the customer would look for the travel agency offering the best price.

The reason for that could be that industrialization of services may not necessarily entail the same benefits as product industrialization. Perceived value is a very complex concept and it can happen that managing it in the services sector can be much more difficult than in product industry.

It can be argued that this is not true when it comes to self-services of any kind, for in such cases a highly industrialized end can be held while on the other end, the customer chooses what is more convenient for them, thus keeping some kind of personalization. Nonetheless, one may wonder if these companies use the trace left by the customers in order to get closer to them and get a better understanding of them, thus being able to intensify their experience when using the service.

It can also be claimed that those services with a substantial use of technology can be industrialized and personalized simultaneously. This happens, for example, in book selling portals: millions of customers use the same site but this can offer different suggestions to each customer. Obviously, this is true but the buying experience in these websites is, in spite of some variations, basically the same, since the search engines, payment system and book delivery mechanisms are virtually similar.

Finally, it can be pointed out that in some cases there is the possibility of personalization for those customers that take part in customer loyalty programmes. Frequent customer cards give access to certain special services that are not available for the rest of customers. However, many customers may feel overwhelmed when registering and giving their personal information in numerous services as the amount of places where one has to enter their user name and password, as well as the number of frequent customer cards a customer might get, has exponentially increased. It is in this context where it is becoming indistinguishable when a customer's register or regular customer card actually offers the customer any added value.

4 Conclusions

The challenge is therefore to keep a high degree of industrialization without destroying the experience of using the service, which according to the authors mentioned above [16, 24], is based on three keys:

- Customer's immersion in the service.
- Customer participation.
- Personalization of the service.

Will it be possible one day that a hotel booking be coherent with a customer's flight schedule? Will the catering and entertaining services be personalized in planes? Which amount of technology is needed so that each customer can design their saving plan for mobile telephones instead of having to accept a few predefined types? Will there be restaurant chains where each customer decides the ingredients they want for their dishes? Will there be Internet shops where different shopping experiences can be provided within the same sector? How to design an experience of service use that is coherent with a company's strategy? How to be different in a world of industrialized services? And finally: how should companies deal with the paradox of service industrialization?

It may be that the massive data collections we work with in order to know and predict our customers' behavior are not yet quite ready to identify people's subjectivity. It is then possible that we need to conduct more research into how customers describe services and which complex emotional bonds they share with them, thus increasing the level of information we gather in each contact that a customer has with a service allowing us to react accordingly.

It is also possible that regarding the contact with the customer, we must consider losing in automatization in order to win in personalization thus providing our customers with the experience of using the service that they in turn value and turn into loyalty. In this sense, it may be relevant to create ways in which to measure the impact of more or less personalization in the costs of service delivery.

Perhaps we must produce more research showing how the customers' personal features have an impact on their usage level of a service [10] and how these customers could be categorised.

Maybe we ought to be more aware of the importance of introducing Design as a key discipline in service delivery, since it plays a key role in the usefulness and meaning of the service for the customer [25]. In this line, industrialization may not need to be regarded as a question present along the service's whole life cycle, but its importance may increase as we move down from the conceptualisation of a value proposal, and therefore from the design of a service to its implementation as it can be inferred from the work by Gautschi and Ravichandran [6].

Consequently, even though the short-term and medium-term issues may refer to the way in which services have to be industrialized, from our point of view, the essential point in a long-term scenario is which role industrialization should play along the life cycle of services.

In this approach we understand that we must consider two main tasks that can help us overcome the paradox of service industrialization:

- To reflect upon which experience we are providing or can provide our customers with, how customers perceive it and the emotional bonds they share with it.
- To consider how to provide enough level of personalization or, at least, how to identify the subjectivity of the customers who come into contact with the experiences we provide them with.

These two considerations may take shape as a set of actions contributing to creating more effective and more differentiating experiences, but the bottom line is to reflect on which the company's strategy in the market is, and which experience must be coherently offered by the services it provides, keeping into account that this experience should be logically different from what other companies from the same sector offer.

From the research perspective a lot more can be done to overcome the paradox of service industrialization. What we provide here is a list of possible research topics, which by no means is exhaustive. It is classified in four areas: information systems, first contact with client, service-client interaction and measuring.

a) Information systems:

1. How to increase the amount of available information and how it is interconnected in customers' databases so that every department knows the whole information about every client.
2. How to present those large amounts of information in a way that can be rapidly understood by computers and humans.
3. How to interpret the behavior of a client in a specific moment according to the past history of that customer with the service, and also how to predict the future behavior of the customer based on that history.

4. How to extract information from client databases so that the systems can assess specific actions for them, in order to customize and enrich the service experience.
5. How to capture and store subjectivity in databases.

b) First contact with a client:

1. How to increase interpersonal adaptive behavior and service offering adaptation to the staff in contact with the customers [4], by devising specific ways to deal with the client depending on his/her profile.
2. How to benefit from the analysis of the first moment in which a customer comes into contact with the service either virtually or personally.
3. How to classify customers who come into contact with a service from the first moment (classifying better to provide a more adapted service).
4. How to gather information about client expectations.
5. How to classify clients depending on their need for customization.

c) Service-client interaction:

1. How to improve research on customers' perception of the experience by introducing qualitative research techniques [9].
2. How to store customers' perception of the experience (mainly if it is negative) and how to use that information.
3. How to increase clients self disclosure of information.
4. How to benefit from service improvement ideas spontaneously given by clients.
5. How to interpret a client's emotional state by analyzing natural language automatically (written or spoken).

d) Measuring:

1. How to measure the impact of outsourcing, offshoring and lean manufacturing in customization.
2. How to measure the influence of using automated systems in customers' perception of service value.
3. How to measure the impact of customization in service production cost.
4. How to measure the number of contacts or information which a service needs in order to gather enough information from clients to provide the required level of customization.
5. How to measure client satisfaction with the customization level.

As it has been written, predicting events instead of narrating them is the true evidence of our ability to understand the world [23]. It is clear that industrializing services means making them predictable and therefore controllable. It is then easy to see how this generates immense value for both the companies and their customers. Researching more on the complex relationships between customers and the services they use, we could create this value in a reliable way without jeopardizing personalization and the creation of memorable experiences.

The field for research and creation of value in services is still immense. With no doubt, research and technology will in time allow the creation of highly industrialized cores operating as engines for services, meanwhile an external layer remains where automatization and the human factor go together to provide customers with a high degree of personalization and unforgettable experiences.

Nevertheless, we conclude that the fact that each customer lives in the context of their own subjectivity, will require in the forthcoming years a deeper analysis on the particular way in which each customer gives meaning to a new experience. People are, doubtless to say, the centre and most valuable element in solving the paradox of service industrialization.

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Services Science: Filling the Gap between Knowledge and Needs

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Abstract. Governments, Universities, Industry and Society all work with the aim of creating a better world by undertaking initiatives to solve problems and improve our way of living. The role of Service Science is essential in this process as an introducer of knowledge through theoretical and practical investigation that allows new, better, more effective and lower cost service solutions. We focus on the fact that very often in innovation we are aware of the problem or the need, we might even know the solution, but we miss the insights to create an effective, on time and, very specially, sustainable solution. This paper underlines the importance of this field, and the mission of Service Science in developing it. We introduce insights and describe the elements to be considered for innovation to take place from a service perspective and we recall the need to develop and disseminate this knowledge under the framework of Service Science.

Keywords: Social Sector, Social Entrepreneurship, Services Innovation, Services Design, Strategic Services Design, Reverse Mode Innovation, Private Public Partnerships, Project Financing, Triple Helix.

1 Service Science: The Need Perspective

It is not new to anybody that in today's world we receive more and in more detail information about things happening thousands of kilometers away, such as the floods in Pakistan, or the next elections in Brazil. Internet news, social networks, digital television, radio, more frequent travelling, and better foreign language knowledge (especially in English) among population, enable us to access information of all kinds, coming from different spots of the world, sometimes intentionally or even not. This awareness has consequences in the way we conceive the world, increasing our responsiveness and commitment towards, what in other times could be considered, problems beyond our reach. The detail and continuity of the information helps the development of our interests and concerns. Additionally, different views from different places, perspectives and disciplines improve our understanding, giving us an appraisal of importance and magnitude. Information that twenty years ago was only available for experts is now at our ease through the new information technologies. But more than this, not only do we receive information, but social networks enable us to access expert opinions, contrast ours and create trends with fast dissemination. Observation is a must for innovation and no doubt that internet is an accessible

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"observatory" of the world. We know internet was not meant specifically for this purpose, but we have created the most powerful and useful tool for innovation in a point of no return.

Never before, have we had so much information about the existing problems of the world and people's needs and demands, becoming more and more difficult to avoid opinion or not taking position upon request as access to information becomes more obvious through technology and education. And not only the problems appear clearer, but solutions and best practices are raised on the internet and elsewhere so that governments, industries, private and public institutions are called to be responsible implementing them.

What differences modern societies from others, is change being their basic principal. Modernization was the result of the interaction of three socio-anthropological dynamics with footprints that can be found in many societies but that entering in resonance in Europe during the middle age, lead to the modern societies: individualization, rationalization and social differentiation [1]. Present modernization, according to François Ascher, is *reflexive*, meaning a constant examination and revision of social practices from the information referred to them we receive. This infers a constant awareness of what we do, and how things are, that exerts an impulse to change and improvement.

What characterizes the present modernization is the speed of change. The fast growth of cities is a good example. In 1800 only 3% of the world population lived in cities. In 1900 it was 13%. In 2007 it reached 50%, and it is expected to get to 70% by 2050. In 2020 we expect 500 cities in the world to surpass the figure of 1 million inhabitants. Labor opportunities in big cities play a pervasive role in this. Consequently, disorder and unbalances occur. Losses in fuel expenditure in urban traffic jams rise to 78 billion dollars per year, and 30 to 50% of urban water supply goes through losses in the pipes. The social and human implications are also alarming. It is a fact, all over the world, that urban population living in slums is increasing year after year. In these environments, education, habitat, healthcare and community integration in all its meaning, become challenging features. In other areas of these same towns, citizens are demanding services with impact in their quality of life in return for the taxes they are paying. On top of this, cities find themselves struggling in an endless competition in the "livability rankings" that will make them attractive to young and talented people contributing to their economies.

The problems and challenges are there, but as we said before, and thankful of it, our awareness and reflection are too. Are we prepared to create the new services according to the new demands, opportunities and speeds of change of our cities? Can our municipalities and governments bear the costs by themselves? Do they have the skills to cover all the needs and to propose solutions? Should it be them? Could private initiative procure sustainable services? Would a service innovation approach introduce new insights for a more efficient, effective, and especially, long term sustainable solutions for our communities? These are only some of the questions. For some people it's a big problem, but for others like the architect, planner, and Brazilian politician, Jaime Lerner: *"The City is not the problem, it is the solution"*. We believe Service Science will be a contributor to it.

2 Service Science: The Solution Perspective

The present economical downturn has put municipalities in a struggle. In many countries, municipal financing is strongly dependant on the health of its construction sector. For some cities in Spain, for example, building licenses have represented over 60 to 70% of their total income in the past years. As a result of the present crisis, which has left the building sector stagnant, the average debt of cities with more than 50,000 inhabitants grew a 9.4% in 2009. With such a financing system and an economical downturn, it is barely impossible to face other challenges than the municipalities' own survival.

Another issue is that the centre of gravity of the world's economy is "going to town". The 52 most important cities in the world accumulate 30% of its GDP. Tokyo or New York's GDPs are higher than the ones of countries like Spain or Canada. Tokyo concentrates about 33% of Japan's economy, and Mumbai reaches 40% of India's. So the problem overwhelms the local spheres and becomes national due to the magnitudes of the population and what cities represent for each country's economy.

The solution must therefore not only refer to create new services, but introducing elements to make our society create them in a much better, faster and dynamic way. This brings into consideration that the traditional channels and sources, namely the Public Sector, is insufficient to tackle the problems due to its diversity, speed and especially its economical viability. We are talking about the need to find new ways for *social sector* (public services plus charity) *innovation*.

The Triple Helix [3] approach for innovation, introduced by Henry Etzkowitz and Loet Leydesdorf through many publications and the cycle of Conferences on Triple Helix that began in Amsterdam in 1996 and continues until the "Triple Helix VIII Conference" celebrated in Madrid in October 2010, gives us meaningful insights of the roles of University, Government and Industry in innovation, together with concepts and examples of how effective innovation has taken place through the collaboration, recombination, interaction and adaptability of each player in their roles towards the others. This framework was initially originated to study the dynamics of innovation, fundamentally based on insights, sources, examples and experiences from the technological fields. Nevertheless we would like to outline what we believe are relevant issues to consider for innovation in the social sector revealed from a basic Triple Helix approach.

3 A Triple Helix of Innovation for the Social Sector

The traditional role of University as generator of knowledge through research and the education of future professionals has lead, according to the Triple Helix model to an *Entrepreneurial University* that creates new companies, obtains profits from research licensing, collaborates with Industries and Government in innovation and is interested in acquiring and exerting entrepreneurial skills. The concept of University *reflexivity* is used by Henry Etzkowitz as part of the norm of the Entrepreneurial University: *"There is a continuing renovation both of the internal structure of the University as its relation to industry and government changes and of that of industry and government as their relationships with the university are revised"* [3]. The Entrepreneurial University as a developer of knowledge and with the commitment of putting it into use is an invaluable possible contributor. The internal mechanisms to become entrepreneurial yet must be introduced in many of today's Universities. We know that some of them are still not completely defined, because of their implications on internal structures and regulations, but together with the economical benefits, the contribution to the quality of the research results through the collaboration with Industries, has already been proven by many Universities for a long time in technological fields. It is true that the social sector`s issues on innovation differ from the technological or industrial, but it is time that for research in social and humanistic disciplines to find their paths towards innovation. This will also bring benefits for the technological sectors.

Since the first formation of firms out of research activities at MIT and Harvard at the end of the 19th century in the fields of industrial consulting and scientific instrumentation, we have gone a long way in the knowledge of technology transfer management [2]. From Edison's "Invention Factory" until today's "Open Innovation" [7] models, innovation methodology has changed and adapted to the existing tools and the prevailing opportunities, whether it was productivity, quality or the application of new technologies, for instance. Technology driven innovation, with the Science-R&D-Technology-Production-Market model, not always necessarily in this order sequence, has created its own ingredients that contribute to successful and early to market innovation. Of course, luck and good decision taking are pervasive, but we know that the existence of laboratories and expertise, talent, a range of early phase financing, venture capital, a fair business environment, intellectual property regulations, an international approach, a failure tolerant culture and a freedom working environment all determine innovation positively.

Dealing with demand driven innovation (innovating from the need) undertaken by Universities requires its own environmental conditions and instruments, because it seems clear that the different approach and origin require new driving forces and hence different instruments and tools to make it happen. The links between the Social Sector Entrepreneurial University to the industries, the public sector and very specially the social entrepreneurs are key issues. New instruments such as new invention factories and research results transfer offices together with new ways of participation in the social sector should be experimented, considering new incentives for the faculty. Some are new but many do not differ from models coming from the technological field where the reverse mode of innovation is also working today. Important venture capital firms placed close to the Universities has been a decisive tractor element for technology based innovation to prosper. Unfortunately for the social sector we cannot assume this will happen in the same way, because of more limited internationalization and scalability capabilities of services, which limits business magnitude, and the social character of the business. We do not mean that there will not be extraordinary business opportunities, but the role and character of the venture capital in this field will differ, as we describe further in this text. On the other hand the role of Industry still remains relevant.

Industries are always willing to participate in challenging projects for sustainable gains, but the social sector is not always in the outreach of many Industries' usual operative environment and information systems, unless they belong to a specific related sector, or there is a resonant opportunity. In other words, we cannot expect them to be the initiators of social innovation projects unless it falls in the recognized existing application fields of their products or services, or they have detected a wide opportunity sector. Nevertheless, technology based firms can be the most effective tractors for social innovation projects as long as there is an attractive market behind in terms of magnitude or the quality of a niche segment.

In administrative concessions for public services, such as maintenance works, security, traffic control, transportation or telecommunications for example, it can be a practice to include additional social services or collaboration with other companies in the field as a complementary activity or by-service. Contacting several company managers of municipal service concessionaries, they have expressed that offering additional social services in their scope of supply in long term, wide variety and high volume service concessions can result in a competitive advantage as well as good business, and an image towards citizenship improver. Earnings would come after the learning curve, cost reductions would arise with the eventual introduction of technologies or the development of new innovative services derived from the information accumulated and skills acquired from the previous, with incomes generated by new channels. Again, collaboration with information technology companies in the development of these new services is a promising winning field for all, service providers, technology firms, municipalities and citizens.

Public Private Partnerships have proven to be excellent tools for undertaking important and necessary infrastructure projects when the private party has an opportunity to recover the investment costs exploiting the service the infrastructure was meant for, or having access to partial or priority use. It is common practice in civil works like highways, airports, docks, etc. Constructors have the same tractor effect as technology firms. Schools, hospitals, orphanages, residences for handicapped, all can be subject to be initially faced with the collaboration of a constructor, leading to a Public Private Partnership. Once the infrastructure is built, either the constructor exploits the service himself, if he agrees to acquire the skills, subcontracts the service, receiving a fee from the Public part to cover costs and keep the interest of the partnership from all the sides in the long term, or sells his participation to the exploiters of the service, who will get to an agreement with the Public side. It will remain in the initiative and ability of the parts to generate other new services in the facilities to make the business less costly and dependant on the public fee. Fixing the legal issues to guarantee and assure that all the sides get what was expected and agreed is pervasive for the efficacy of this instrument. The fact of being long term agreements, introduces many uncertainties and the legal tools, norms and expertise must be available or created to make parts get into yes with all the possible future uncertainties, risks and scenarios covered.

Corporate Social Responsibility (CSR) is a promising concept for innovation in the social sector, “Unfortunately prevailing approaches to CSR are so disconnected from business, as to obscure many of the greatest opportunities for companies to benefit society” [5]. The moral imperative in which CSR is still imbued casts a shadow on the basic principal that nothing can oblige a corporation to do something which is not in the direction of the business. Companies that focus their corporate social responsibility aligned with the social impact of their value chain and the social influences of their competitive context will undertake its CSR initiatives with a higher guarantee of success, bigger impact and longer term sustainability. Promoting or contributing to the development of Services and Projects with social impact that improve the competitive environment or that enables corporations to generate positive social impacts while performing their business activities is the direction to head.

From a Services Design for People [6] point of view, CSR is, together with marketing, processes, people and products design, one of the five (5) axes that determine the perceived value of a service by its stakeholders and the contextual systems and people they are linked to; the last two exerting an influence on the first. Being CSR a frontline value perception axes together with the other four (4), it is desirable to be in consonance with the company's business strategy, its shared knowledge, shared values, infrastructures and facilities for better efficacy, impact and credibility. All the elements together should form a harmonic interdependent block with flowing connections in all directions. It is not irrelevant that the model includes stakeholders as value perceivers of the company's CSR activities. In other words, let's focus primarily on CSR activities that create perceived value for our stakeholders (their concerns), acting as a good corporate citizen and mitigating the adverse impact of our business activities. Of course, the favored by our CSR activities will be the others, and as extended as possible.

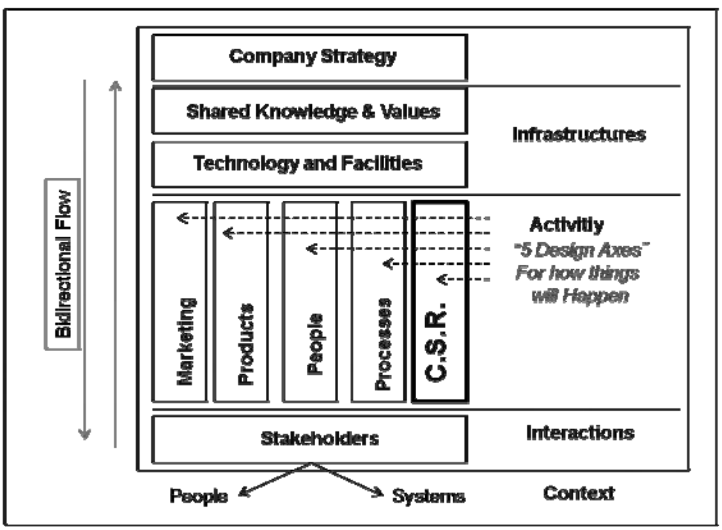

Fig. 1. Strategic Design Concept. Adapted from [6].

Creating and developing projects in line with the foundational objectives of Private or Public foundations, determines the chances to receive their support and assistance. Strategic alliances and cooperation with Public and Private Foundations will allow access to their expertise, connections and influences. Nevertheless, this is not sufficient to receive their funding. Although created as non lucrative institutions, they do not dismiss the sustainability aspects of the projects they take in consideration.

Feasibility studies are required and donations or participations are decided only after investigating thoroughly and in detail the business models' income channels and operations. We are facing more and more the creation of a foundational venture capital for the social sector. Operative examples can be taken from foundational venture capital for technology development such as the Markle Foundation in the U.S., or the Knowledge Competency Foundation in Sweden.

With the premises of the problem we have posed, it could seem that the role of the Government would be remaining passive attending solutions. Nothing is more distant than this. Linking with the previous paragraph, Government funding is essential, and creating the institutions that will distribute those funds is a decisive task. In this sense it is relevant to mention, for example, President Obama`s recently created Social Innovation Fund (SIF), with a 50 million dollar Public participation and 74 million dollars coming from philanthropic foundations. This funding will be provided to the most successful American non-profit organizations in order to expand their work in health care, creating jobs and in supporting young people. This fund, together with other efforts, shows the will to promote new partnerships of government, private capital, social entrepreneurs and the public pushed by the House Office of Social Innovation and Civic Participation (OSICP) that President Obama created soon after taking the office. There is also another fund "i3" for investing in innovation, in the Department of Education and cash prizes for novel answers to social problems. At the other side of the Atlantic, Britain's Prime Minister is intended to create the Big Society Bank that will help finance social enterprises, charities and voluntary groups through intermediaries, very similar to President Obama's initiative. The reason behind, according to Mr. Cameron's words is to *"open up public services to new providers like charities, social enterprises and private companies so we get more innovation, diversity and responsiveness to public need" and to "create communities with oomph"*.

The new perspective will need a reconsideration of legal instruments and norms to facilitate the settlement of Public Private Partnerships with social entrepreneurs, assure governance, and distribute responsibilities in case of non-fulfillments. Simple, fast to apply and understanding regulations are extremely necessary as well as simplified bureaucratic requirements for the creation of the partnerships and new companies.

4 Service Science and the Fourth Helix: Society

In the Triple Helix framework, entrepreneurs are professional individuals that interact and move in between the actors and through the Triple Helix`s internal boundaries in their search to set up their business ideas and developing their projects in their different phases and aspects, i.e. technology, commercialization, financing, etc.. Their drivers may differ, but we may say that economical benefit is the generalized common one. Entrepreneurs are either considered belonging to the Industry, University or Government or to two, or even three of the actors at the same time. These dual or even triple assignments are considered essential in the Triple Helix framework as enhancers of communication and linkages between the spheres for the result in innovation.

We are tempted to go ahead with the same philosophy including social entrepreneurs as belonging to the Industry and moving around in the market field. But it is difficult to believe that they would assume and accept such positioning, mainly because social entrepreneurs do not pretend only to create firms that compete in a market to gain benefits and brand positioning. They are not necessarily willing to introduce a technology or product/service for the sake of their own benefit either, but for what they may confer to the others (people and society). This introduces new elements in the way the social sector may work regarding innovation. Entrepreneurs can be volunteers or part time professionals, and this opens a variety of implications in terms of their objectives, commitments and the values they support. Their personal earnings may not be the main issue for them, as they probably have them covered in other planes of their lives. In other cases, we can be talking about individuals who are happy developing a professional career in an area and activity where they can contribute receiving a fair compensation that can allow them to live according to normal standards of the community they live in and, why not, with a social recognition for what they do. Their drivers differ from the ones of the other three (3) spheres. Therefore, we do not dare to assign social entrepreneurs to any other sphere than the one they originally come from and belong to: Society. Contrarily to the position of Society for technological innovation playing a contextual role, innovation in the Social Sector, takes place within Society itself as an active player as a new Helix to join and interact with the other three (see figure 2).

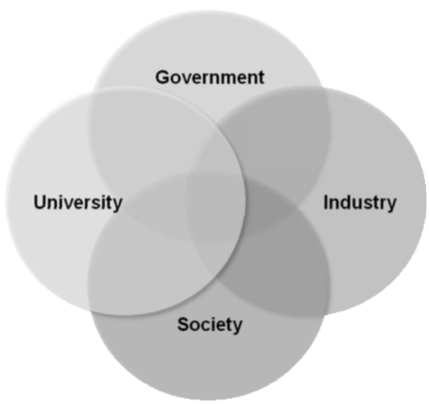

Fig. 2. The Triple Helix and the Fourth Helix: Society, for Service Sector Innovation

Private and Public social institutions and social entrepreneurs articulate new initiatives and make linkages to the other spheres developing new relevant and creative projects, collaborating with University, Industry, Government and other Social spheres and institutions, intervening in the creation and development of the Triple Helix so called “knowledge, consensus and innovation spaces” (see Table 1).

Table 1. Regional Triple Helix Spaces as described in [3]

Triple Helix Spaces	Characteristics
Creation of a knowledge space	Focus on collaboration among different actors to improve local conditions for innovation by concentrating ralted R&D activities and other relavant operations.
Creation of a consensus space	Ideas and strategies are generated in a "triple helix" of multiple reciprocal relationships among institutional sectors (academic, public, private).
Creation of an innovation space	Attempts at realizing the goals articulated in the previous phase; establishing and/or attracting public and private venture capital (combination of capital, technical knowledge and business knowledge) is central.

The development and dynamism of these spaces for the social market is essential as a context base for innovation to take place. Cities have advantages as innovation spaces and agglomeration economies, where activities may be more easily clustered, suppliers are shared, and bigger markets increase probabilities of matching employers with employees and facilitate learning [8]. These advantages are transferable to the social sector as well, contributing to cities being part of the solution.

Individualization, as one of the three dynamics of modernization, mentioned above in this paper, is a main character of our days. Today, individuals are not only allowed to choose but must choose individually (work, family, religion, politics, living style, etc.). This new context favors the emerging of individuals with new and own ideas looking for spaces to develop them. Present unemployment rates of people with University education in the developed world is a sign of the inefficacy of our system. It is necessary to open new ways for self-employment and new safe dynamics of collaboration between individuals, institutions, networks, associations, etc. to tackle today’s challenges. A full awareness and knowledge about innovation in Services is highly demanded. Educating individuals in Service Science will make them create more valuable and sustainable services. On the other hand, Service Science must anticipate problems and solutions for new entrepreneurs to implement and for University, Industry, Government and Society to adapt and improve.

The simplest definition of Services as those tasks we have others to do on our behalf because they can do them better, faster, cheaper, or we just wouldn’t have the capability to do them ourselves even if we wanted to [4], infers a welcome to all kinds of disciplines to contribute with the knowledge, skills and values so that specific tasks are performed in a way that value is perceived by people. The field for humanistic and social disciplines in solving better and more effectively social problems is unlimited. The way we have learned to create perceived value and sustainable results, in other words, to innovate, in goods/products (things) differ from what is required for services (tasks) and Service Science should answer these questions.

5 Conclusions

Our modern society's speed of change generates unbalances, disorders and inefficacies. It is necessary to develop new and better services in a faster way to tackle the problems that day after day appear. Many of these problems are in the domain of our cities, but local administrations and governments do not have all the tools. We have outlined insights for services innovation by means of a Triple Helix of the interrelations between Governments, Industries and Universities framework approach, for innovation in the social sector. Society as a new helix has been introduced, contributing as the sphere from where social entrepreneurs and institutions must emerge to interact with the previous three.

Creating and developing the knowledge, consensus and innovation spaces for the social market, considered as a fourth sphere is essential. Service Science, linked to social and humanistic academia is, with no doubt, a main player and contributor to the knowledge space we are looking for, and specific services innovation methodologies, institutions and services education for entrepreneurs, are downstream essentials in the consensus and innovation spaces that will enable us to face today's and future challenges with new and better solutions.

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Service Systems and Value Modeling from an Appreciative System Perspective

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Abstract. Since its inception Service Science has created a substantial body of knowledge about services and their provision. Most notably, the concept of Service System was defined in order to describe the co-creation of value by the service provider and customer. We introduce the concept of Appreciative System defined by Vickers in the study of the way individuals and organizations apprehend and act on their environment. We show how the appreciative system concept can be applied to a service system model with the SEAM enterprise architecture method.

1 Introduction

The concept of Service System was defined in Service Science in order to describe the co-creation of value by the service provider and customer [8]. The definition of service as a system results in much attention given to Systems Thinking in recent Service Science publications [8, 14]. It has been proposed that the concept of service is linked to system survival. Most research in this direction has thus far used Beer's Viable Systems Model to analyze properties of Service Systems [2].The substantial research into Service Systems has raised as many questions as answers about value co-creation [14].

In this paper we propose to analyze service systems and value co-creation from the perspective of Vickers's appreciative system. We begin from the roots of Systems Thinking to explore the notions of system and system survival based on the works of Weinberg and Weinberg [21, 22]. We then analyze the valuation process with Vickers's Appreciative System [15, 16]. We then show how these concepts can be used for the practical modeling of service systems using the Systemic Enterprise Architecture Method (SEAM) [18. 19]. We use the running example of Apple's iPod to illustrate the theory and the method.

In Section 2 we first survey the state of the art of the research in Ser-vice Science concerning service systems and value. In Section 3 we introduce the fundamental aspects of systems and survival. In Section 4 we explain Vickers's appreciative system. In Section 5 we illustrate these concepts with SEAM models and the iPod example. In Section 6 we compare our work with related research before outlining future re-search directions in Section 7.

M. Snene, J. Ralyté, and J.-H. Morin (Eds.): IESS 2011, LNBIP 82, pp. 146–157, 2011.

2 Service Systems and Value Creation in Service Science

The following basic concepts of Service Science are defined in [14] as:

- Service is “the application of competences (knowledge and skills) by one entity for the benefit of another.”
- Service Systems are interactive configurations of mutual ex-change in which value is created collaboratively.
- Value is “an improvement in system well-being” and is measured in terms of “system’s adaptiveness or ability to fit in its environment.”

Further [14] state that “A service system’s function is to make use of its own resources and the resources of others to improve its circumstance and that of others.”

Service Science takes the view that marketing thought has to evolve from the Goods-Dominant (G-D) logic to a Service-Dominant (S-D) logic [14], G-D logic, according to [14], is based on the exchange of goods from supplier to consumer. In G-D logic, a supplier organization transfers or sells a product to a consumer. The value derived from this product by the customer depends on the customer’s ability to use the product, resell it or transfer it to others. This is called value in exchange.

Conversely, S-D logic, also according to [14], is based not on the independent creation of value following the transfer of goods but on the co-creation of value jointly by the service supplier and the service customer. This is called value in use. The Co-creation of value refers to the need of the provider to be available for as long as the consumer uses the service. Contrast this with the G-D logic in which a product is sold to a customer (i.e. transferred to a customer for a fee). Thereafter, the product provider is not involved anymore in the value created by the customer because the product is not in its jurisdiction anymore.

S-D logic describes value in use as emerging from the cooperation between supplier and consumer within a Service System [2, 14].A Ser-vice System is said to create value when interacting with other service systems [14].

The transition toward S-D logic shifts the focus of attention from value in exchange to value in use. Value in exchange, however, has not completely disappeared. Hence, for [14] “Co-creation of value inherently requires participation of more than one service system, and it is through integration and application of resources made available through exchange that value is created. The process of co-creating value is driven by value-in-use, but mediated and monitored by value-in exchange. The concepts of mediation and monitoring are not further specified.

Value creation has been linked to both the survival of the organization and to the disappearance of distinction between producer and consumer. [14] states that, “…at its core, value depends on the capabilities a system has to survive and accomplish other goals in its environment.” and “When value creation is seen from a service systems perspective, the producer–consumer distinction disappears and all participants contribute to the creation of value for themselves and for others.”Erasing the distinction between systems amounts to denying their survival. It is therefore unclear from these statements how a system survives and at the same time erases its distinction between itself and its producers and/or its consumers.

The discussion above shows that:

- Value in use and value in exchange interact in complex ways that are not yet fully understood. It is not clear what it means for value in use to be monitored and mediated by value in ex-change.
- Erasing the distinction between producer and consumer may lead to denying their existence and hence their potentially differing points of view
- It is not clear how value creation influences survival.

In the following sections we formulate some answers to these points by linking the aspects of systems survival and valuation.

3 Systems and Survival

We base our discussion of systems and survival from the point of view of General Systems Thinking, the study of general principles that can be applied to all systems [21, 22].

Reflecting on system survival brings the obvious question of what is a system and what determines its survival. In its most general form, a system is defined as a set of interrelated elements as viewed by an ob-server [11, 12, 13, 21]. The system exists, or survives, for a given ob-server for as long as the observer can identify it. The system therefore must maintain some unchanged states that the observer uses to identify it as different from any other system. The observer also must maintain a memory of these aspects of the system so that he or she can identify it. The observer has some limits on the variability of the aspects he or she sees in a system. We use the term norm to denote these stable, unchanging, states of both system and observer. For Apple, this means that once they launch a product named iPod, they must be very careful with any changes made to it. When some changes are made to the iPod product line, the new devices must be labeled accordingly so that customers may understand their differences as well as their relation to older versions. Hence, when new versions of the iPod are introduced they are called iPod Classic (the one that keeps the small screen and the wheel user interface) and the more innovative are called iPod Touch.

The elements and relationships that the observer considers as being part of the system fix the boundary of the system. Everything else is considered to be outside the system and is called the environment of the system. In the iPod example, considering only the iPod device with components such as screen, hard disk, and control software (and their relationships) fixes a boundary that corresponds to the iPod's value in exchange. If we add to it the iTunes service, we have a boundary that corresponds to the value in use.

The second law of thermodynamics states that a closed system will evolve towards disorder. That is, it will not be able to maintain its components and their relationships (its norms) in stable enough states for the observer to identify the system. Disorder is measured in terms of entropy. Higher entropy means more disorder. Lower entropy means less disorder, i.e. more order. The system therefore has to have relationships with other systems to exchange energy and information with them thereby maintaining the system's negative entropy (internal order, also called negentropy).

While these relationships are necessary, they are also potentially dangerous. For example, Apple needs the relationships with its suppliers in order to manufacture an iPod, but a supplier may supply components of insufficient quality, thereby threating the overall quality of the iPod. Apple must have mechanisms in place to control its relationships, including its suppliers and customers. The way a system manages its relationships is therefore of paramount importance to its survival. In the following section we describe Vickers's ideas about the way individuals and organizations manage their relationships, his concept of appreciative system.

4 Appreciative Systems and the Valuation Process

Vickers specialized General Systems Thinking to the study organizational and individual valuation. Noting that most research in psychology and communication sciences alike has been targeted to the study of human action rather than to the study of the stages that predate action, Vickers proposed the concept of the Appreciative System, to model the way in which humans and organizations understand and act on their environment.

Vickers [15] calls metabolic relations the relationships that bind the elements of the system (its internal relationships). He calls functional or service relations the relationships with the environment (external relationships). Metabolic and service relations are interdependent one feeds the other. At Apple, for example, the selling of iPods (a service relation) is dependent on engineering, manufacturing and marketing (metabolic relations). Both metabolic and service relations need to be maintained in very specific states over time for the system to maintain its identity for a given observer.

The activity that maintains a relation in a specific state is called regulation. One of the simple regulation mechanisms is the automatic control mechanism, or feedback mechanism. An automatic pilot, for example, has to maintain an airplane in specific relations to its spatial environment in order to steer it to destination. Such an automatic pilot has a cyclical regulative process that can be separated into three stages [15]:

1. "information is received from the compass;
2. it is compared with the course to be steered;
3. action or inaction is selected in response to a signal generated by the comparison."

4.1 Reality Judgment

Reality Judgment defines what a person or organization is ready to notice in themselves and in their environment. They form what the person or organization will be interested in, [15], "We notice only those aspects of reality which 'interest' us; we have language to describe only those aspects which interest us. Interest is the basic fact of mental life – and the most elementary act of valuation."

4.2 Value Judgment

Value judgment defines how what is noticed will affect present and future relations. This judgment is made on both service and metabolic relations. Value judgments are therefore closely linked to the survival of the individual or organization making the judgment. Remember that survival is the maintenance of an identity for a given observer. Hence altering the relationships with an observer can affect the survival of the individual or organization for that observer.

Vickers specifies that value judgment consists of a three-step process [15]:

- Matching: attaching a noticed phenomenon to an existing category.
- Weighing: Evaluating the result of the matching step on present and future relations.
- Innovating: Creating a new category thereby enabling new phenomena to be observed and valued.

4.3 Action Judgment

Action judgment defines what behavior is appropriate to what has been noticed and the way it was valued. Vickers notes that visible action doesn't necessarily follow from the valuation. It is very possible that the valuation will be followed by a change of what to notice and how to value, in essence changing what is desired.

4.4 Judgments and Readinesses

The essential difference between an automatic pilot and an appreciative system is that for the former the norms (the course, the measurement of the direction and the comparison) are given at construction, whereas for the latter the norms evolve from within through experience.

For Vickers [15] each of these stages creates over time a readiness that defines what the system expects. Reality judgment creates a readiness to see. Value judgment creates a readiness to value. Action judgment creates a readiness to act. Or in Vickers's own words [15], an appreciative system is characterized by "the kinds of information it is ready to notice, the kinds of valuation it is ready to make, and the kinds of action it is ready to take."

Each of these readinesses can be studied as a system in its own right but they are interdependent in their functioning as a complete appreciative system [15], "The elaboration of the reality system and the value system proceed together. Facts are relevant only to some standard of value; values are applicable only to some configuration of facts."

These standards of value and configuration of facts can be studied as norms that the appreciative system (and its subsystems of reality, value and action) adheres to. The appreciative system constantly attempts to maintain these norms in a consistent state, resisting change that threatens the stability of each one of the sub-systems and of the whole system. The adherence to norms, by definition, insures the stability of the system. But it also hampers creativity [12]. This process sets limits on the amount of change that an appreciative system can accept [16]. Hence, these norms are not impossible but are simply difficult to change.

Each appreciative system builds its own readinesses (its own norms) by which it apprehends the world, judges it and acts on it. In a service system what brings together a service supplier and a customer, as de-scribed in Section 2, each will have a different appreciative system. They may agree to see and value some aspects in the same way but because of their different interests, may very well disagree on many other aspects. The appreciative system concept tells us that it is very likely that one party may not even notice aspects that are valued as very important by the other party. What one party considers as improvement may be judged by another party as a deterioration, see for example [3]. The very “function” of a service is likely to be a subject to debate among its stakeholders, see [21].In the next section we show how these differing views can be modeled with SEAM.

5 Modeling Service Systems and Value with SEAM

Having explained the Appreciative System concept, we show how it can be modeled with SEAM. We use the example of Apple’s iPod’s valuation by a teenager called Kate. We first model the valuation leading to the purchase of an iPod by Kate, i.e. the value in exchange of an iPod. We then model the valuation of the service offered by Apple to Kate, i.e. the value in use of the iPod.

Within a service system we usually identify several interrelated systems, e.g., a service provider, a customer, competitor and regulator. For reasons of space, we limit our example to the interactions between the service provider and the customer.

The models we present in Figures 1 to 4 are extensions of the models presented in [19].

5.1 The iPod’s Value in Exchange

When Apple launched the iPod in 2001 [10], it entered a market where many players existed already. Apple was by far not the first to offer an MP3 player. It therefore didn’t enjoy the first mover advantage. Instead it was able to capitalize on norms that already existed and that have formatted customers’ appreciative systems. MP3 players have existed for several years and consumers have come to understand their potential. Price ranges differentiated between low-end and high-end players.

Customers began by appreciating the iPod purely for its value in exchange, e.g. its design, price and performance.

Establishing the iPod as a reference in the market was made possible by offering several features that set it apart from its competitors, such as a large screen, playlists, a good user interface, but these are not by themselves sufficient in explaining why Kate and her friends flocked to the iPod. Preceding the iPod, Apple created the iMac, which set a norm in PC design. This no doubt has helped Apple to launch the iPod and to make into its own standard. It also set the norm in the market that Apple was a manufacturer of very desirable computer devices, setting the stage for the successful introduction of the iPod.

The SEAM Systemic Value Network model in Figure 1 shows the market segment of the iPod Classic with Apple's Value Network providing an iPod Classic product to an adopter called Kate. The top left box within the iPod segment represents the Apple value network as a whole (designated by a [w]). Only the externally visible features of the iPod are shown. These features are, a 2.5" screen, a sleek design, the Apple brand, usability and 120 GB memory.

The bottom left box shows Apple's value network as a composite (designated by a [c]). This exposes the participants in the Apple value network. These are: Innolux who supplies the screen, Apple who supplies the software and industrial design, Toshiba who supplies the hard disk and Foxconn who assembles and packages the iPod. If so many of Kate's friends have iPods it means that Apple also maintains a set of norms that allow it to literally flood the market with iPods. We model this capability with the *High sales volume* feature in the model as a whole. All of Apple's suppliers will have to uphold this norm as well. We model this norm with the *High production volume* feature assigned to each supplier.

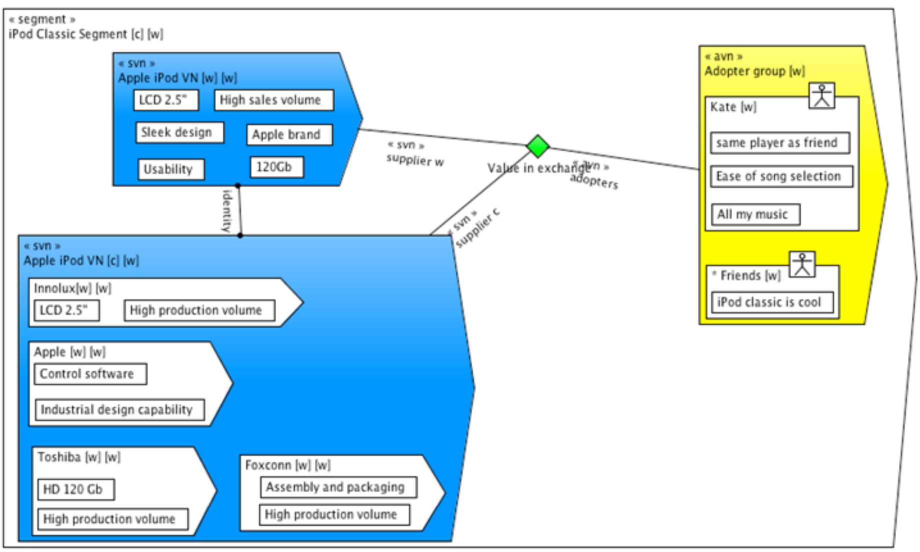

Fig. 1. Service system model for value in exchange

The top right box represents Kate who wants to buy an MP3 player. Kate has links with a network of friends who influence her appreciative system, and in effect create the reality judgment that Kate uses to make her choice of MP3 player. In this case, most of her friends have an iPod or would like to have one, which sets the readiness to notice mostly iPods even to the exclusion of any other MP3 when purchasing time comes. Kate sees the following value in an iPod, it is the same player as her friends, it is easy to select songs with it, she can have all her music on the go and the iPod is a cool device.

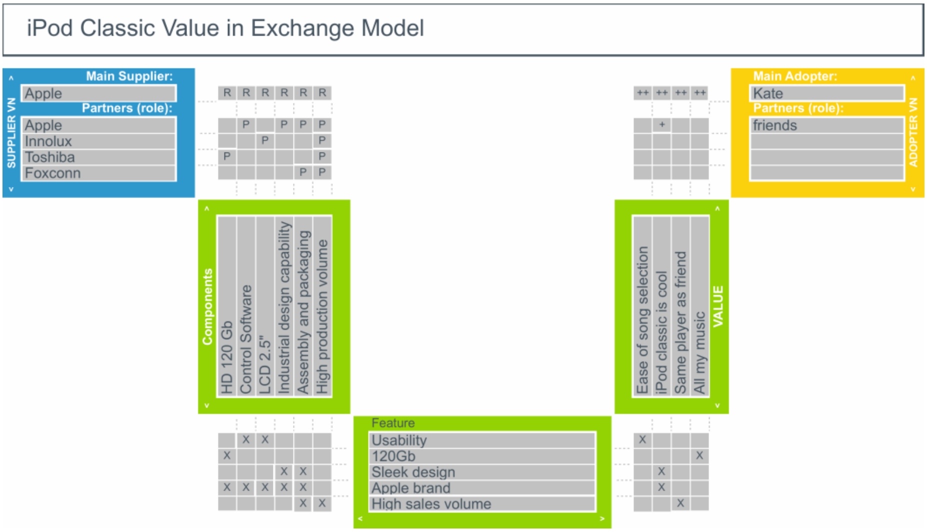

Fig. 2. Value model for value in exchange

Figure 2, shows the value model corresponding to the service system model. From left to right we show a supplier value network creates components that exhibit features that are valued by a network of customers. The left side of the model corresponds to Apple's value network with its set of suppliers. We represent the suppliers in the horizontal list on the extreme left of the model and the component of the iPod in the vertical list on the left of the model. We match which supplier delivers which component with the responsibility matrix that links both lists.

The middle and right side of the model correspond to Kate's appreciative system. The +, ++ (and potentially – and --) signs correspond to the weighing step in the value system as described in Section 3. The value itself (e.g. iPod classis is cool) corresponds to the matching step of the value system. In the middle of the model we represent the features of the iPod that the Apple value network creates and that Kate notices through her reality system. The features of the iPod are common to both the Apple value network and Kate's reality system. Kate's reality and value systems together form Kate's appreciative system. We can see that Kate's network of friends gives much value to the coolness of the iPod. Kate places much value on having the same MP3 player as her friends in order to maintain her relationships with them. This means maintaining her membership in her peer group, i.e. surviving in that group. This explains Kate's choice of the iPod. Notice that this valuation is aligned with Vickers's description of the value system, which consists of judging how what is noticed will affect present and future relationships.

5.2 The iPod's Value in Use

Figures 3 and 4 show the model of the iPod value in use. It corresponds to a different value network for Apple and a different appreciative system for Kate. The ubiquity of iPods in the market (due to their value in exchange) enables Apple to provide a service centered around the iPod, and therefore dependent on its value in exchange. The iTunes store proposes a service with which iPod users can buy music from the iPod or from the web. Apple's value network for the value in use is made of Sony Music Entertainment, Apple's iTunes, Warner Music Group and Independent musicians, each providing part of the service.

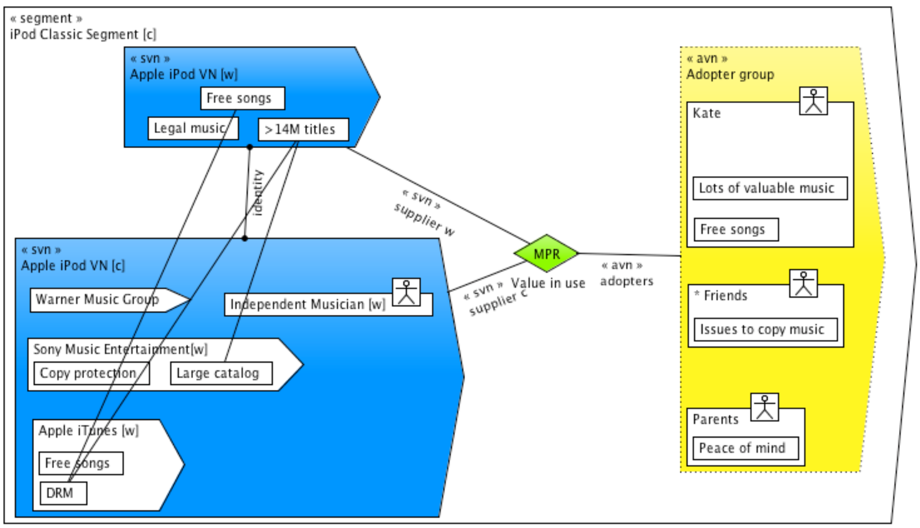

Fig. 3. Service system model for value in use

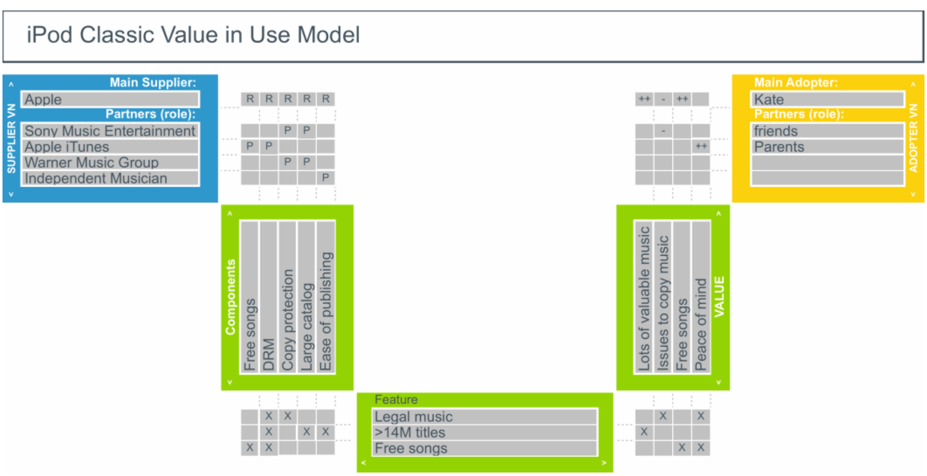

Fig. 4. Value model for value in use

For a teenager such as Kate with a limited budget, the value in use represented by iTunes is not all positive. The relatively high prices of individual songs and albums compared to budget CDs available in stores is a big strain on her budget. The effect of copy protection on the possibility to copy songs is also a problem. The high price of songs and the difficulty to copy songs are therefore modeled as negative values by Kate and her friends. Kate, however, values positively the free songs offered weekly on iTunes.

The Service System modeled in Figures 3 and 4 contains an additional player in Kate's relationships, Kate's parents. Kate's parents highly value the legal music offered by iTunes since it gives them peace of mind by striking a bargain with Kate that a few iTunes card every now and then and the free songs offered by iTunes will be enough to dissuade her from downloading music from the internet.

We therefore see that Kate and her parents have different appreciative systems. While Kate sees and values mostly her relationships with songs and friends, her parents see and value their relationships with society as exemplified by their adherence for legal music. Hence, they see different features of the iPod and value them differently.

6 Related Work

Value modeling has been introduced long ago in the fields of Requirements Engineering, Information Systems, and Service Science see for example [5, 6, 9]. E3Service [5] is a method for semi-automatically reasoning about matching service offerings with customer needs. In order to make this semi-automatic reasoning possible, e3Service assumes that the customer and supplier share the same ontology, that the customer specifies her needs in the same vocabulary as the supplier specifies its offering. As we have shown, this is a strong assumption when different appreciative systems are connected. Osterwalder and Pigneur [9] define value as a benefit for a customer and describe several kinds of value propositions: Value creation, value appropriation, value consumption, value renewal and value transfer.

ValIT [7] is a governance framework designed to assist organizations to improve the success rate of their IT investments. ValIT seeks to bring value to the organization by balancing the expectations of stakeholders and the resources needed for meeting these expectations. Most notably, Val IT defines that Value is in the eye of the beholder. Val IT focuses mainly on the delivery of projects that bring value to the organization. Business value is also a central pre-occupation in other business frameworks such as ITIL, COBIT, PRINCE2, PMBoK and BABoK.

Soft Systems Methodology (SSM) [3] is a well-known stream of research that is a direct descendant of Vickers's ideas. Checkland [4] proposes a simplified model of Vickers's appreciative system. SSM uses rich pictures as visual models.

Weick [20] proposes an organizational theory called sense making that has sometimes been compared and opposed to Vickers's appreciative system. Even though Weick talks less explicitly about the valuation process, sense making can provide a useful perspective on this process.

7 Conclusions and Future Work

In this paper we have shown how Vickers's appreciative system can be used as a theoretical background for modeling and analyzing service systems and their co-creation of value. We have shown how the customers appreciate different aspects of an iPod and the service that Apple has built around it depending on the relationships they manage in their quest for survival in a network of actors.

In the quest for a fuller understanding of service systems, much work is needed still.

Vickers's work, for example, is much richer than what we can capture in this paper. For example, Vickers notes that the norms that serve individuals and organizations in their appreciation remain very often tacit and therefore difficult or impossible to express. It is necessary to create methods to elicit these norms. Requirements Engineering elicitation methods can be used for this purpose. Vickers makes another important point, these norms are not only tacit, they are mutually inconsistent, leading to the need to make multi-valued choices. We will need to extend our models to take these aspects into account.

Independently of Vickers's framework, we need to explicitly link the value in exchange and value in use models to show their interdependence and extend our models to show the flow of value from customer to supplier.

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Business Process Flexibility in Service Composition: Experiment Using a PLM-Based Scenario

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Abstract. In recent years, service oriented systems that compose services in a loosely coupled manner, have emerged as a new paradigm to provide automated support for business processes. These process based composition and their support need to survive in a highly volatile environments under which the business operations are subject to continuous changes. Consequently, many approaches have been proposed to address the issue of flexibility support in business process enactment in order to facilitate the coupling with the business reality. However, it remains a challenge for researchers. In this paper we provide some requirements for process flexibility in the context of service composition and analyses existing approaches in workflow domain and in AI planification domain against these requirements. Some perspectives are addressed based on a practical experiment conducted with these approaches.

Keywords: Business process, process flexibility, service composition, BPEL, SOA.

1 Introduction

Current manufacturing industries are facing an increasing challenge to satisfy customers and to compete in market. They are adopting Product Lifecycle Management (PLM) systems which have the goals to foster collaboration among different actors involved in Product Design processes [1]. Design processes are business processes associated to product design that determines the procedure for developing and distributing value for the customers. These design processes have become increasingly important in such enterprise since they determine the procedure of work of the enterprise. Most PLM systems are integrating a tool to model, execute and control design processes. Business process management (BPM) provides automated support for business operations to achieve business efficiency [2]. However, in a context where the organizations are in a constant seek of balance facing up to more and more constraints of the competitive environment; work methods (i.e. business processes) cannot be fixed definitively, especially when dealing with design processes which are emergent, non deterministic because of the creativity aspect in design projects. Furthermore, various events may occur during design processes due

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to external constraints (such as customer requirements evolution, standards changes, sub-contractor or supplier constraints) and/or internal constraints (such as priorities changes, delay constraints, technical feasibility problems and staff absence). Design processes are thus constantly changing [3]. Thus, the automated support for the business operations needs to continuously evolve and reflect such changes. Reflecting these changes in business process management in time is critical and represents an ongoing challenge.

Furthermore, new paradigms appear such as services oriented approaches focusing on services composition [4, 5, 6]. Services Oriented Architectures (SOA) tend to be a new generic architecture model that is used in enterprise architectures [7, 8], and software-sensitive system architectures [9]. One of the main interests of Service-Oriented Architectures is basically the underlying ability of such architectures to inherently being evolvable; because the underlying idea of SOA is that the services are loosely coupled and can be composed on demand. Thus, services composition is a crucial feature in SOA: new services can be offered by composing existing ones. Therefore, some standards development organizations have been involved in the development of standards for PLM with SOA. Currently there are two initiatives in terms of PLM services, OMG PLM Services [10] and OASIS PLCS Web services [11]. These standards propose a set of services which provide the necessary PLM computational functionalities to create, read, update, and delete instances of data. These services should allow the reuse of existing functionalities in order to shorten the time between design and implementation when business requirements change. In this context, SOA is considered a powerful candidate providing mechanisms for making design process and thus enterprises more agile and flexible. Moreover, the survival of businesses is dependent on how flexible the service compositions are. This requires that the techniques used to model and enact the business processes in service compositions be flexible. Traditional service orchestration is always implemented by business process workflow or I/O matching (BPEL) [12]. The process execution language which seems to dominate today is the standard BPEL. How can BPEL enable business process flexibility achievement? Does it fit to business processes? In case BPEL is not suitable, which other alternatives can be considered? That's the focus of this paper. To answer these questions, we will conduct a case study based on a PLM scenario. We do not aim to treat all aspect of services composition through this case study. By cons, this study will draw some conclusions and identify some perspectives.

This paper is then organized as follows. First, we provide an overview of BPEL's interaction model on a specific example scenario (section 2). In particular, we identify a set of drawbacks for BPEL process flexibility according to process definition and service relationship requirements for service composition. Then, section 3 evaluates the existing approaches to process flexibility support against these two requirements. In section 4 we present an overview of service composition methods related to AI planning. We will specially focus on Planning Domain Definition Language's ability to achieve the process based composition in a flexible manner. The last part concludes the paper and gives some perspectives.

2 BPEL and Flexibility Requirements of Process-Based Composition

In this section we announce the process flexibility requirements we have identified. We then provide an overview of BPEL's interaction model on a specific scenario. In particular, we identify a set of limitations of BPEL against flexibility requirements of process-based composition.

2.1 Flexibility Requirements of Process-Based Composition

A design process definition needs to evolve over time to facilitate the coupling with the business reality. Thus the service composition needs to evolve too. Moreover, a service composition can be seen as a collection of services relationships. Process definitions are defined on top of these relationships to coordinate the activities. There are dependencies between the process definitions and services relationships, and both evolve over time. As the definition of design processes are subject to changes, it's possible that's these relationships are required to change. Consequently, the flexibility in process puts requirements on the flexibility of the process definition and is constrained by the degree of flexibility in the services relationships. So, the process flexibility in a service composition can be monitored by two levels of flexibility: process definition flexibility and services relationship flexibility.

To conclude, to provide the necessary flexibility support at the process-based composition we should satisfy two requirements:

- Services relationship flexibility: the services should not be much coupled (all entities of the composition can communicate with each other)
- Process definition flexibility: the process definition (interaction activities) should be decoupled from service interface (activity implementation dimension).

2.2 Evaluating BPEL Interaction Model

Business Process Execution Language (BPEL) is the standard for specifying services-based business processes and has gained broad acceptance in industry and research [13]. It defines a model for services composition, which is, the aggregation of existing services into new services. Thus, BPEL provides a recursive aggregation model for service [14, 15]. In order to evaluate the flexibility of BPEL interaction model, let us consider the following scenario managed in PLM systems (cf. Figure 1). This example describes the process for updating the CAD attachment of a given product reference according to illustration of figure 1 (a). It includes two major activities; searching product attachment reference and updating attachment information. This process may change due to organizational or regulation rule. For example, due to internal rule change, the need to lock (check-out) a document instance before updating it and to unlock (check-in) it after the update, the process may evolve to the one shown in figure 1 (b). Therefore the process needs to have a flexible modeling and enactment mechanism, so that it can be quickly changed.

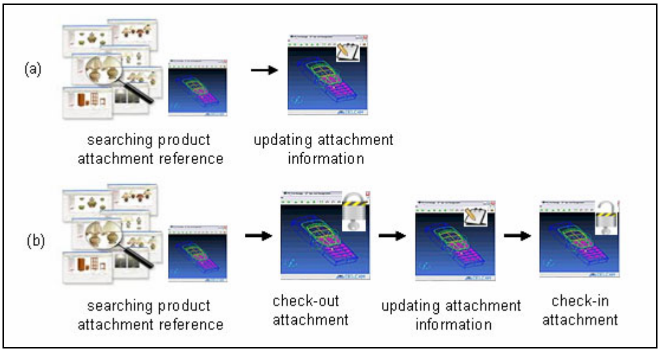

Fig. 1. Updating Product attachment; CAD document

On receiving the update order from a design actor the process initiates the first task (searching product attachment reference) according to the product reference given by the business user. There are data dependencies between the first task and the other ones. In particular, the attachment reference is required to finalize the check-out attachment, updating attachment information and check-in attachment. So, when the first task is completed, check-out attachment can proceed and then the attachment can be updated and finally checked-in. Assume we have two available services. A *Search* service which allows, thanks to its "searchAttachment" operation, to find the attachment reference of the product in question. A *ModificationAttachment* service which allows to check-out, updating attachment information and to check-in attachment, respectively through its "initiateModif", "modification" and "endModif" operations. Therefore the process can be specified, using BPEL, as a flow between these services operations and the process (cf. figure 2). BPEL provides several so called structured activities that facilitate prescribing the interaction activities between the process and its partners. The control flow between the activities mentioned above can be structured block-based by nesting structured activities like <sequence> (for sequential control flow).

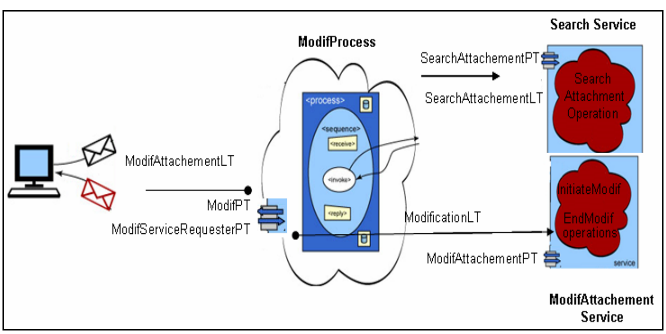

Fig. 2. Updating Product attachment process; flow between services and process definition

The interaction with each partner occurs through service interfaces, and the structure of the relationship at the interface level is encapsulated in what we call a *partner link*. In order to enable this relationship (process communication with services) BPEL introduces the concept of a *partner link type*. A partner link type binds two *port types*. The first port type consists on the one offered by the process to a partner. The second port type consists on one required by process from the corresponding partner. The port type offered by the process to the *ModificationAttachment* service (ModificationServiceRequesterPT) and to the business user (ModifPT) are shown in the following figure (WSDL document, cf. figure 3 (a)). The port types for the services providing search attachment reference and modification attachment functions are also defined in the same document.

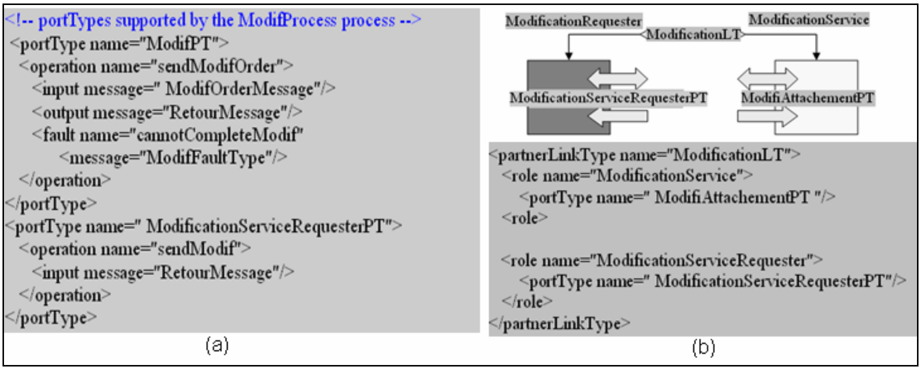

Fig. 3. On the left: *ModifProcess* Port types. On the right: Partner Link Type between *ModifProcess* and *ModificationAttachement* service.

Partner link types can be used to represent dependencies between services or the process and other services. The partner link types included on the right of the Figure 3 represent the interaction between the *ModificationAttachment* service and the *ModifProcess*. Each partner link type defines up to two *role names*, and lists the *portTypes* that each role must support for the interaction to be carried out successfully. In this example the "ModificationLT" partner link type; defines two roles because both the modification process and the modification attachment service must provide callback to enable asynchronous notifications to be asynchronously sent ("ModifAttachmentPT" and "ModificationServiceRequesterPT" portTypes). The two other partner link types, "SearchAttachmentLT" and "ModifAttachmentLT", define only one role (cf. Figure 2). The "ModifAttachmentLT" partner link represents the connection between the process and the requesting user, where only the process needs to offer an operation ("sendModifOrder"); the "SearchAttachmentLT" partner link represents the interaction between the process and the Search service, in which only operation of the *Search* service ("searchAttachment") is invoked.

The rest of the process definition contains the description of the normal behavior for handling a modification request (cf. Figure 4). The structure of the main processing section is defined by the outer <sequence> element, which states that the activities contained inside are performed in order. The business user order is received

(<receive> element), then processed, and a reply message with the modified attachment reference is sent back to the business user (<reply>). Note that the <receive> and <reply> elements are matched respectively to the <input> and <output> messages of the "sendModifOrder" operation invoked by the design actor. The activities performed by the process between these elements represent the actions taken in response to the design actor order from the time the order is received to the time the response is sent back (reply). These actions consist of the four activities searching product attachment reference, check-out attachment, updating attachment information and check-in attachment.

```
<sequence>
    <receive partnerLink="ModificationProcess"
        portType=" ModifPT "
        operation="sendModifOrder "
        variable="ModifMsg">
   </receive>
      <assign>
        <copy>
          <from variable="ModifMsg" part="objectInfo"/>
          <to variable="Recherche"   part="refObject "/>
        </copy>
        <copy>
          <from variable="ModifMsg" part="modifInfo"/>
          <to variable=" ModifInfo" part=" infoModif "/>
        </copy>
      </assign>
       <invoke  partnerLink="RechercheAttachement "
           portType="SearchAttachementPT"
           operation="SerachAttachement"
           inputVariable="Recherche"
           outputVariable="AttachRef">
      </invoke>
      <assign>
        <copy>
          <from variable=" AttachRef" part="attachRef "/>
          <to variable=" ModifMsg"   part="attachement "/>
        </copy>
      </assign>
      <invoke  partnerLink="ModificationAttachement "
            portType="ModifiAttachementPT"
            operation="initiateModif "
            inputVariable="AttachRef ">
      </invoke>
      <invoke  partnerLink="ModificationAttachement "
            portType="ModifiAttachementPT "
            operation="Modification "
            inputVariable="ModifInfo"
       </invoke>
      <receive partnerLink="invoicing"
            portType=" ModificationServiceRequesterPT "
            operation="sendModif "
            variable="Retour">
      </receive>
      <invoke  partnerLink="ModificationAttachement "
            portType="ModifiAttachementPT"
            operation="EndModif"
            inputVariable="AttachRef">
      </invoke>
    <reply partnerLink="ModificationProcess"
        portType="ModifPT"
        operation="sendModifOrder"
        variable="Retour">
    </reply>
</process>
```

Fig. 4. Business process for the Updating Product attachment service

The interaction activities [13] (<receive>, <reply>, <invoke>) are used to define the actual message exchange corresponding to a partner link, i.e. data transmitted and style of communication (synchronous vs. asynchronous). For that purpose, interaction activities reference a partner link and a port type operation. Receiving activities (<receive> and the <reply> activities) reference an operation of the process's port type, whereas the <invoke> activity references an operation of the partner's port type. Note, that a synchronous invocation of a process is specified via a receiving activity and a matching reply activity. The information is passed between the different activities in an implicit way through the sharing of globally visible data variables that are referenced and accessed by interaction activities and manipulation activities (e.g. <assign> activity).

2.3 Discussion

BPEL process has a predefined sequence of activities by adhering to both the interaction activities and the grouping mechanism that allows modelling complex message exchanges. For this reason, the control flow is very rigid and thus flexibility of BPEL processes is very limited. Furthermore, in BPEL process the 'what' and 'which' dimensions are strongly coupled since activities which are an aspect of the process logic ('what') directly refer to WSDL operations ('which'). This is a major drawback because it inhibits the reuse of processes definition with different partners and the possibility to participate with other services which offer the same computation. This tie between services and process increases dependencies between services, and thus decreases services relationship flexibility. Also, on account of the strong coupling between activities and services interfaces, process definition flexibility requirement is not supported by BPEL. BPEL does not provide evolution mechanisms that should be used for evolving activities orchestration; consequently, when an unanticipated situation occur, the activities orchestration model has to be manually and off-line changed and a new execution (an instance of the modified model) has to be fired. So, the published assumption that business process flexibility can be achieved immediately by using BPEL is far from reality. The reason is obvious: the composition is static and there is clear separation between (process) design time and (process) execution time. A BPEL process can be seen as a flow between services operations. This explicit ordering of activities in a BPEL process makes it relatively easy to understand the coordination of activities even for a non-technical stakeholder. However, this imperative nature results in rigid and hard to change business process definitions.

Consequently, many efforts [16, 17, 18, 19, 20, 21] have attempted to overcome the BPEL flexibility limitations. There are many efforts to come up with alternative ways with different perspectives to model and enact business processes, such as data-based, constraint-based, dynamic routing and event-driven paradigms. In the next section we present some of these approaches that attempt to increase flexibility of processes by decoupling process logic from the services interfaces and supporting the flexibility requirements.

3 Alternatives Approaches Using Workflow Perspectives

We identify some approaches [16, 17, 18, 19, 20, 21] for discarding the static specification of process composition in BPEL, by eliminating the tight-coupling of process logic 'what' and activity implementations 'which', and thus improving process flexibility. A large amount of work has been done in the past on this regard. Our selection of approaches was based on the uniqueness of the methodology, in order to highlight the diverse ways to achieve the process flexibility.

Van der Aalst et al. [16, 17] propose a data-driven approach to deal with business processes flexibility in order to meet the first requirement mentioned above; process definition flexibility. In their approach the progress of the process focuses on the values and statuses of the data objects. The aim here is to make the process definition more flexible and applicable to the operating environment. They attempts to add that support in the process definition mechanism by allowing data model configuration at runtime and consequently improving the flexibility of process definition which depends on data objects values. Somewhat process definition flexibility can also be seen in the dynamic routing approach proposed by Barros et al. [18]. In this approach the process is specified as the definition template is routed among actors until the case is completed. So, the definition can be changed by actors based on task delegation. Moreover, we can say that this approach supports service relationship flexibility (actors of activity can be changed at runtime) since actors can change future participants. Likewise, the constraint driven approach proposed by Pesic et al. [20] is capable of supporting somewhat the service relationship flexibility by modeling the constraints of service relationships. Actually, in constraint driven approaches the progress of process instances is such that it does not violate the defined constraints. So, by providing the ability to add/remove or change the level (soft/mandatory) of those constraints we have some flexibility in service relationship. Furthermore, the constraint driven approach provides a way to merge the business process definitions and thus to provide some process definition flexibility. In fact in their approach a constraint set can be seen as a process definition which specifies what shouldn't be violated. They allow mapping/re-mapping single process definition (constraint set) to Constraint Model (CM). The constraint model mapping mechanism can be used to merge two different process definitions (constraint sets) or to update a process definition (constraint set). We can see also this capability of process definition flexibility in the event-driven approach [19]. In this approach the progress of the process is driven by the firing of a combination of events. Since the events, actions and event-action relationships are allowed to be specified later by Alexopoulpu, they can be altered at runtime to deviate a particular process definition. The event-driven approach is also capable of changing the service bindings in a way such that, different bindings are represented as actions. Based on the triggered event(s), a suitable binding could be selected by a selection of suitable action. Pourraz and Verjus [21, 22] propose a pi-calculus based dynamic language: such language (pi-Diapason) provides mechanisms for expressing evolvable services orchestration. Such mechanisms enact the pi-calculus mobility principles. Thus, a services orchestration expressed in pi-Diapason is executed and can be dynamically changed on-the-fly at runtime.

To synthesize, the approaches for business process flexibility in service compositions attempt to address the process flexibility requirements by alternatives way to BPEL. In these approaches, the progress of the process instances is focused on some aspects other than the process flow. For example in the data-driven approaches the progress of process instances are modeled based on the values of the data objects. In dynamic routing, the definition gets changed by actors based on task delegation. In constraint driven approaches the progress of process instances is such that it does not violate the defined constraints. In event-driven approaches the next activity is triggered by the firing of a combination of events. One common observed characteristic of these alternative approaches is that these alternatives avoid having a predefined sequence of activities. The idea is to improve the flexibility in the control flow to allow late modifications. However, there is an implicit flow of activities even if it is not explicitly represented in the process model. As an example, in the event-driven approach the event-action relationships define this implicit flow. Although pi-Diapason is interesting and supports agile business processes, no support is offered for changing decision: it is up to the user to manually modify the executing services orchestration by dynamically sending new behaviors.

Finally, by analyzing the approaches mentioned above, we can see that different techniques are proposed to achieve automated support for process flexibility. However, none of these techniques have addressed all and well the requirements of process flexibility because most researchers conducted fall in the realm of workflow composition. Indeed, they have to specify the flow of work items either implicitly. So, the challenge of providing effective flexible process support remains. Actually, dynamic composition methods are required not only to provide automated services composition and automated binding of the abstract nodes with the concrete services but also to generate the plan automatically. Most methods in such category are related to AI planning. In the next section we present a service composition method related to AI planning which allows doing that.

4 Process-Based Composition Using AI Planning (PDDL)

To provide the necessary flexibility support at the process-based composition we should have a flexible process definition and flexible services relationships, as mentioned in the section 2.1. To fulfil these two requirements, dynamic composition methods are required to (1) generate process definition automatically, (2) to locate the correct services necessary to the given process definition and (3) to dynamically change the process at runtime. Some proposal in AI planning deal with the above mentioned requirements. In general, a planning problem can be described as a five tuple $\langle S, S', G, A, T \rangle$, where S is the set of all possible states of the world, $S' \subset S$ denotes the initial state of the world, $G \subset S$ denotes the goal state of the world the planning system attempts to reach, A is the set of actions the planner can perform in attempting to change one state to another state in the world, and the translation relation $T \subseteq S \times A \times S$ defines the precondition and effects for the execution of each action [23]. To our knowledge, some researchers have attempted to deal with services composition using this method. An important pre-requisite for such methods does already exist: PDDL [24], the "Planning Domain Definition Language", is a widely accepted language for expressing planning problems and domains. It allows describing the planning domain and problem. The domain contains information about the world (Properties of objects that we are interested in) and the specification of actions (functions of services). The problem defines the objects of the world that interest us, initial state of the world and goal conditions (objective state) (Figure 5).

```
(define (domain <domain name>)
   <PDDL code for predicates>
   <PDDL code for first action>
   [...]
   <PDDL code for last action>
)

(define (problem <problem name>)
   (:domain <domain name>)
   <PDDL code for objects>
   <PDDL code for initial state>
   <PDDL code for goal specification>
)
```

Fig. 5. Relevant parts of the conceptual models of PDDL

The general assumption of such kind of methods is that each service can be specified by its preconditions and effects in the planning context (cf. Figure 6). Firstly, a service takes the input data and produces the output data. Thus the preconditions and effects are the input and the output parameters of the service respectively. Secondly, the service also alters the states of the world after its execution. So the world state pre-required for the service execution is the precondition, and new states generated after the execution is the effect. In the terms of process (composite service), S' is the initial states of the system under which the process will be executed and G the goal states after the execution of the process. A is a set of available services which will participates to the process execution. T further denotes the state change function of each service.

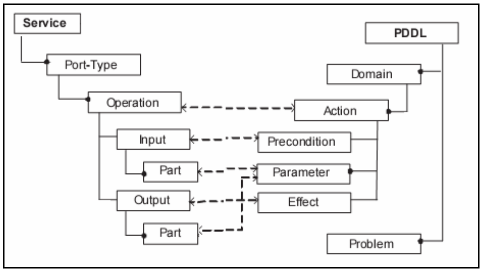

Fig. 6. Mapping between service and PDDL models

4.1 PDDL Model – through Example

To illustrate how service composition can be accomplished using PDDL and then AI planners for expressing the process based composition, we consider the Updating Product attachment process described in the section 2.2. The domain is described in terms of four actions schemata (shown below) which correspond to the *Search* and *ModificationAttachment* services operations. We encapsulate these actions by defining the domain (cf. Figure 7).

```
(define (domain attachment)
        (: requirements :typing)
        ( :types DocVersion UpHeader SearchHeader  PLMObject Key String)
        ( :constants Part Document – PLMObject REN_1349_OP10 - String)
        ( : predicates

                    (known ?NP - String)
                    (IdentifiedAttach ?P –PLMObject ?DocV – DocVersion)
                    (Updated ?DocV – DocVersion)
                    (CheckedIn ?DocV – DocVersion)
                    (CheckedOut ?DocV – DocVersion)
          ...
```

Fig. 7. The domain types and predicates of Updating Product attachment process

All domains include a few types, such as object and numbers. Most domains define further types for objects, such as DocVersion and PLMObjectKey in this domain. Predicates represent the properties of objects that we are interested in, these properties can be true or false at a given moment. Inside the scope of a domain declaration, we specify the actions for the domain (cf. Figure 8).

The "searchAttachment" action specifies that the attachment can be found according to the relevant PLM Object reference. The symbols starting with question marks denote variables. The precondition dictate that initially the relevant PLM

Object reference must be known "known ?NP" and the attachment (DocVersion) is not yet known. The effect equation says that after the execution of the "searchAttachment" action the attachment related to the PLM object will be known "IdentifiedAttach ?P ?DocV". The "initiateModif" action definition specifies the effect of checking-out the identified attachment. This action can not be executed if the attachment is not yet identified ("IdentifiedAttach ?Part ?DocV" precondition). The "modification" action allows updating the attachment ("Updated ?DocV" effect). This action necessitates an checked-out ("CheckedOut ?DocV" precondition) attachment reference ("?DocV" parameter). The final action; "endModif", provides a way to check-in ("ChekedIn ?DocV" effect) a checked-out attachment ("CheckedOut ?DocV" precondition).

```
(:action endModif
  :parameters (?DocV - DocVersion)
  :preconditions ((CheckedOut ?DocV))
  :effects ((CheckedIn ?DocV))
)
(:action initiateModif
  :parameters ( ?Part – PLMObject ?DocV - DocVersion)
  :preconditions ((IdentifiedAttach ?Part ?DocV))
  :effects ( (CheckedOut ?DocV) )
)
(:action searchAttachment
  :parameters (?P - PLMObject ?NP – String ?DocV - DocVersion)
  :preconditions (and ( known ?NP) (Not (Keyknown ?DocV ?P)))
  :effects ((IdentifiedAttach ?P ?DocV))
)
(:action modification
  :parameters ( ?Part – PLMObject ?DocV - DocVersion)
  :preconditions (and (CheckedOut ?DocV)(IdentifiedAttach ?Part ?DocV))
  :effects ( (Updated ?DocV) )
)
```

Fig. 8. The domain actions of Updating Product attachment process

The Updating Product attachment problem description contains the objects under which the process will be executed, their initial states and the goal states of the system objects which the planning program attempts to reach (cf. Figure 9). The problem is defined with respect to the "attachment" domain. The initial states ("init" section) specify that initially the relevant part reference is known ("known REN_1349_0P10"), the attachment reference is not yet identified and thus is not checked-out, updated or either checked-in.

The problem goal will be implemented by an appropriate AI planner which will try to solve the problem and to find a plan (makes the services relationships). The PDDL data (domain and problem information) is fed into this planner and the planning process is started. The result is a plan consisting of a series of actions such that the action sequence is feasible starting in the given initial situation; and the goal is true in the situation resulting from executing the action sequence [25]. For instance, for the "attachment"

```
(define (problem AttachementModif)
        (: domain Attachement)
        (: objects Part DocV  REN_1349_OP10)
        ( :init
                ...
                (known  REN_1349_OP10)
                Not (Key known  DocV Part)
                Not (IdentifiedAttach Part DocV)
                Not (CheckedOut DocV)
                Not (CheckedIn DocV )
                Not (Updated DocV)
          )
          (:goal (and (IdentifiedAttach Part DocV)(Updated DocV)(CheckedIn  DocV))
```

Fig. 9. The problem description of Updating Product attachment process

domain and the "attachmentModif" problem the result is a plan consisting of the "searchAttachment", "initiateModif", "modification" and "endModif" actions. Since "searchAttachment" is an information retrieval action, it gets extracted from the plan as a sensing sub-plan and is executed. The output of that operation, the ground fact (IdentifiedAttach PartREN_1349_0P10 DocVRef_003) is then added to the fact base which will modify the initial states. Thereafter, "initiateModif" can start as their precondition is fullfield by the previous executed action. So on, for the "modification" and the "endModif" actions.

4.2 Discussion

In this section, we presented a solution for automatic and flexible service composition. It takes a novel approach by decoupling the tasks of composition and execution from particular technologies. The service composition problem is expressed by PDDL specifications which are supported by a wide range of planners, while the execution can be realized by any technology. This allows us to use the process definition (problem and domain) with many service specification languages, providing a degree of flexibility that the existing monolithic approaches for service composition do not deliver. This increases both the degree of process definition and services relationships flexibility.

Moreover, every time an action is executed the planner generates again a new plan according to the new states in the base and to the goal specified in the problem. So, it's possible to change the problem description (the goal) automatically while the process runs and thus the process definition (plan) changes. This provides process definition flexibility. However, this implicit process definition in PDDL makes hard the understanding of the process for a non-technical stakeholder.

Furthermore, by using PDDL and AI planning the 'what' and 'which' dimensions are decoupled since the problem goal which is an aspect of the process logic ('what') does not refer to the domain actions ('which'). This is a major advantage because it allows the possibility to use any action (service) which offers the needed computation. This increases services relationship flexibility. This decoupling allows also using the domain for solving other problem.

Finally, we can say that process flexibility requirements are supported by PDDL and AI planning approaches and that they provide evolution mechanisms that should be used for evolving service composition.

5 Conclusion

This paper has aimed to improve the flexibility of design process based compositions especially in service-oriented environments. First, we have identified the requirements for business process flexibility in service compositions. These requirements concern process definitions and services relationships flexibility. We have then provided an overview of BPEL interaction model and analyzed how it handles the process based composition on a specific scenario. Thus, we have identified a set of drawback related to BPEL. In BPEL the two dimensions of process compositions; business logic ('what') and the activity implementations ('which') are coupled which inhibits the flexibility of process definition. Moreover, because run time binding to appropriate interfaces is not permitted in BPEL, the service relationship requirement is not fulfilled. Then we have analyzed and compared existing process modeling and enactment approaches as to how they fulfill these requirements. Based on this analysis and evaluation, we have drawn some observations. On the one hand, the studied approaches cover some criteria necessary to the process based composition; such as locating the correct services necessary to the given process definition and automating service composition. On the other hand, we have observed that dynamic composition methods are required not only to provide automated services composition and automated binding of the abstract nodes with the concrete services but also to generate the plan automatically. This observation leads us to resort to AI planning methods in order to achieve full flexibility support for business process modeling and enactment in a service composition.

We presented a new technique for achieving service composition that facilitates decoupling of the two dimensions of process compositions - ('what' and 'which'). This technique takes a novel approach by de-coupling the tasks of composition and execution from particular service, and thus improves process definition flexibility. The service composition problem is expressed by PDDL specifications which is able to describe the problem independently of a specific service interface. This allows to dynamically replace a service with another one that achieve the same goal (which has the same effect on objects). We can also change the process definition (service composition problem) without need to change the services interfaces. This approach improves the flexibility of service relationship because service binding can be generated automatically at runtime according to the generated plan and based on information about service effect defined in PDDL domain file.

In our view, a process based composition approach related to AI planning can be an answer to the needs businesses have with respect to processes definition flexibility and service relationship flexibility. But, if we consider other criteria such as power of expression of language, we are not sure that these approaches remain interesting. However, to our knowledge, not much overview on process based composition methods related to AI planning has been published yet. As such, further research needs to be conducted to determine the most appropriate techniques that should be used in service compositions to enact the business processes in a flexible way. Is it possible to consider together the two approaches; the I/O matching solutions which have strong power of expression and AI planning approaches for the automatic generation and dynamic evolution support they provide for the process?

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Strategy-Based Service Business Development for Small and Medium Sized Enterprises

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Abstract. The result from an empirical study conducted in 3 European Countries show that the key factor, that has the largest effect on service development performance is the adoption of a service development strategy [9]. For that, the strategic advantages of comprehensive service systems were set out in this article at hand by the authors. It is explained how companies can develop and choose their strategies for service extensions by using the various types of services with or without IT support. Possible strategies include service extensions through follow-up services, IT-based and smart services, ensuring compatibility with the existing core product/service. This position paper presents a systematic strategy-based service innovation procedure based on a stage-gate concept and a company-specific toolbox of methods and management tools. The application of a field-proven process model and selected method set as a provisional result of a research project is proposed to bring the advantage of immediate commercial use, together with the targeted generation of competitive advantages and a reduction in time and money spent on service business development.

Keywords: service development, product service bundle, innovation, service strategy, service extensions, hybrid products, comprehensive service systems, product and service portfolio, service engineering, smart services, it-based services.

1 Introduction

New economy companies are facing substantial changes regarding markets, customer requirements and competitors. To lead a company successfully it is becoming increasingly important to organise strategically, to focus, improve and innovate the product- and service portfolio in order to enhance customer value and to concentrate on the companys core competences. The systematic development of new innovative services and the improvement of existing services via the complete life-cycle become extremely important for several reasons in an

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information- and service-intensive age as manufacturing declines. Thus in today's dynamic markets systematic development and improvement of services has become one of the key success factors in business. The systematic integration of service shares to product-service systems is continuously gaining importance in a service society. Services especially allow better insight into added customer value in times of increasing global competition. But to date most companies still focus on improving their physical product, neglecting the great potential of services to satisfy customer needs holistically.

2 What Are Complex Product-Service Systems?

The Service Concept, illustrated Figure 1 shows the approach to satisfying customer needs with services [7]. A service product bundle or a comprehensive

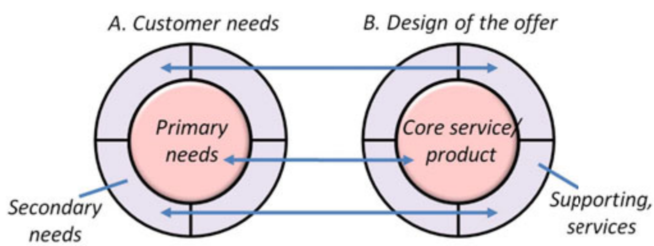

Fig. 1. The Service Concept [8]

service offer derived from this concept consists of a core product which can be physical goods or services. Physical goods are tangible, whereas classical services are intangible. Tangible physical goods and products often deliver most of the customer value of the product-service bundle. But the core product can increasingly be exchanged or substituted by the customer. Meanwhile the physical product or the service product as a core product has often become a component in an umbrella service concept. Today it is insufficient to develop a technical solution. It is also necessary to develop long term customer relationships by offering innovative services to differentiate from the competition. The pure technical solution represented by the product core of a holistic product-service bundle is often exchangeable. That is the reason why service content in the manufacturing industry, for example, is still increasing and the various offers comprise combinations of tangible and intangible elements to provide a higher and unique value of interactions with the customer along the whole life-time cycle. The core product and the core value of the whole solution can either be a physical product or a service itself, whereas services continually join the product. At the moment of purchase the service does not really exist. Therefore the customer bears the risks related to the resources, the service processes and the result of the service in distinction to physical products. In this case the result of the production is tangible and product quality can be proved easily through performance indicators [11], [12]. In general one can distinguish two different approaches when designing and integrating services to develop a comprehensive product- service bundle: *Standard services* and *IT-based or smart services*.

3 Standard Services vs. Smart Services

Traditional standard services use service efforts by adding them to the product (physical product or core service), (see Figure 2). This concept refers to the

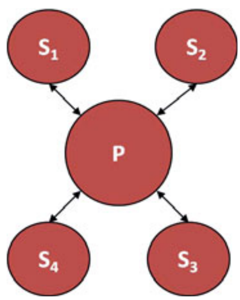

Fig. 2. Classical bundling of services around a product or service - architectural concept of standard services

customer needs along the customer contact cycle before, during and after the use of the product. In literature these kinds of services are sometimes called "Must-Be-Services" or "Value-Added-Services" [4]. One characteristic of these services is the fact that they are expected by the customer to be offered. Typical examples of standard services are listed in Figure 3. Standard services have been well described in literature in the fields of marketing and innovation management over the last decade. However, the era of **smart services** has not started yet. The main difference between standard and smart services is in the potential of smart services to enable service providers to establish closer ties with customers by identifying customer needs intelligently by using IT [2]. Smart services are embedded in the core product itself (see Figure 4). The designer of products and services has to change perspectives in order to use the potential for differentiation. Smart services offer the following service characteristics for the customer [1]:

- Diagnostics: The application enables a device to self-optimise and allows troubleshooting, monitoring and repair.
- Replenishment and commerce: The application monitors the consumption of a device and consumer behaviour.
- Status: The application reports on performance and usage of the product or the service.
- Upgrades: The application optimises the performance of a given device.

Kind of Services \ Moment of usage	Before usage	During usage	After usage
Technical service	•Technical consulting •Demounting •Project planning	•Instruction •Installation •Repairing •Maintenance	•Modification •Extension •Dismounting •Disposal
Commercial service	•comm. consulting •Order service •Testimonial	•User manual •Training •Replacement parts •Complaint Mgmt. •Incident Mgmt.	•Information about updates/new products •Discount

Fig. 3. Categorisation and examples of standard services based on moment of usage [4]

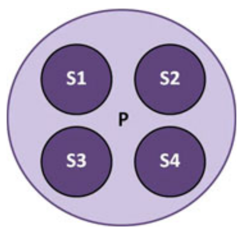

Fig. 4. Integration of smart services into the "product core" itself

– Profiling and behaviour tracking. This application monitors variations in location, culture, performance, usage and sales of the device.
– Location mapping and logistics: The service support system can be optimised with this application.

Smart services can be seen as connected components that offer at least one of the above listed add-ons [1]. The big challenge for marketing smart services lies in the visualisation of these services to the customer: The fact that smart services are often operated hidden or behind the core-service and/or product, requires visualisation in order to communicate the benefits of the smart services and to make the benefits transparent for the customer. From the perspective of the service provider the goal should be to charge for the smart service, therefore it is necessary to make the case for customer value and to visualise the benefit. In case a smart service is not directly chargeable other business opportunities are available for the smart service provider. In order to describe and to identify the whole product-service bundle of a service provider all services and activities of a business area in the customer contact circle are evaluated in a service portfolio analysis. It is important to categorise the services for the customer by specific characteristics. The main advantages of holistic service product bundles when integrating IT:

- A tighter relationship between the service provider and the customer business partner
- The chance to implement an automatic feedback system
- Reduction of quality problems
- Fulfilment of customer requirements
- Smart services assist in building closer customer relationships
- In distinction to value-added services following the core product/service IT-based services and smart services are not as easily matched by competitors

By using smart services and standard services a more complex product-service bundle can be offered to satisfy the needs and wants of a customer related to a specific problem. Due to the fact that the modern customer demands a sophisticated turn key product-service bundle and in addition to this new innovative business concepts and models can only be realised by using IT (information systems, human workflows supporting specific steps of the processes) there is also a trend to higher IT usage in classical bundling of value-added services. When

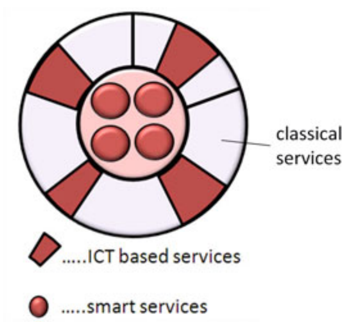

Fig. 5. Hybrid product-service bundle with integrated smart services in the core product, follow-up (classical) services and IT-based services

discussing the approach of smart services which have the potential to act agilely one must have a closer look at so called IT-based services [7]. IT-based services offered by companies cover a wide range of IT-products and IT-services between standalone services and information technologies [7]. On the left side of Figure 6 the service focused on are services supported through an IT system (e.g. a ticket machine). On the right side of Figure 6 the product (e.g. PC, server) or the service (e.g. IT consulting) itself is dominant and will be accompanied by services which assist the operation of (IT) products or services. In the middle of Figure 6 so called integrated hybrid products are classified as IT-based services (e.g. educational video via web on demand). Increasingly, companies are extending their product/service offerings by applying IT-based services systems, providing

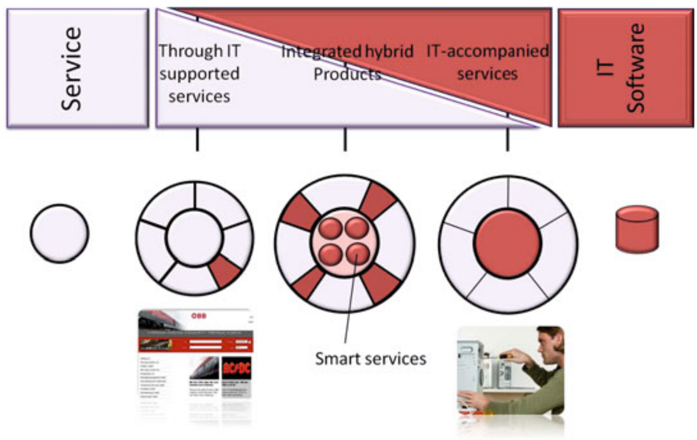

Fig. 6. IT-based services follow-up services [7]

customers with full-service contracts. IT-based services offer "sensors" that are easy to incorporate because of their inherent technological nature. Consequently one is able to implement automated or autonomous sensor systems [17]:

- automatic systems are systems that carry out fixed functions without the intervention of an operator.
- autonomous systems are systems that are adaptive, learn and can make decisions.

These sensors which are implanted into the IT-based services enable more responsive business. As a result one is able to collect data about the market and the service use. Furthermore, intelligent processing of the data leads to knowledge about the market system and offers the company the ability to act and react proactively.

4 Strategies to Develop Complex Product-Service Bundles

The key to discovering new value is to prove the alternative strategies figured out above. Many of the well-known success stories and new business models in the last years have followed these development paths of increasing customer value to create new markets. The following three-dimensional Service Development graph with origin 0 (representing the current service offering) provides a model for systematic strategic service extensions based on the three kinds of service types (Figure 7):

1. Classical or standard services (CS)
2. Smart services (Sms)
3. IT-based services (ITbS)

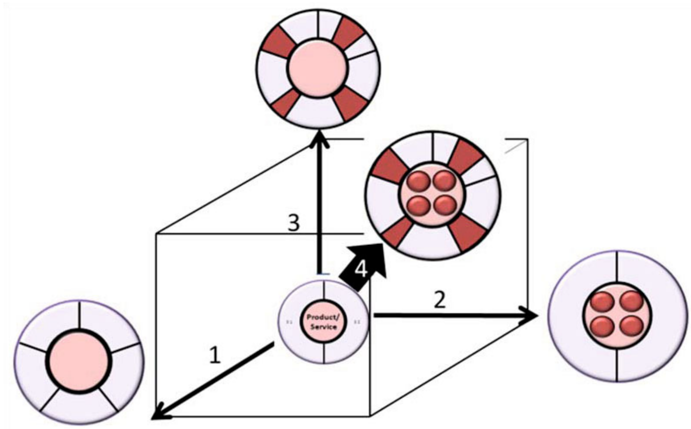

Fig. 7. The service development path taken to increase differentiation and customer value

It is essential to start with a strategic analysis of the current product-service system (origin 0 in the graph) by using specific tools like the customer contact circle to identify and map the whole current product-service offer (see also Figure 13). The service development path taken to increase differentiation and customer value is based on specific strategies. To improve the whole system (product-service or service) one has different strategic options:

Strategy 1: Adding classical (value added) services. Here there are two issues: what new added value services the service provider and company can develop and offer and which of these services in the customer contact cycle will be of value to existing or new customers and be chargeable.

Strategy 2: Integrating smart services in the core service/ product. All forms of smart services can be integrated in the product core to increase customer value and secure relationships.

Strategy 3: Integrating IT-based services into the service umbrella. It may be also a good strategy to enhance customer value by integrating IT based services in the accompanied type of service.

Strategy 4: Finally a mature product or service system is represented by combining the three strategies altogether. In this case a Co-Design or integrated development of services and IT (software) is recommended [7].

Combining these strategies can help you to expand your service business faster and more systematically based on a systematic development of new innovative services.

5 New Service Development in Europe and Austria

In 2010 an empirical study was conducted in Germany, Sweden and Switzerland of over 500 service firms. The study investigated several key factors, including service development strategies, formalised development processes, customer knowledge development and organisational aspects such as the use of cross-functional teams. The results from this empirical study show that the key factor, that has the largest effect on service development performance is the adoption of a service development strategy. In particular, the research notes that a service development strategy is the missing link in research into new service development [8]. However, while the term is used frequently in the new service development literature, surprisingly little has been written about the service development strategy itself and the important role it plays in new service development [9]. In an empirical study (started in November 2009) conducted by the UAS CAMPUS 02 and supported by the Styrian Chamber of Commerce, Styrian IT companies were interviewed about aspects in their service competence and their approach to innovate service systems. The design of the interviews is based on expert interviews. In this paper the study results from January 2010 are published (N=33), the study will continue until the end of 2011 [2]. In Figure 8 it can be observed that nearly 50% of the interviewed IT companies only have an ad-hoc development of services. This means that in fact there are no real processes described. It can be stated that about 80% of the interviewed IT companies have insufficient development processes for the efficient development of their (IT-based) services. The survey indicates the fact, that IT companies have insufficient service

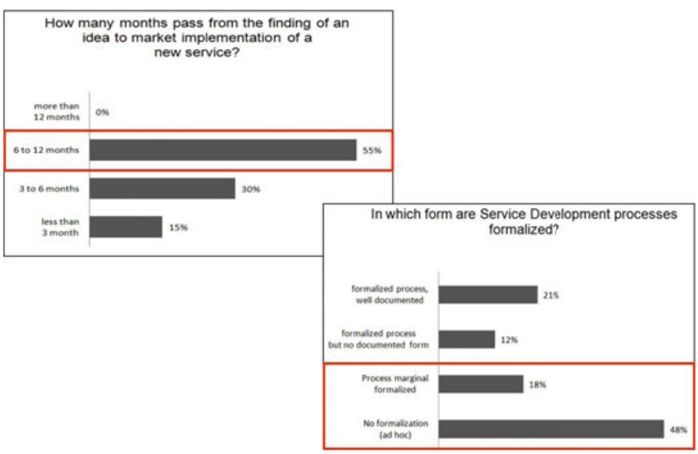

Fig. 8. Formalisation of service development

development processes to deal with the challenge in developing IT-based services (poor time-to-market levels, service design inadequate). As a development partner of Styrian companies, the main skill areas taught by the Information

Technologies and Business Informatics department at the University of Applied Sciences focus on service engineering, geared to the systematic development and design of product-supporting and/or IT-based services, so-called "smart services". The application of a field-proven process model and selected method set as a provisional result of a research project brings the advantage of immediate commercial use, together with the targeted generation of competitive advantages and a reduction in time and money spent on development. A farreaching goal of this research is also the enhancement of teaching methods and tools to develop new innovative services.

6 Systematic Development of Product-Service Bundles

The field of service research can be divided into two different mainstreams. The first is the new service development approach which is based on the focus of customer satisfaction and quality issues of services. The term is strongly linked to typical areas of marketing and was coined in the USA with the service design and service management model of Ramaswamy [16]. Torney et al. [19] presented the state of the art of service development and implementation where a framework for the classification of service development approaches is described based on three aspects: activity dimension (individual stages of the service development process), service dimension (related to the constitutive service characteristics) and aggregation layer (dependent on the aim of the service development) [19], [14]. The second mainstream is the development of a new research discipline named Service Engineering. The term service engineering is defined by Bullinger et al. as "the systematic development of predominantly technical services by deploying engineering methods, practices and by using tools of the engineering design field" [5]. The main focus of this concept is systematic development and a planned procedure in developing new innovative services. The approach can also be used to improve existing services and product service bundles.

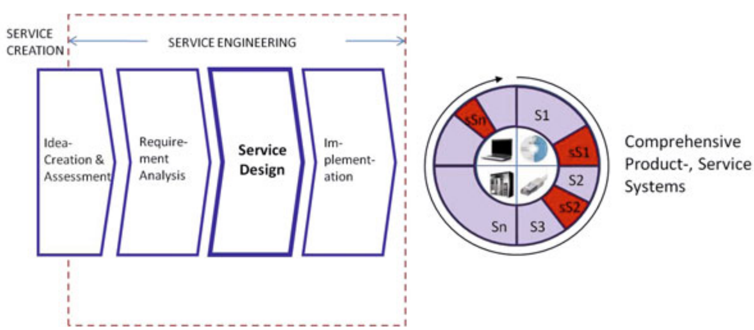

Fig. 9. Service Engineering to develop complex product service bundles

7 Five Phases to New Innovative Services

The following generic process is the outcome of a research project with pilot studies conducted with five local business partners between 2007 and 2009. The whole process follows the concept stage-gate system [13], [18]. The service innovation process is divided into a number of stages and starts with the strategic dimension:

1. Strategic analysis
2. Idea generating and idea assessment
3. Business case description
4. Service concept
5. Concept testing and test marketing
6. Service management

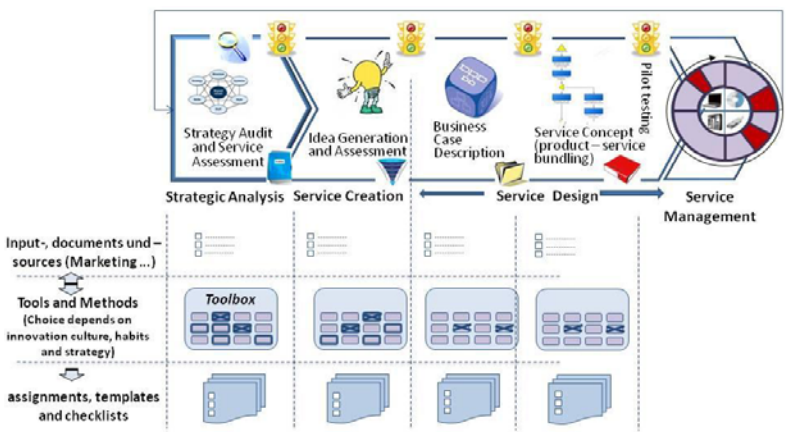

Fig. 10. Strategy-based service engineering approach with its five phases - general overview

All these stages are defined by

– specific inputs (documents and results of the step before e.g. market research, customer satisfaction survey etc.)
– a number or set of recommended methods and tools (SWOT analysis, customer contact circle, portfolio analysis, 9 Windows operator, etc.)
– and a specific outcome and deliverables (e.g. search box for targeted generating of ideas – phase 1, idea descriptions – phase 2, rough business case description – phase 3, product and service model, process model, resource model, marketing plan – phase 4 etc.)

Between each stage, there is a quality control milestone and the selected service must pass before continuing to the next stage. The work itself is done in several stages and the gates ensure that the features of the future services fit the customer requirements.

7.1 Strategic Analysis and Development

It is essential to start with a strategic view of service innovation. Thus in the first phase the current product-service system is to be analysed. This phase ends with the SWOT analysis integrating the internal and external aspects influencing the service offer. Analysing the product-service systems requires a systematic view. There are a number of different methods and tools to analyse the strategic position. It is important to configure a customised best-fitting toolbox for each company. Therefore a detailed evaluation of each of these tools is necessary to ensure the right choice of tools. Note that from the applicable methods and tools one already being used is to be selected. The great advantage is that one is familiar with the method and the skills already exist therefore it is quicker than applying a completely unknown and new method.

7.2 Service Creation - Idea Generation and Assessment

After identifying the search field for new services, the next step is to generate and evaluate ideas using a systematic approach. Brainstorming, brainwriting and other creative methods can be used in this stage. It is important that ideas should not be criticised, no matter how off-beat they are. A systematic assessment of all ideas allows concepts to be compared. Simple portfolio techniques help in selecting those ideas with the greatest potential for further research. The main question is whether the service idea really matches the organisation's goals and does the planned service fit into the current product mix? Before starting

	Strategic Objectives								
Accompanying services	Raise revenue	Customer binding	Customer aquisition	Reduce costs	raise image	develop new markets	to fend competitors	to enforce a higher price	supports market research
Logistic support		●	●	●	●	●	●	●	
Integration into the value chain		●	●	●	●	●	●	●	
Marketing support	●	●	●		●	●	●	●	
Sales support	●	●	●		●	●	●	●	
Employee training	●	●	●	●	●		●	●	●
Maintenance services	●	●	●	●	●		●	●	
Sales support	●	●	●	●	●		●	●	
Financial assistance	●	●	●		●		●	●	
Planning tools	●	●	●		●		●	●	
Promotion		●	●		●		●	●	
Trade forum	●	●	●		●		●	●	
User workshops	●	●	●		●		●	●	●
Fair support		●	●		●		●	●	●

Fig. 11. Strategic fit of services - the right service strategy for each strategic goal

this process in the first stage the current services offered have to be identified. By using the Customer Contact Circle method it is possible to chart the status quo of the service landscape while delivering new aspects and ideas for service extensions [10]. This tool can used both as an analysis method in the strategic analysis phase to map the whole service offer and as a tool for generating ideas in stage 2 of the above described service engineering process. As Figure 12 shows

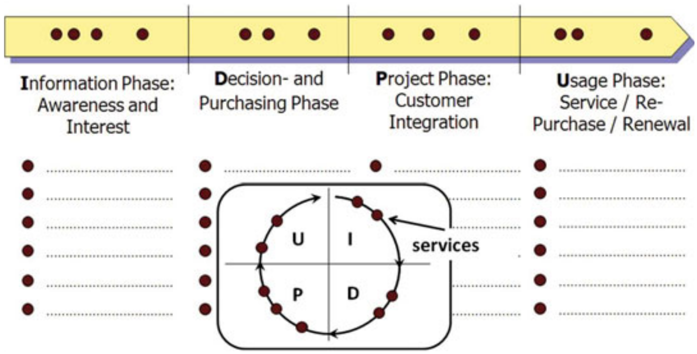

Fig. 12. Customer Contact Circle (service offer) [10]

the Customer Contact Circle can be divided roughly into four stages:

- Information stage: Awareness: When a prospective consumer is looking for solutions to satisfy specific needs. The potential customer is first exposed to your service system, e.g. when exposed to an ad or reading a review.
- Decision and purchasing stage: Now the customer is interested in purchasing your product/service. Examples include visiting the service provider or trying out the service.
- Project stage: The services are customised in consultation with the customer. The service provider or front-line employee must maintain a professional role and treat the customer with respect and dignity.
- Service/re-purchase/renewal: When a customer returns with a problem or with the intention to re-purchase/renew.

The Customer Contact Circle is a pragmatic tool to diagnose service offer bottlenecks from the information phase to the usage phase of the service [10].

7.3 Service Design – Business Case Description and Business Analysis

In both stage 1 and 2, selected business cases are worked out for innovation project decision making. The business case comprises market characteristics, competition characteristics and customer characteristics and the analysis of the potential contribution to sales, costs and profits. It is vital to look at the nature and needs of the customers and possible environmental changes. In the case of the development of IT-based services one must find out if it is technically feasible to develop a new (smart) service. Further questions one must answer are: How will the changes and innovation of the service offerings affect sales?

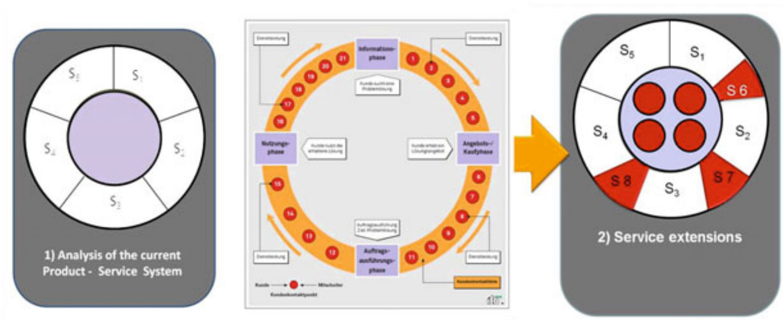

Fig. 13. Customer Contact Circle (service offer) [10]

Are the internal and external resources (development partners, software firms, etc.) adequate? Would this smart service meet real customer needs? Would ones key customer order the service? Is financing available?

7.4 Service Development in the Narrow Sense of the Term – Service Concept

This phase of actual development of the services is often undertaken in a number of parallel and sequential cycles. The aim of phase 4 is the design of the service-, resource- and process model to develop the service from the perspective of processes, resources (employees, facilities) and customer benefit (tangible and intangible result of the service process) [12].

7.5 Concept Testing and Test Marketing

In this stage the attributes that customers have identified that they want must be communicated through the design of the service. Thus one must develop a prototype service, perform a service lab test, etc. Define a sample of potential customers and prospects and present the product idea through a written or oral description to determine the attitudes and initial buying intentions. The aim is to determine the reaction of probable customers and represents also the sample launch of the marketing mix. Before offering the service in the defined target market one must modify the service or the marketing plan or drop the service. The final step (service management) includes the implementation of the service into the (product-) service system, market launch, training the employees and service provider and other activities to achieve commercial success.

8 Implementation Issues - Importance of Standardised Reference-Generic Processes

A primary component of implementing systematic service innovation is organisational development of a company. This means that the service strategy, the crucial service processes and the IT support of those processes is to be defined. But this also means that the way in which the service engineering procedure is implemented to guarantee improving existing- and innovating new services determines its success. While a systematic approach is a prerequisite for success, the company's culture is the basis for a climate to generate new ideas. Strategy-based systematic innovation by using a reference process like service engineering would not be complete without the discussion of implementation. The strategy-based life cycle outlined in this paper involves specific implementation challenges.

An important issue is the role of the management or CEO. Successful implementation will create value and add growth especially in the long run. Of course the real potential of systematic service innovations is achieved only if the management of the company has a basic understanding of the service engineering processes. There is a lot to learn about the "what" and "how" of service engineering processes and the tools and techniques used. Due to the fact that we are standing at the beginning of a systematic service innovations revolution only time will tell how many of the tools will ultimately yield new successful services for companies. But if past research projects are any guide the numbers that are successful will be high. Service Engineering is a powerful methodology, one with which all innovation managers should be familiar. By following the procedure, the innovation manager should be in a strong position to incorporate the methodology into the whole organisation and convince the management board. Figure 14 shows an approach of integrating service engineering tasks as described in this paper into the concept of the circle of strategic leadership [15].

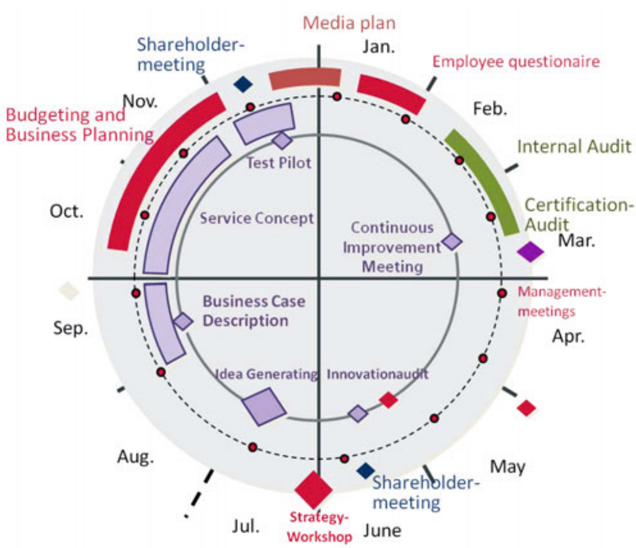

Fig. 14. Circle of strategic leadership

9 Summary and Outlook for Future Work

To continuously improve the whole offer it is vital to recognise that complex product-service systems have different strategic options and could give rise to new businesses and new business models. Companies with a formalized strategy based service innovation procedure and an open innovation culture can certainly benefit from a comprehensive and unique service offer. In general terms it can be said that a strategy based service engineering procedure:

- Reduces time from design concept to successful market launch.
- Reduces the risk of failure.
- Supports total quality from the start of service operations, and with earlier opportunities for continuous improvement.
- Simplifies after-sales service.
- Increases life-cycle profitability throughout the service system.
- It resolves the design dilemma, and helps to achieve all the strategic service goals.

The background of the discussed aspects in this position paper is an ongoing research project at the University of Applied Sciences CAMPUS 02, wherein one of the issues is focused on agile co-development of product service systems with IT integration. Agile processes need agile organisations. Another unsolved potential challenge is the question of co-design of services and software in a fluid environment [2]. However, there are many issues and open research questions in the relatively new service engineering discipline. Thus future work should focus on developing agile procedures, methods and supporting tools to combine the development of IT-based services and products for a comprehensive service offer. In addition an IT-system should support all phases of the innovation process. Indeed services and manufactured goods in product-service bundles become indistinguishable when they are jointly co-developed. The integration of and the support through IT facilitates service innovation in a new dimension. The importance of IT-based services to develop unique offerings cannot be overstated. Finally, it should be noted that in a service dominated age as IT-based services evolve and business processes change, SMEs need agile and efficient service innovation management procedures and tools.

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Designing a Dynamic Competency Framework for the Service System Innovation Architect

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Abstract. This article reports a research investigation related to an EU strategic action of enhancing lifelong learning of e-skills which has been pursued by the Luxembourgish public research centre, the CRP Henri Tudor. The operated project and the specific presented research activity demonstrate how the CRP Henri Tudor contributes to the EU skills agenda of 2007, "E-skills for the 21st century" and to the service science emerging field. During the last three years, research efforts were invested in designing a pan-European competency framework. The present research was operated in a project named DELLIISS (Designing Lifelong Learning for Innovation Information Service Science) supported by the EU Lifelong Learning Programme (LLP). Within the project a specific work package was dedicated to capture and structure requirements to qualify skills and competences in order to define the SSIA (Service System Innovation Architect) job profile. We will illustrate how a common skill card was build across 8 European countries.

Keywords: Lifelong learning, e-skills, service science, competency framework, skill card.

1 Introduction

It is commonly recognized across ICT related disciplines that European competitiveness in the knowledge based economy relies on ICT competences [2], [8]. European incentives such as E-skills strategy point out the added value of Pan-European reflections to define common frameworks and to consolidate standards regarding e-skills formalization and use. In fact the lack of EU-wide approach and the prevailing existing fragmented approaches make it difficult to compare lifelong learning policies and methods across EU member states [1]. The contemporary ICT market is described as in need of cross disciplinary competencies, combining both technical and business aspects [8]. To address this need a research program was elaborated by the CRP Henri Tudor through an Erasmus project focusing on cooperation between universities and enterprises. The project aims were to set up a dynamic operational framework as a mean to collect the necessary value added information to build a European skill card for the emerging new role of Service System Innovation Architect (SSIA) in organizations.

M. Snene, J. Ralyté, and J.-H. Morin (Eds.): IESS 2011, LNBIP 82, pp. 189–200, 2011.

1.1 EU Skill Card Structure

Designing a new Skill card corresponding to the emerging services science domain challengers implied prerequisites such as acquiring a clear understanding of the future missions and roles which would be allocated to the service system innovation architect [9]. It entailed also the capability of translating the indentified missions and roles into tangible skills. The choice of a robust skills identification process was mandatory to allow the definition of the necessary adaptation of existing lifelong leaning trajectories and the formalization of a new job profile in a scientific discipline concerned with innovation in service related industries [1]. The core objective was to reach an alignment of the requirements for the new job profile as identified by professionals in the private and public sectors.

A skill card building process, developed by the CRP Henri Tudor, was adopted to identify the lifelong learning components. The CRP Henri Tudor has an expertise in previous projects focused on ICT related job profiles evolutions evaluation[1]. The framework used to generate the service system innovation architect skills card was based on a set of iterative processes combining information capture methods such as interviews, focus groups, and information watch techniques.

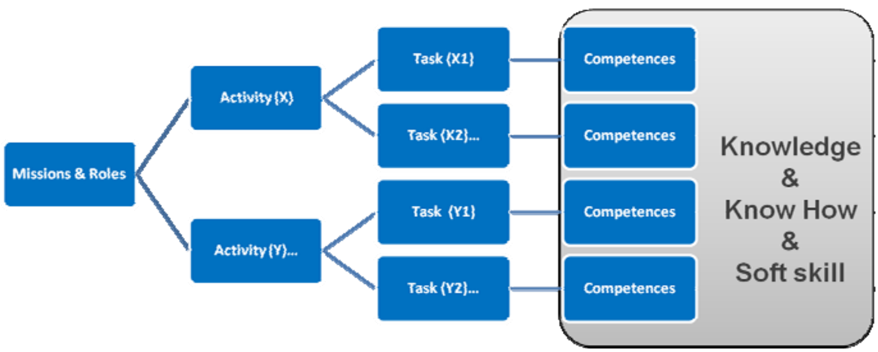

Fig. 1. EU Skill card process

The skill-card is structured according to 4 levels as illustrated in the figure Fig. 1. The first entry describes the missions that are allocated to specific professions in their daily job. This entry also represents the expected outcomes of an individual effort. The second level defines activities which are needed to complete a mission. The third level describes employed methods and techniques in the form of tasks and sub tasks needed to fulfill activities previously identified. Finally the fourth level characterizes the skills sustaining the completion of the 3 other levels, task, activities and mission. To summarize, a skill-card can be seen as a job definition tool describing the operated missions, activities, tasks or subtasks and the associated activated skills [11]. In order to define a skill card in the European context, a customization work has been proposed to elaborate a EU skill card on a distributed basis across 8 countries.

[1] http://www.abilitic.eu/

The proposed method is a systematical approach where each participating European DELLISS partner could operate information capture and matching related to the service innovation industry needs, R&D practices and educational offer. The resultant information was used as basis for the skill card definition and from which lifelong learning components could be defined. This approach based on contextual information capture was mandatory as there are no European references on lifelong learning in service innovation. The project aims were to build a single European lifelong learning program applicable by all the academic partners of the DELLIISS project. It has required an integrated approach for the lifelong learning components definition [7]. The coordinated operating mode to reach a common job profile requirements definition was sustained by the adopted skill card building method and work scope. Each participating DELLIISS partner had to carry out information search, conduct interview and focus groups to build and validate a national skill card. These national cards were the basis of the European skill card which generated the overall shared lifelong components among the project participants. In the next paragraphs, we will detail the skill card elaboration process followed by each DELLIISS partners at the national level, as well as the process used for the creation of the European skill card.

1.2 Skill Card Elaboration Process

The skill card elaboration process is operated through 10 steps engaging various information capture and analysis techniques as illustrated in figure Fig. 2.

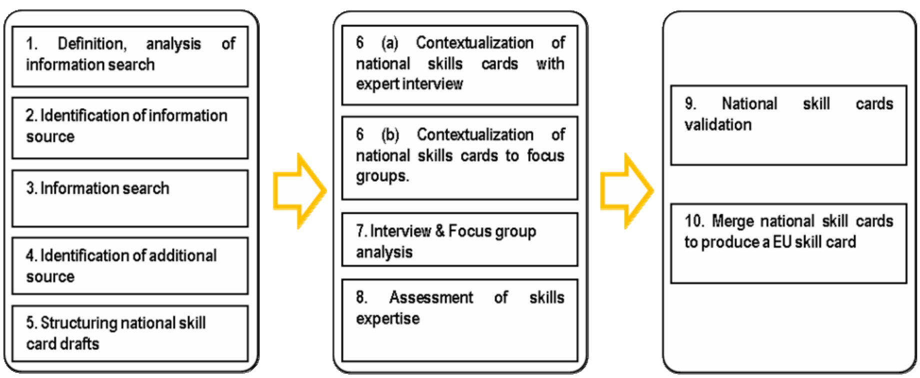

Fig. 2. Skill card elaboration process

The figure above illustrates a general overview of actions performed for skill and competences formalization. Each described topic represents a compilation of the skill card method steps regrouped in a common work scope. This illustration summarizes the operational view of the skill card method deployment in the DELLIISS project.

The use of the skill card method at a distributed European level has required a set of introductory and training sessions among project partners to ensure the skill card format standard appropriation. The operating process of the step by step method was delivered through various project meetings and structured as in figure Fig. 3. The central working topics were on the methods for eliciting and collecting requirements and methods to consolidate and structure data to produce the skill cards.

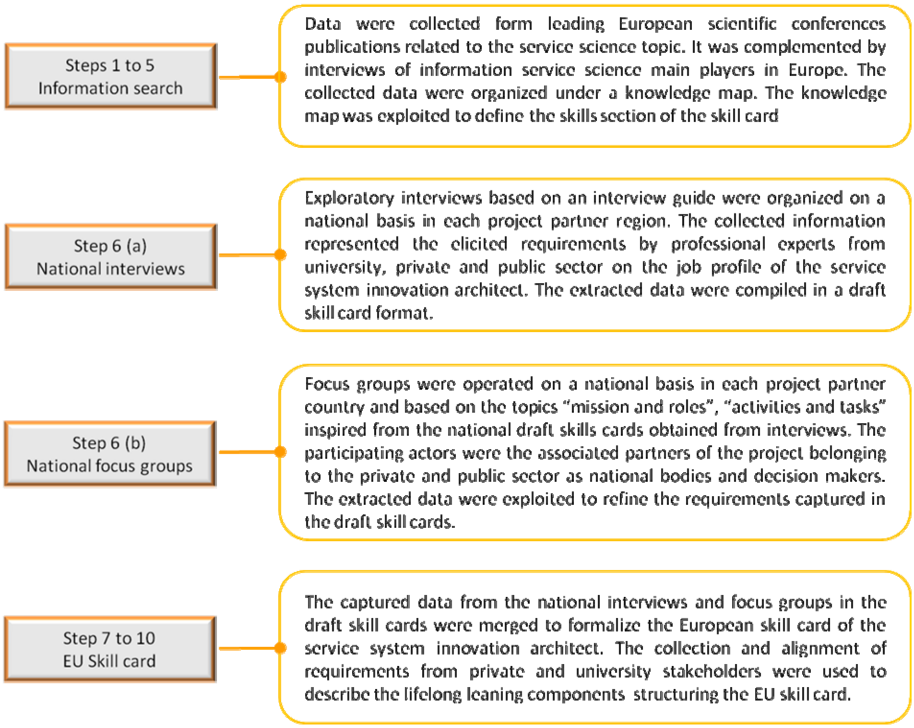

Fig. 3. Skill card step by step detailed procedure

The collection of the job profile requirements through national skill cards within each project partner country was published on a think tank web platform. This action was meant to generate discussions among professionals and interested stakeholders for capturing their feedbacks on the presented materials. The think tank web platform allowed discussions and interactions among scientific and professional stakeholders involved in the project. It was also the mean to present the carried investigations to external parties. The think tank instrument was also supported by physical events where stakeholders were invited to participate in forums, goal modeling, brain storming, classification, scenario building and action plan building regarding lifelong learning components.

2 Results from Operated Interviews

The type of participants in the interview sessions which were held in each DELLISS partner location is described in the next figures (Cf fig 4,5). In reference to the skill card elaboration process the effort which was deployed at this level was to attract interviewees so as to capture their elicited requirements on the skill card definition. The next figure illustrates the activity sector of the 47 participants who were mobilized for interviews by all project partners.

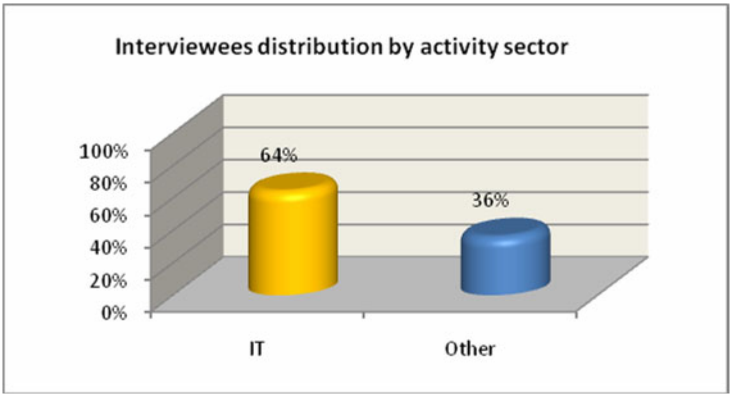

Fig. 4. Interviewees' distribution by activity sector

We can notice in figure Fig. 4 a high participation level from the IT sector; this is due to the fact that the networks of the DELLIISS partners were closely related to the ICT domain. Nevertheless we can observe that other sectors were represented. The obtained distribution seems to be aligned with the skill card theme which was oriented in innovation in information service science. The next figure provides an illustration of the organisation type in which the interviewees were operating.

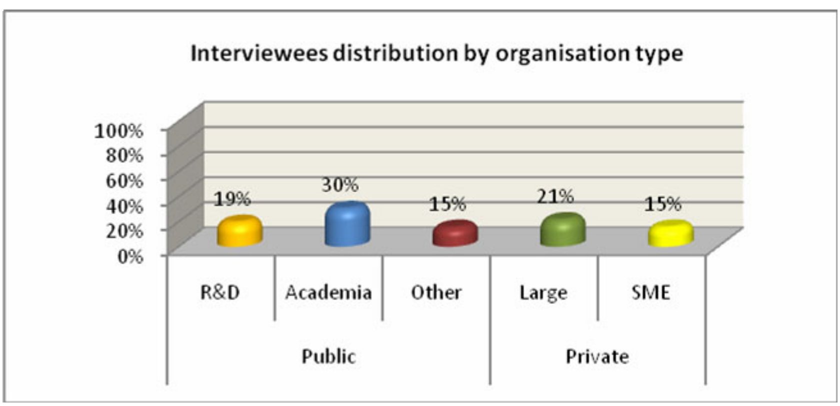

Fig. 5. Interviewees' distribution by type of organisation

As ICT practices are closely related to the activity and type of organisation to which it is applied, attention was given to respect an almost equivalent participation level of actors coming from varied organisation type. As illustrated by the figures in figure Fig. 5, we may observe a slight over representation of academic organisations.

These results reflect the difficulty to attract a varied span of participants for interviews. Nonetheless, we can notice by combining all DELLIISS partner interviewees' data that we have reached a satisfactory level of participation from both the public and private sector.

2.1 Draft Skill Card Elaborated from Interviews

Within the operated national interview sessions, the interviewees were asked to describe activities and tasks which the service system innovation architect will have to carry out in his profession. The most representative answers obtained after analysis are expressed in the following table.

Table 1. Draft skill card obtain from compilation of interviews

Activities	Tasks
Analyze/ Prospect	• Identify current situation/context/domain/model/problem • Inventory available resources and needed resources in order to answer to the problem/situation • Characterize current model, taking into account defined goals and strategy and context T (politics, human factors, laws…) • Assess commercial/technical feasibility of a service and trends/evolutions • Assess interoperability • Monitor/analyse market (national and international strategies culture, concurrence)
Design a service	• Study and model a (business) service • Define properties of a service • Align/push service with (business) strategy needs • Make commercial/marketing/communication/quality packages • Define specifications/technical requirements of a service
Build and execute/ deploy a service	• Take into account software and human resources (psycho-sociological specificities, usability…) • Train actors and involve users (with wiki…) • Deploy the service • Monitor/assess the deployment with qualitative metrics • Monitor/assess the deployment with quantitative metrics • Improve the service by managing the change
Manage a service like a project	• Plan the whole project • Manage scope, objectives, and deliverables • Build up and lead a team • Organize and chairing meetings • Monitor and evaluate quality, cost, timescales • Administer the budget
Promote innovation in and out of the company	• Organize internal trainings • Promote innovation, entrepreneurship, design-thinking, system-approach • Identify needs of customer • Propose new service customer • Organize customer events (conferences…) • Identify and use internal/external communication channels

3 Results from Operated Focus Groups

The results obtained from the interviews were used by each DELLIISS project partner to evaluate the relevancy of the EU skill card draft through organising national experts' focus groups. The aim was to expose the findings from the previous operated draft skill card and to validate the captured items. The focus group stake was to define the related competences (Knowledge/Know how and Soft skills) with the previous captured activities and tasks from interviews. The mobilisation of multi-sector participants at the focus group session was a problematic task in the sense that the external actors needed to comply with a common date. Many participants have variable schedules and were not able to assist to the various organised focus group sessions across Europe. 40 participants were nevertheless gathered within the DELLIISS project partner networks. A description of the type of participants in the organized focus group is provided in the next figures.

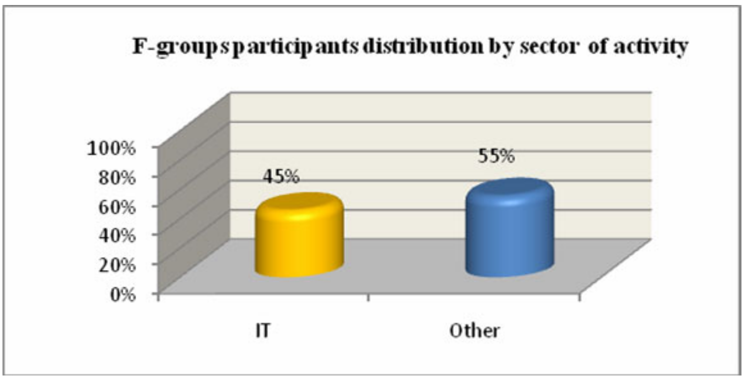

Fig. 6. Focus group participants' distribution by sector of activity

Considering the figure
Fig. 6 we observe that there was almost an equal participation of IT and other sectors focus groups participants across Europe.

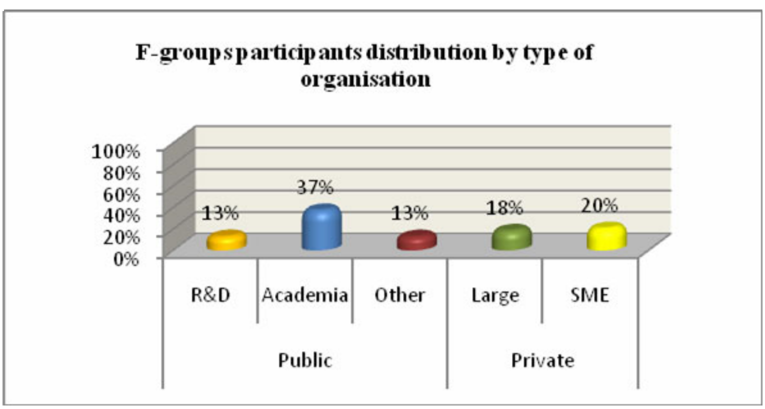

Fig. 7. Focus groups participants' distribution by type of organisation

The focus groups participants were also mostly from the public sector as showed in figure Fig. 7. We nonetheless observed a participation level of private enterprises at a rate of 38%. Those figures allow us to conclude on the existing diversity in the type of organisation considering all the 40 participants of the focus groups sessions.

3.1 National Skill Cards Validation and Merge

After confronting the drafted skill card to external actors throughout national focus groups, each DELLIISS project partner consolidated their national skill card. The results were uploaded on the DELLIISS think tank platform so as to allow discussion among project and external partners on the existing skill cards.

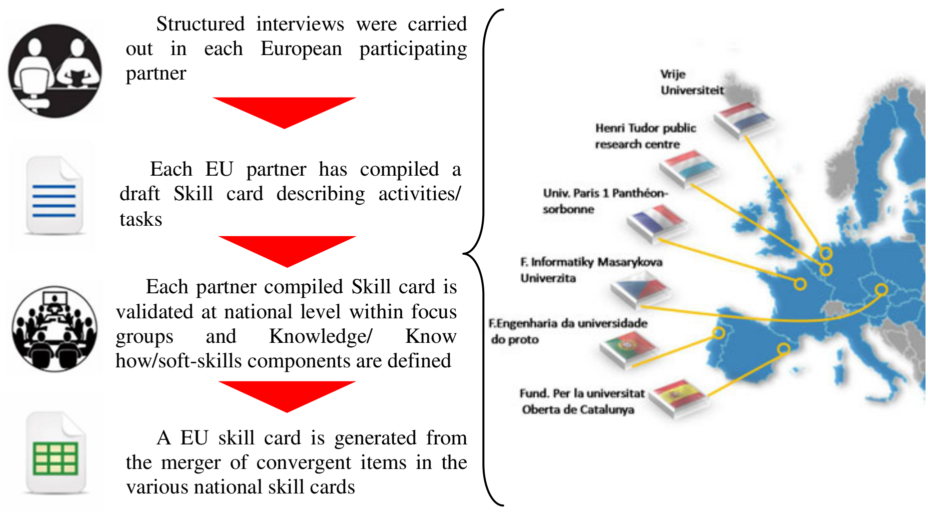

Fig. 8. Integrating data from interviews and focus groups to generate EU Skill card

The national skills cards content requirements definition was the following elements: description of Activities/Tasks and related Knowledge/Know-how/soft skills. The table 2 illustrates the variety and number of items collected in each national skill card. The empty cells are the result of invalidated data due to the fact that in some of the organised focus groups the participants did not evaluate the data captured at the interview level. This procedure allowed us to respect a coherency in the analysis of validated data from focus groups when aligning results among each national project partner. Nevertheless the reliable information was included for the general merge of the national skill cards. In fact as all elements of the national skill cards were discussed among project partners through the think tank platform, the missing data hurdle was levered by ensuring the reliability of each defined category (Activity, Tasks, Knowledge, Know-how, Soft skills) used to merge the skill cards.

Table 2. Rate of items in the national skill cards

	Activities	Tasks	Knowledge	Know-how	Soft-skills	Total
LUX	4	20	*	21	18	63
POR	6	35	145	27	*	213
SPA	7	25	*	*	*	32
CZE	6	28	62	17	33	146
FRA	7	36	36	30	32	141
NEV	4	16	*	14	10	44
Total	34	160	243	109	93	639

Applying the skill definition framework among 6 distributed national project partners was a challenge. In fact applying the skill card definition methodology requires a certain expertise to manipulate and extract comparable data so as to enable a general merge among skill cards. We have fulfilled the challenge by developing an analysis method for skill card content merge. This method is the topic of the next subsection.

3.2 National Skill Card Convergence Analysis

Producing the convergent overview of the national skill cards topics implied developing an analytical framework to collect and characterise in a unified way information collected by the participating project partners.

Each project partner uploaded their national skill card on the think tank platform. From these skills cards a comparative analysis was operated and convergent elements were retained. Different levels of convergence were observed among the considered national skill cards. In fact some items were more commonly shared within specific countries and each country had a different level of contribution on the amount of items. A standardisation process was engaged through the think tank platform and through operated meeting among partners. It allowed retaining a number of items most representing convergent skill card components related to Activities, Tasks, Knowledge, Know-how and soft skills.

Table 3. National skill cards analysis framework

National skill cards/ Contents	LUX	POR	SPA	CZE	FRA	NEV	Captured Convergent elements are merged
Converging Activities							
Related Tasks							
Related Competences							

Table 4. Composition of the EU skill card

Items	**Activities**			
	1	**2**	**3**	**4**
Task	8	7	7	2
Knowledge	12	39	28	8
Know-how	12	26	8	7
Soft skill	12	7	8	5
Total items	45	81	54	26

Four main activities were identified as being the most representative and describing the best the job profile of the information services innovation engineer. Each of the retained activities has a specific number of tasks which is almost equivalent except for the fourth activity. Considering the related competencies (Knowledge/know-how/soft skill) we observe a high level of data per activity. This heterogeneous number of competency components is due to the wideness of the treated domain and academic field to which is related an activity. The “Knowledge” components have been established upon the SFIA[2] (Skill For the Information Age) knowledge framework. The use of this framework allowed the analysis to rely on a widely shared IT skills definition reference. The know-how and soft skills components were not based on any normative reference but directly extracted from the focus groups participants elicitations. Convergence was easily found on those two last aspects as the described elements were homogeneous. We will illustrate in the next section the elaborated European skill card.

3.3 The European Skill Card Description

The retained activities for the European skill card were listed upon the importance level regarding the roles characterising the central position of the service system innovation architect in organisations.

The first activity which was identified as the most important role is the Exploration and analysis of new markets, business orientations definition and concepts across disciplines and the identification of opportunities.

The second activity is related to Service design and qualifies the role of the information services innovation engineer in aligning business and technology, building innovative service proposals and designing business cases and strategic plans.

The third retained activity is related to project management and cross domain coordination to develop and run services.

[2] `http://www.sfia.org.uk/`

The fourth and last activity relates to the promotion of innovation and of producing an integrated view of services by communicating and sharing information and knowledge in and out the organisation.

The main activities and the related tasks and competencies are illustrated in the next table.

Table 5. Service system innovation architect EU skill card

Task	Knowledge	Know-how	Soft skills
Activity 1. Periscopic activity			
Identification & analysis of market situation/ context/domain and opportunities, existing problems and technological watch	**Technical strategy and planning** -Emerging technology monitoring **Business/IS strategy and planning** -Research	Analyze and model information, interpret, reformulate, formalize Create market and technical vision	Awareness Competitor Openness Curious/Observant/ Spotter
Activity 2. Service design			
Explore Study and understand, analyse/ define properties of (business/service/ domain). Generate new business ideas	**Technical strategy and planning** - Methods & Tools - Solution architecture **Business change management** - Business analysis	Apply a service attitude Elaborate and participate to innovation awards Exploit technical knowledge (knowing the possibilities) Design strategic goals	Communication facilitator, Openness, sociable Results orientated Entrepreneurship, Visionary
Activity 3. Project Management			
Monitoring, assessment and control	**Advise & guidance** -Business risk management **Human factors** -Human factors integration	Apply a service attitude Enterprise sociology and anthropology	Communication facilitator Leadership Persuasive Rigorous
Activity 4. Promote Innovation			
Identify, plan, use internal/ external communication channels to share service vision	**Education and training** - Education and training delivery **Sales and marketing** - Marketing	Innovation enabler Create favorable environment Popularize concepts, promote offers	Convincing, Counsel Openness

A detailed service system innovation architect EU skill card is available on the DELLISS project website[3].

4 Conclusion

The undertaken research action in the DELLISS project which aimed at defining the service system innovation architect EU skill card was the first step to build lifelong leaning trajectories for a master program. The produced skill card allowed a common representation across 8 countries. We have been able to operate an EU-wide lifelong learning method across member states. This will allow to candidates coming from

[3] `http://www.delliiss.eu/skill_card`

various disciplines to design an adequate learning path corresponding to their expertise. Based on the designed EU skill card, the leaning trajectory will represent the educational paths which need to be completed to build robust competencies within the Service Science, Management and Engineering (SSME) field. An executive master will be introduced in January 2011 by the DELLIISS project partners.

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Towards an Ontological Foundation of Service Dominant Logic

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Abstract. The development of service science requires an appropriate theoretical foundation; S-D logic has been proposed as a candidate. Nevertheless, the application of the principles of S-D logic in service science suffers from inconsistencies and misunderstanding. In this paper we provide an ontological representation of S-D logic in order to clarify its key concepts and analyze their relationships. The paper contributes in the establishment of S-D logic as the foundational theory of service science, the resolution of inconsistencies and misunderstandings, the improved understanding of the concepts of S-D logic and the improved communication of experts from diverse areas in the multidisciplinary field of service science.

Keywords: service, value co-creation, service system, service science, service dominant (S-D) logic.

1 Introduction

The development of a service-based economy has stimulated a great interest in the study of service. Once a marginal research domain for the study of the 'exception' [28] (i.e. goods with some odd characteristics, such as intangibility, heterogeneity, inseparability and perishability), the study of service grew extensively in importance and "service science" was proposed [6] as a new, multidisciplinary field with the purpose of providing a deep understanding of how to innovate in services. Service science aims to integrate a variety of research areas in business, engineering, computer sciences and other related fields by focusing on service as the central phenomenon of research interest and envisages the discovery of the underlying logic of service systems and the establishment of a common language and shared research frameworks [18].

Spohrer and Maglio [19, 12] single out service systems and value co-creation as the two most fundamental concepts of service science, with the one referring to the basic entities in service-based environments and the other to the basic action that takes place in the interaction between service systems; they add that "[v]alue cocreation is the primary object of study in service systems" and they explain that "service science is the study of value-cocreation phenomena".

M. Snene, J. Ralyté, and J.-H. Morin (Eds.): IESS 2011, LNBIP 82, pp. 201–215, 2011.

However, the concepts of value, value creation and value co-creation, even though extremely significant, still remain rather unclear and vague in the literature. For example, Spohrer and Maglio [19] believe that value is necessarily co-created, as a result of interactions of multiple service systems. But does every interaction result in value co-creation? Does value co-creation happen merely because of the interaction between entities? And how could one proceed with the study, analysis and modeling of value co-creation in service systems? The vagueness and the complexity of value co-creation result in a limited understanding of value co-creation processes in general and a lack of methods for the analysis of value co-creation in service systems.

Service-Dominant (S-D) logic, a conceptual business framework that is based on an 'alternative' concept of service, has been recognized and proposed as "one of the corner stones of service science" [13] and "the philosophical foundation of service science … [providing] the right perspective, vocabulary and assumptions on which to build a theory of service systems, their configurations, and their modes of interaction" [12]. Nevertheless, Maglio, Kieliszewski and Spohrer [13] admit that service science was inconsistent in applying the principles of S-D logic ("[b]ut we are coming around"). This inconsistency was pointed out by Vargo and Akaka [26] and Vargo, Lusch and Akaka [28], who relate it to misunderstandings or misconstrues in several fundamental principles of S-D logic related to the meaning of service in general, the concept of "service as the basis of all exchanges" and the nature of value co-creation among service systems.

Why service science hasn't managed to adopt extensively and successfully the principles of S-D logic? Alter [3] suggests that service science and S-D logic attempt to explicate fundamental ideas about service, but they do it at different levels of analysis and for different purposes; S-D logic focuses on business, whereas service science aims to help IT professionals and engineers to understand, analyze, implement and improve service systems. Ferrario and Guarino [8] point out several weaknesses in current research in service science, including shortcomings in the definition of service and other key concepts and a lack of alignment between business and IT approaches. In a similar vein, Vargo, Lusch and Akaka [28] suggest that service science has an inherent engineering nature and production orientation, which tends to be focused on design specifications and operational processes. Vargo, Lusch and their colleagues are repeatedly arguing for the need of an S-D logic lexicon [22, 23, 27, 28], because many words and concepts carry specific connotations that are often incompatible with the conceptualizations of S-D logic and, consequently, can lead to misunderstandings.

The purpose of such a lexicon would be to provide the basic terms and conceptualizations of S-D logic and interpret originally their meaning. In this paper we move beyond the need for a lexicon and attempt to develop an ontological foundation of S-D logic, which not only identifies and explains the key concepts, but most importantly, analyses their relationships as well, providing this way a means for the clarification of the concepts and relationships and the deeper understanding of S-D logic. We prefer to say 'ontological foundation', rather than 'conceptual model' or 'ontology', because, on the one hand, S-D logic is basically a conceptual model in itself and, on the other hand, our work targets at a preliminary stage of ontological development, lacking the rigour of formal ontologies.

The proposed ontological foundation of S-D logic is based on concepts that derive basically from the 10 foundational premises of S-D logic [21, 23], the discussion on the need for a lexicon of S-D logic [22, 23, 26, 27] and the literature of S-D logic, in general. It is represented here as a class diagram, which is a familiar and friendly way of knowledge representation, especially for scientists and practitioners in computer science and engineering.

An ontological foundation of S-D logic can support in multiple ways the development of service science. An ontology provides a common framework of concepts and relations in order to conceptualize and describe a specific domain of interest. The most popular definitions of ontology are “formal and explicit specification of a shared conceptualization” and “classification of the existing concepts” [9]. Both these definition have significant implications for the development of service science. First of all, the development of a “shared conceptualization” is a key requirement in itself [12], because it can accommodate and support multidisciplinarity. In addition, it is necessary for the value co-creation between different service system, as it can remove the possible misunderstandings and misinterpretations. The “classification of concepts” applies to the need for the development of a lexicon for S-D logic, which was suggested by Vargo and Lusch [22] as a major challenge in the advancement of S-D logic.

The purpose of this paper is to contribute in the development of service science, the establishment of S-D logic as the foundational theory of service science, the improved understanding of the concepts of service and value co-creation and the improved communication of experts from different areas in the multidisciplinary field of service science.

The remainder of this paper is organized as follows: in section 2 we provide an overview of the state of the art with regard to approaches to service knowledge representation and service modeling. In section we 3 make a brief overview of S-D logic and analyse its key concepts. In section 4 we develop an ontological representation of S-D logic and analyse its content. The paper concludes with the results of the study and directions for future research.

2 Analysis of the State of the Art

In this section we provide a critical review of the state of the art on the conceptual analysis of service systems. We focus on approaches that take into consideration the business aspects of services and service systems, rather than approaches that stay simply with technological aspects and concerns. Note that, while there are numerous technical specifications to describe computerized services, including Web services and SOA, the research on the business aspects of service systems is rather limited. We distinguish two basic research streams in this particular part of the literature: the first one foregrounds the development of conceptual foundations of service systems; the second one aims at the business modeling of service systems.

2.1 Conceptual Approaches

Ferrario and Guarino [8] provide a general ontological foundation for service systems that emphasizes the business aspects and the social role of services. Services are considered as complex notions of commitments and activities with spatiotemporal characteristics that are related to actual circumstances and experiences. The proposed service ontology is informal and includes the concepts of service commitment, service content, service roles (i.e. service trustee, service producer and service customer), service process, service availability, service delivery, service acquisition, triggering event and (reciprocal) service value exchange.

Stanicek and Winkler [20] provide a conceptual meta-model for service systems. They use the definition of service system provided in service science [12] and enhance it with contextual and temporal aspects. Given the contextual character of services, they suggest that it is better to focus on relationships, rather than on objects. They notice three core elements in any service system: a Service Provider, a Service Consumer/Client and a Target. Hocova and Stanicek [11] propose the concepts of "prime service system", that creates benefit for the client, and "dual service system", as a collaborative service system that consists of two prime service systems and creates benefit for both systems.

Alter [2] proposed the Service Value Chain Framework (SVCF) as a business-oriented framework that introduces ideas related on service co-production. The framework is based on nine elements, four of which constitute the work system (processes and activities, participants, information, and technologies) and the rest five provide a basic understanding of the situation (products and services, customers, the organizational environment, infrastructure and strategies).

O'Sullivan [14] proposes a taxonomy of the non-functional properties ("constrains") of services under the premise that service is not simply a function, but "a function performed on customer's behalf at a cost" expressed both in monetary terms and with other types of restrictions. The categories of the non-functional properties of services include: temporal and locative availability, payment, price, obligations, rights, quality, security, trust, penalties and discounts.

2.2 Business Modeling Approaches

Poels [15] proposed the "Resource-Service-System model" for the study of service exchanges between service systems. Based on the conceptual background of REA and concepts from service science (e.g. the definition of service system) and S-D Logic (e.g. value co-creation, operant and operand resources, etc.), service is considered as a process and service systems are viewed as participating in the co-creation of value, by playing the roles of resource provider and resource integrator. The author provides additional model views referring to the reciprocal nature of service interactions, the composite (nested) structure of the service systems, the accountability of service agents and the articulation of service processes.

REA and other approaches from the business modeling literature are used as a basement by other authors, as well. Weigand et al. [29] proposed a Unified Service Ontology and a Service Layer Architecture, regarding service as a type of resource and unifying conceptually business services and software services. Andersson et al. [4] developed a Reference Ontology of Business Models which includes the concepts of Actors, Resources, Events (categorized in transfer and convert events related to production and consumption), Processes, Commitments, Contracts, Agreements, Value Activity and Value Proposition.

Serviguration [5] emphasizes the component-based structure of services: service is seen as a bundle of benefits that satisfies customer needs. It includes two perspectives, the service value perspective, referring to the customer, and the service offering perspective, referring to the provider. E3-service [7] builds on Serviguration and extends it by emphasizing on the customer perspective and on service compositions in "value constellations".

Sorathia, Van Sinderen and Pires [17] propose a process-based framework for service management; the key concept is the Service Process, which is associated to Operations, Roles, Outcomes and Work Products. Scheithauer [16] provides a reference model that classifies service descriptions and outline two meta-models for the conceptual modelling of services (the Business Service Meta-model and the Value Properties Meta-model).

2.3 Critique on the State of the Art

There is a remarkable variety in the origin of the concept of service, as well as in other basic concepts. Because of their business concern, many approaches receive input from the business management or the economics literature for the definition of service, service systems and other critical concepts (e.g. value, customer, need, etc.). Some approaches [2, 8, 15, 17, 20, 29] refer to service science and only a few [2, 15] refer to S-D logic, in particular as current research trends, but without incorporating them organically in the proposed models. Only Alter [2], Poels [15] and Stanicek [20] base their work on input from service science and/ or S-D logic.

We distinguish three main approaches in the definition of the concept of service: service as an event, service as a process and service as a resource. The example of Poels [15], who integrates elements of all these approaches, is indicative of the complexity of the service domain: he considers service as a process, defines a service system as an aggregation of resources and comments on the similarity between the concepts of economic event in REA and service in S-D Logic. The concept of the service as an event (in fact, as triggered by an event) is developed in Ferrario and Guarino [8] and adds contextual dimensions to service. Service as a process is a common approach in the literature [2, 14, 15, 17], which complies apparently with the notion of service in S-D logic; however, S-D logic considers service as a value co-creation process, rather than simply as a business or production process. Service is viewed as a resource in Weigand et al. [29] and Andersson et al. [4].

Only a few approaches make a step beyond business concerns to include the needs of the customer. Note that the inclusion of the role of the customer or of some customer-related terms (e.g. needs) is not a necessary condition to characterize an approach as customer-oriented, if otherwise the perspective still remains with business concerns and aims at business objectives. For example, Serviguration [5] provides a methodology for formalizing customer needs and service offerings in business networks and includes the perspectives of the customer, but the match making process takes for granted suppliers' offers and, hence, the purpose is to fit customer needs into suppliers' offers (demand).

Co-production and value co-creation is examined in Alter [2] and in Hocova and Stanicek [11]. Co-production is a basic assumption in SVCF [2], where the Service Responsibility Table is used for describing the activities and responsibilities of both the provider and the customer (this tool is also used by Ferrario and Guarrino [8]). The collaboration in “dual service systems”, as described in Hocova and Stanicek [11], imply value co-creation, because the “target” is the same for both service systems.

One could argue that some other works make some implicit reference to customer participation, in general, and to value co-creation. For example, the concept of reciprocity of value, included in Poels [15], Weigand et al. [29] and Andersson et al. [4], implies that the customer is also creating value; however, here emphasis is put to the value created by the customer and returned to the provider, rather than the value that is co-created with and by the customer for his own benefit. Ferrario and Guarino [5] refer to the role of the customer with the concepts of service acquisition, negotiation and invocation and service value exchange; however, such customer’s activity fits better to the G-D logic, rather than the S-D logic.

3 Overview of S-D Logic

S-D logic considers service as the process of using one’s competences and resources for the benefit of another party, distinguishes between direct and indirect (i.e. through goods) service provision, emphasizes on value creation, focuses on knowledge and skills as resources of value and recognizes the primary role of the customer in the value creation process. The spirit of S-D logic is reflected on ten foundational premises (FPs) [21, 22, 23]. One could argue that FP1 to FP5 refer roughly to the notion of service, while FP6 to FP10 refer to the notion of value and value co-creation. A brief explanation of the foundational premises of S-D logic, along with some key ideas, follows.

The core concept in S-D logic is the ‘service’ (in singular). The basic definition of service is “the application of specialized competences (knowledge and skills) through deeds, processes, and performances for the benefit of another entity or the entity itself” [21]. Hence, service includes also the various activities of the beneficiary to enhance or improve the benefit received from other entities, a process that could be described in general as ‘self-service’.

Goods (i.e. products and services) are involved indirectly in the process of service provision, as conveyors and distribution mechanisms of the competence of the providers (FP3). The process of providing service for another party in order to obtain reciprocal service (FP1) is the core of all economic exchanges (FP5), even though indirect exchanges, that is through goods and with the use of money, mask this service-based notion of exchange (FP2). In S-D logic ‘service is exchanged for service’. The primary meaning is that, when people participate in exchanges, they do not exchange in fact products or services, but their special knowledge and skills. From a certain aspect, the service that the provider takes back is the feedback of the customer (direct or indirect, through the consumption choices) and the opportunity of learning from the interaction with the customer.

Service is based on the application and use of resources. S-D logic distinguishes between operant and operand resources. The creation of value is based on operant resources (FP4), such as knowledge, skills or competencies, that act upon other resources to create value. Operand resources, on the other hand, such as natural resources, goods and money, require operant resources to provide value. The customer himself, with his intentions, knowledge and skills, is one of the most important operant resources in S-D logic.

Value is always co-created (FP6) with the collaboration between the customer and other economic and social actors (e.g. peers), who interact to provide their resources in value creation networks of different levels of aggregation. The role of the customer in the co-creation of value is fundamental and takes place by providing his resources (e.g. knowledge and skills, especially in co-production settings), integrating resources or simply providing the context for the creation of value. For this, Vargo and Lusch [23] suggest that value co-creation is a positive condition ("neither normative nor optional" [24]). Accordingly, besides business organizations, which integrate and transform micro-specialized competences into complex value propositions with market potential, customers function as resource integrators as well; all economic and social actors are resource integrators (FP9) and, thus, the producer–consumer distinction is eliminated. To make it clearer, Lusch and Vargo [22] distinguish between value co-creation and co-production, with the latter being defined as a way of value co-creation, in which the customer participates directly in the firm's production process somehow.

Firms cannot create and deliver value by themselves, but they can only make value propositions (FP7) and provide service as input to the value co-creation process; if the proposition is accepted, value is co-created in concert with the customer and in the customer's context. In other words, firms support the customers in their value creating processes. Value creation, therefore, is inherently customer oriented and relational (FP8).

Since resources, in general, do not have intrinsic value, they acquire value when they are used ('value in use'). The value is not created until the customer, as beneficiary of the service, integrates and applies the resources of the provider(s) with other propietary resources that exist in his context. Thus, value is always uniquely and phenomenological determined by the beneficiary (FP10). Accordingly, Vargo [25] uses the term 'value-in-context' to describe the value that is uniquely co-created at a given place and time and is phenomenologically determined, based on existing circumstances, resources and capabilities.

The concept of 'service ecosystem' was added in the literature recently, to describe a complex series of mutual service-providing and value-creating relationships and to capture the dynamic, self-adapting and relational nature of value creation [25]. In service-ecosystems, all actors have the dual role of providers and customers/ beneficiaries. The service ecosystem extends in effect the concept of 'business ecosystem' by adding the customer's ecosystem. Hence, in service ecosystems business firms and individuals participate to co-create value for themselves and for the others.

4 An Ontological Representation of S-D Logic

In this section we present an ontological model of the key concepts and relationships of S-D logic. The proposed model is different in several aspects from other similar efforts in the literature of service modeling. The key difference is that we do not aim to develop a new conceptual framework for service systems, service exchanges or service management, but we limit our scope to the ontological representation of S-D logic. For this reason, we stay with the concepts of S-D logic, without attempting to combine and enrich them with additional concepts from service science or business modeling frameworks. If we did it, it would introduce an implicit assumption that S-D logic does not provide the right or a complete theoretical framework for service science. On the contrary, a major problem in service science is the assimilation of the concepts of S-D logic and the resolution of misunderstandings and contradictory knowledge. Our effort aims at contributing in the resolution of this problem.

4.1 The Ontological Model

The ontological model of S-D logic involves the following concepts: Actor (as a generalization of Customer and Provider), Service (as a generalization of Direct Service and Indirect Service), Value Co-creation (as a generalization of Co-production Integration and Customisation), Value (as a generalization of Knowledge and Experience – and other concepts possibly), Resource (as a generalization of Operant Resource and Operand Resource), Context (as a generalization of Situational Context and Idiosyncratic Context). Note that in most cases the categorization of the concepts is indicative and not complete (e.g. in Value or in Value Co-creation). The ontological model of S-D logic is depicted in Fig. 1 in the form of a class diagram. A brief explanation of each concept and relationship of the model follows.

Actor. It is a general term used to address to the entities that participate in the value co-creation process. We consider that such a general and neutral term can accommodate the different roles of the participants in value co-creation processes in service ecosystems. Besides, the term 'actor' is widely used in the S-D logic literature to describe the transcendental role of the economic entities as providers and customers/ beneficiaries of service. In FP9, in particular, it is declared that "[A]ll economic and social actors are resource integrators". In this phrase, 'actor' refers to the subject, while 'resource integrators' is a characterization of their behaviour. Any other term, such as resource integrator, value configurator, value creator, etc., that may be used in the literature to describe the functions of entities focuses on some aspects of their behaviour and, hence, they are not appropriate candidates. In other words, all actors may integrate resources, but it is not the single kind of their activity (or at least the key activity) that can determine their existence. Different kinds of actors can participate in the service ecosystem, such as business firms, individuals, social groups, intermediaries, governmental agencies, etc. This categorization, not included in Figure 1 for reasons of economy of space, enriches the concept of Actor by providing information on his special attributes.

Customer and Provider. They are the two key roles played by Actors in value co-creation processes. The Provider is the Actor that provides Service for the benefit of the Customer, while the Customer is the beneficiary Actor that receives the Service provided. As value co-creator, the Customer may receive and integrate Service from many Providers and supplements them with proprietary resources. We prefer to include the Customer and the Provider as separate entities in the model, even though they reflect basically the different roles of the Actor, because it allows relating

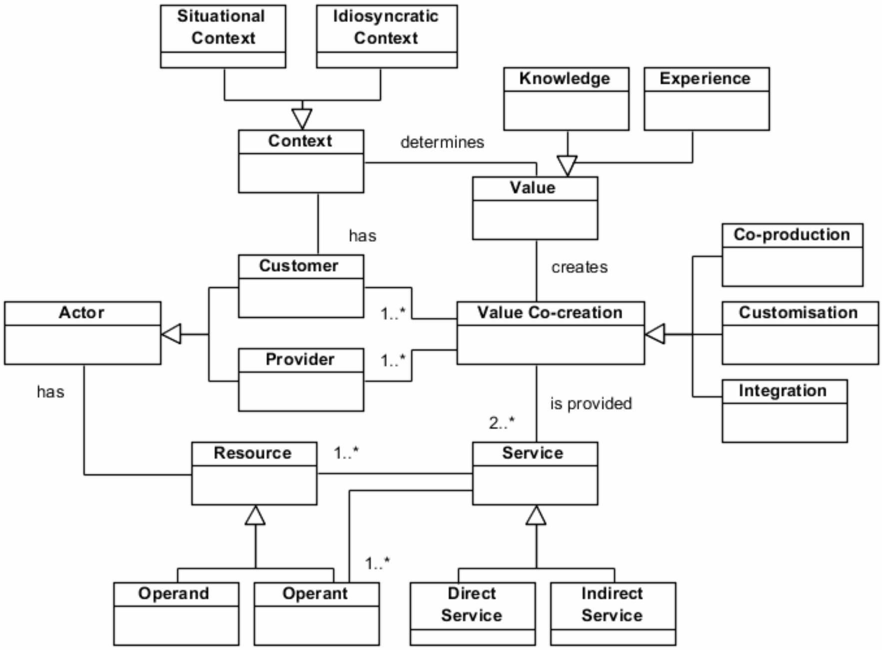

Fig. 1. An ontological model of S-D logic

specific phenomena to each particular role (e.g. in FP 10, Value is manifested in the Context of the Customer). If we eliminated this categorization, two Actors at least would participate in Value Co-Creation, which is in accordance with S-D logic.

Resource, Operant Resource and Operand Resource. Resource refers to any kind of input used by Actors in value co-creation processes, either physical/ tangible or spiritual/ intangible. In S-D logic, Resource is classified in Operant and Operand Resource; the former are those that are able to act upon others to create value (e.g. knowledge and skills), while the latter need to be acted upon (e.g. goods).

Service. It is the application of specialized competences (knowledge and skills) for the benefit of another entity or the entity itself; hence, Service is a process of applying Resources. Operant resources participate always in service processes because they have the power to transform other resources (operant and operand) to produce effect. We depict it in the model with an association named 'resourcing' between Service and Resource and an association between Service and Operant Resource. 'Recourcing' [27] refers to the activity of rendering resources into a specific benefit, which describes the way that value creation occurs.

Direct Service and Indirect Service. Service does not refer to (the physical attributes of) a process output, but it is a transcendental term for the activity of doing something for the interest or benefit of somebody else. Hence, service is a superordinate concept that includes both tangible and intangible goods ('services'). Service is what is always exchanged, either in Direct Service interactions (services) or in Indirect Service interactions, through tangible goods (products). Self-service for instance, that is the application of resources by the beneficiary entity for itself, can be considered a special kind of Direct Service (not depicted in the Figure 1).

Value Co-creation. It is a key concept in S-D logic that refers to the service-based collaboration of at least one Provider, who provides Service, and at least one Customer, who integrates and complements it with proprietary Service, for the co-creation of value. The cardinality of the association between Provider and Customer on the one hand and Value Co-creation on the other hand includes both dyadic and network relationships. The concept of the service ecosystem is accommodated here as well, as it is allowed the participation of multiple Customers, each one with his own value ecosystem.

Co-production, Customisation and Integration. Value Co-creation is a general concept that can be actualized in many different ways. Co-Production, Integration and Customization are three of the ways that are described generally in the S-D logic literature and are included in the model as subcategories of Value Co-Creation. Co-production refers to the direct participation of the Customer in the processes of the Provider. Customisation refers to the activities of the Provider to adjust the Service to the preferences of the customer, after receiving some relevant input. Integration refers to the basic function of the Customer for combining Service from different Providers, and potentially adding proprietary Service as well, for the creation of value. Additional types of Value Co-creation may exist.

Value. It is the output of the Value Co-creation process. In S-D logic, value is related to the customer (e.g. in FP10); for this, the concept of Value is related to the (Customer's) Context, with the exact content of value to be determined 'contextually and idiosyncratically' by the customer. The concept 'value-in-context' was introduced recently in the literature of S-D logic, in order to enhance the concept of 'value-in-use' with contextual dimensions. Value affects also the Provider, as a result of FP1 ("service is the fundamental basis of exchange"), namely that 'service is exchanged for service'. This premise introduces a reciprocal relationship in value co-creation, which takes the form of feedback (direct and indirect, through market success and monetary measures).

Knowledge and Experience. They are two basic kinds of Value that is co-created between the Customer and the Provider. Knowledge refers to learning opportunities and the improvement of the Resources. Experience is a basic way that the Customer perceives Value. Additional types of Value may exist.

Context, Situational Context and Idiosyncratic Context. The term 'context' is introduced in S-D logic with PF10, referring to "the context of the beneficiary". The Context refers to the general conditions that exist with regard to spatial, temporal, social and relational dimensions, as well as to the personal needs and traits of the Customer. Situational Context and Idiosyncratic Context are two types of Context; the former refers to the general environment surrounding the Customer, with its physical and social dimensions; the latter refers to the subjective situation of each Customer, with concern to his personal traits, psychological or mental situation, needs and experiences.

4.2 Discussion

The central concept in the model, that interconnects most of the key entities (i.e. Actors, Service and Value), is the Value Co-creation. It is interesting to note that, even if we exclude the concept of Service from the model, its explanatory power remains almost intact, other than cancelling the types of Service (Direct Service and Indirect Service). The Service in the model (Fig. 1) is an intermediating concept between Resource and Value Co-creation, meaning that the application of Resources, namely Service, is used for the Value Co-Creation. With the potential exclusion of Service, Value Co-creation becomes the result of the direct application of Resources from the Actors, which is compliant with S-D logic. This case is depicted in Fig. 2. Again, in the Value Co-Creation process participate at least one Customer and at least one Provider that provide their Resources, of which at least one must be Operant Resource (e.g. the knowledge or the experience of the Customer for the integration and use of Resources).

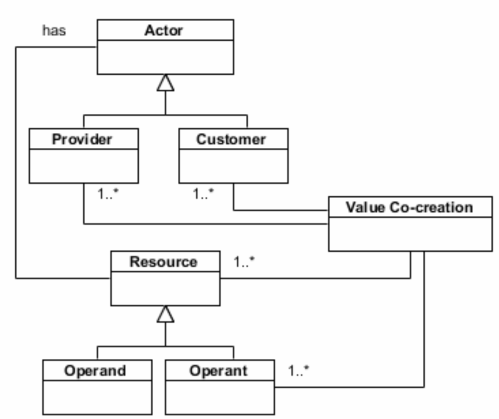

Fig. 2. An ontological model of S-D logic without the concept of Service

The point of this argument is to not to lower the importance of the notion of service, but to indicate that the key concept in service interactions is value co-creation. This argument is in accordance with service science, which regards value co-creation as the core phenomenon of service systems. Note that this argumentation does not derive theoretically, but logically, as a result of the ontological representation of S-D logic.

From a first glance, one can see that some important and much discussed notions and ideas in S-D logic are not included in the model. With regard to the foundational premises of S-D logic, the exchange (FP1 and FP2), the competitive advantage (FP4) and the value proposition (FP7) are not included. With regard to the possible entries to the lexicon, the notions of solution, dialogue, reciprocity/ interactivity, value-in-use, value-creation network and service ecosystem are mot included either. Next we provide some explanation for this.

The notion of exchange is basic in S-D logic, as service is considered as the fundamental basis of exchange (FP1) and it is assumed to be exchanged for (other) service. However, in the ontological model of S-D logic, exchange is found to be a competing concept to Value Co-creation, as they both have a similar position in the model and they cannot be both accommodated in it. For example, if we replace Value Co-creation with Exchange, the rest of the model in Fig. 1 would be the same, but its interpertation would be distorted. The exclusion of the exchange from the ontological model does not mean that exchanges as economic phenomena are not important or are not present in S-D logic, but it suggests that, from a logical point of view, the concept of exchange is implicitly included in the Value Co-creation process, with the meaning of contribution of service and resources. We think that 'contribution' also relates to reciprocity and fits better to S-D logic, especially as the concept of exchange has a strong inclination towards G-D logic (e.g. value-in-exchange) and dual relationships.

An option to include both Value Co-creation and Exchange in the model is presented in Fig.3. It is clear that here the spirit of S-D logic is distorted. In this case, Customers and Providers Exchange Service and it is this Exchange process that leads to Value Co-creation (which provides some types of Value, etc.). Another option would be to sacrifice Value Co-creation, by replacing it in Fig. 3 with Value. In this case, the meaning would be that Customers and Providers Exchange Service and through it they create Value.

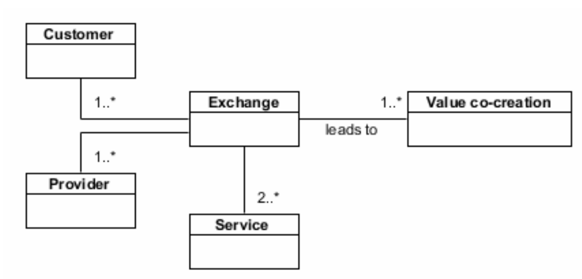

Fig. 3. An exchanged-based model of S-D logic

'Value proposition' has the meaning that the provider cannot create value for the customer by himself, but can only make a value proposition, of which the customer can take advantage in order to co-create value. The notion of value proposition cannot be accommodated in the model, because the concept of Service in Fig. 1 is related to the activities of the Customer as well (i.e. the Customer provides also his own Resource and Service in the Value Co-creation process). A sub-optimal option would be to define value proposition as an associative concept between Service and Value Co-creation – and relate it also to Value. However, we think that it would increase only the complexity of the model, without adding significantly to its explanatory power.

The notion of 'competitive advantage' is implicitly included in the model through the concept of Knowledge as a type of Value (of course, it is different from the conventional concept of competitive advantage in business strategy). Again, the ontological representation reveals that some notions of S-D logic do not fit together in an obvious and direct way and they can provoke misunderstandings. In S-D logic we have, on the one hand, value that is determined uniquely and phenomenologically by the customer and, on the other hand, value through a learning process for the provider. In Fig.1 Value is related only to the Customer through Context. Another option would be to relate Value to the Actor, in general, through Context – but it would add contextual dimensions to the value for the Provider, as well.

The notion of 'solution' is implied in the model as the result of the Value Co-creation process (i.e. when it is successfully performed, it will provide a solution for the Customer). The same interpretation holds for 'dialogue', 'reciprocity' and 'interactivity', as they are all conceptual elements related to the Value Co-Creation process. 'Value-in use' is related to 'value-in-context' [26] and it derives from the association between Value and (Customer's) Context. The notions of 'value-creation network' and 'service ecosystem' refer to the whole S-D logic model.

5 Conclusions

An ontological representation of S-D logic can provide certain benefits for the establishment of S-D logic as the foundational theory of service science. First of all, it can be used for the examination of the completeness of S-D logic from a logical point of view. In the previous section we indicated some cases that the ontological (logical) analysis can provide insights (e.g. the relative importance of Service and Value Co-creation), clarify concepts (e.g. value proposition as a business-oriented concept or competitive advantage as a learning opportunity through knowledge feedback) or single out inconsistencies (e.g. the contradictory relationship between value co-creation and exchange). It is a matter of theoretical research and argumentation to decide on the correctness and the significance of these suggestions that derive from the logical analysis. This way, the ontological analysis can support not only the interpretation of a theoretical framework, but its improvement as well. The ontological representation of S-D logic can provide a basis for transdisciplinary communication, especially with scientists and practitioners from the engineering and computing fields. In addition, it could provide the necessary vocabulary and modeling constructs for the development of information systems [10].

Directions for future research include a variety of options. A key requirement is the elaboration of the foundational ontology of S-D logic with additional concepts, relationships and rules, for example with regard to the types and respective processes of value co-creation, the types of value for the customer and the provider, the contextual parameters, etc. The development of partial views (e.g. a provider's view, a customer's view, a business intermediary view, etc.) would be another research option, which would cast light on specific aspects that are not shown in details in the overall model. The development of particular S-D logic models for specific business cases would provide detailed and practical knowledge on service interactions and value co-creation processes. Another opportunity is to relate, compare and finally merge the foundational ontology of S-D logic with concepts from the literature of service science, in order to provide a related ontology of service science. The formalisation of the ontological model of S-D logic would allow for automated reasoning in value co-creation processes; however, such a formalisation should normally take place with regard to particular business models, because automated reasoning should be based on specific and detailed information about service interactions.

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Comparison of Research Based vs. Industry Developed PSS Models

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Abstract. Product Service Systems (PSS) based competitive strategy uses deep product, process and customer knowledge to reduce the total cost of a product. It allows companies to move up the value chain and focus on delivering knowledge intensive products and services and provide highly customizable product/ service bundles. However, due to the inherent differences between products and services, many companies fail to integrate the two effectively and do not successfully exploit the financial potential of an extended service business model. This paper discusses two research based PSS models and two PSS models developed through industrial application and feedback. Similarities and differences will be explored and discussed in order to gain a further understanding of PSS design approaches.

Keywords: PSS, product, service, innovation.

1 Introduction

The defining lines between product and service are becoming increasingly blurred [1, 2]. The importance of services is increasing within manufacturing companies and trends are moving towards a more product service approach to business, where both are combined to provide high customer value. However, due to the inherent differences between the production of goods and services, many companies struggle to integrate the two effectively and do not successfully exploit the financial potential of an extended service business model [3]. Several authors claim that traditional characteristics used to distinguish from services (intangibility, heterogeneity, inseparability and perishability) are no longer sufficient and distinguishing goods is no longer a desirable objective [4, 5, 6]. Instead, attention is turning toward operations and marketing perspectives on service management which incorporate both products and services. This paper discusses two research based product/ service models (Aurich *et al.*; Sakao and Shimomura) and two models developed through industrial application and development (SD1, and SD2). Similarities and differences will be explored and discussed in order to gain a further understanding of service design approaches.

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2 Service Definition

Service development is a broad and varied subject. To facilitate discussion it is useful to examine the definition of service. Edvardsson *et al.* [7] define it as a detailed description of the customers' needs to be satisfied, and how they are to be satisfied; and what is to be done for the customer and how it is to be achieved. Grönroos [8] defines it *"as an activity or series of activities of a more or less intangible nature that normally, but not necessarily, take place in the interaction between the customer and service employees and/or physical resources or goods and/or systems of the service provider, which are provided as solutions to problems"*. Heinek [9] defines it as "*bundles of benefits*", the things that provide benefit and value to the customer. For the purpose of this discussion, in line with Heinek definition, *service is defined as intangible elements or actions which provide benefit and value to the customer.*

3 Product Service Systems (PSS)

PSS has been described as 'an innovation strategy, shifting the business focus from designing (and selling) physical products only, to designing (and selling) a system of products and services which are jointly capable of fulfilling specific client demands' [10]. It is considered a useful and attractive approach as it fits well into the criteria of strategies to achieve sustainability in relation to product, production and consumption [11]. PSS enables companies to move progressively towards a new way of interacting with its clients. PSS can be classified into three categories: Product-oriented PSS, Use-oriented PSS and Result-oriented PSS [12]. For the purpose of this study, discussion will centre on Product Orientated PSS in which the product is owned by the consumer and delivered services are attached to the product itself.

This paper will discuss four PSS reference models, two of which developed through research and two developed through industry application. The two research based models are Service Engineering Design Process Model [13] and Systemization of service design with a pre-existing product design process [14]. Sakao and Shimomura [13] proposed a design process model based on service engineering principles. Service engineering is used to increase the value of the service, and reduce the load on the environment through focusing service. It aims to intensify, improve and automate the whole framework of service creation, delivery and consumption. Aurich *et al.* [14] focus on technical services which are designed to give support during product purchasing (e.g. sales counseling and commissioning), product usage (e.g. maintenance, retrofitting and tele-service) and product disposal (e.g. take-back and disposal). These models were chosen as they represent two different approaches to product-orientated service models. Both were tested through small scale industry application. The intention of developers is to carry out further testing in industry on a larger scale. This gives an interesting overlap with the selected industry-developed models. The two industry based models cannot be presented in full due to commercial sensitivity but relevant elements will be discussed in detail. Both SD1and SD2 have high levels of expertise in service design and have applied their models in a range of industries. SD1 specializes in PSS with relatively high levels of customer co-creation.

SD2 specialized in PSS with relatively high levels of technology based services. Both companies were intensively interviewed, and the development processes mapped as the interview progressed. Recordings of the interviews were used to add additional detail to the process maps and interviewees were asked to verify that the maps correctly represented their process operations. These models were chosen as service design and development within Ireland (the country in which the research is based) is in its relative infancy. Both companies represent progressive and established service consultancy within the Irish context.

4 Comparison of the Intended Benefits of Models Reviewed

Intended benefit in this context is the planned gain for businesses through the application of the proposed models. Understanding the intended benefits of each model will help establish the rationale behind the approach to service development. The models were reviewed and commonalities identified. Based on these commonalities, the intended benefits proposed were broken down into three main groups: Financial benefit, customer benefit and ecological benefit.

All four models considered PSS as a source of financial gain. Aurich, SD1 and SD2 considered PSS as a method to differentiate their products from competitors, creating higher profit margins and opening new markets. Additionally, SD1 and SD2 note the use of potential financial gain as an important persuasion tool. They found manufacturers were reluctant to develop services as they were unsure of the approach, time, cost and potential return. As SD1 said "*I'm trying to educate business*." Emphasizing the potential monetary gain was found to be the most successful in gaining managerial support. Although noting the potential financial gain through service provision, Sakao points out that the emphasis of companies on profit is one of the largest barriers to sustainable production and consumption.

All four models studied consider the value added benefits in relation to the customer. Aurich, SD1 and SD2 view the addition of services as an opportunity to provide flexible packages for individual customer demands. SD1 and 2 emphasize the need to explicitly express the value added element in regard to the supplying company and the customer. This ensures full management support, validates the addition of a service element, adds true value through needs fulfillment and justifies cost change to the customer. Sakao notes that sustainable product service systems struggle to incorporate the needs of customers effectively, and notes that emphasis on consumer needs is required in PSS in order to be successful.

Both research developed models emphasize the ecological benefits of a PSS model. PSS can reduce environmental loads through conscious product usage and increased resource productivity. Ecological benefits are Sakao's primary concern as he attempts to move producers towards sustainable production and consumption. Although this attribute of PSS is popular in academic fields [15, 16, 17, 18], this element is not considered within the model of either SD1 or SD2. It is proposed that this element is not considered as ecological changes reduce costs, rather than generate financial revenue. In manufacture, cost reduction is typically carried out at a later stage, when a process has been established.

Additionally, Aurich considers PSS in regard to social value. He believes PSS technical support generates and secures knowledge intensive jobs and contributes to a geographically balanced work distribution. This aspect of PSS is not considered by any other reference model.

It can be rationalized that the emphasis on financial benefit with industrial based models is a result of the intended outputs of the models. The goal of the research developed models is to validate the proposed models. Alternatively, the goal of the industry developed models is to generate financial gain. The investment in both the service experts themselves and the additional costs of establishing the service within the company must be justified through value added in regard to the overall offering, or reduced cost in regard to the product. Therefore it is understandable that industry developed models have a higher financial emphasis than research based models.

5 Comparison of Context of Use

Understanding the context in which the models will be used within the company influences their application. Of the models studied, context is approached in several different ways. SD1, SD2 and Aurich aim to tailor the models closely to product development operations. As many of the manufacturing companies have no service experience, it has been found relating service development to current production practices can result in a clearer understanding of the overall service development process. Additionally, SD2 relates the proposed service to the lifecycle of the current products. This provides a foundation on which to base the frequency of service provision and demonstrates the potential profit of service over a period of time i.e. a once off sale of goods compared to a monthly service contract.

SD1 uses this context analysis as an initial phase of the development process. Utilizing Alex Osterwalder's Business Canvas [19], the landscape of the company in which the service will operate is determined. It is then used to create a visual representation of the company and its current customer offerings. Once the layout of the company has been established, it is then used to open and facilitate discussion on possible services. Placing potential services within the context of current processes aids manufacturers in understanding how service provision will operate within their own companies. SD1 uses this framework to explain how the addition of services could change and expand the company offerings.

In contrast, rather than use a non-linear format, Aurich uses a series of product design stages developed in conjunction with two manufacturing enterprises. This provides a backbone on which his models can be built. Stages are adapted to the individual requirements of the companies. When tested, adaptations were needed based on the size of the company, the different organizational structures and, in particular, the complexity of the products. Product design stages are related to technical service design stages, linking them together and creating an integrated development process.

Alternatively, rather than internal processes, Sakao considers the product/ service in relation to the interactions between all actors in its provision. This takes into account outsourcing of both manufacture and service elements. With growth in international trade markets and additional benefits of outsourcing [20, 21] it is of benefit to consider PSS in the context of a network of actors. Similarly, SD2 maps the fit of customers within the business in regard to profit margins. However, this takes place at a later stage in the process. It can be argued that in order for PSS to be successful it must be developed within the context of both the developing company itself and the network in which it operates.

6 Comparison of Service Discovery/ Identification Approach

Service discovery is the means by which the potential services are identified and final service(s) chosen to progress to the following stage. Aurich, SD1 and SD2 determine potential services through unsatisfied customer requirements. Service concepts are then created based on these requirements. SD1 and SD2 both emphasize the importance of defining the problem/ the need the service will solve. The solution of the problem must carry a value for the customer and generate sufficient financial gain to justify investment. Only service concepts with both of these elements progress onto development. At this stage SD2 also introduces the concept of new technologies as a method to enhance existing services or create new service opportunities. Sakao's model concentrates on the discovery of customer values which are then developed into a product or service. Unlike SD1, SD2 and Aurich, the service discovery occurs later in the model. Early stages are dedicated to the network in which the service providers and customers will operate. It can be argued that the method of service discovery among the companies is the same. Unsatisfied customer requirements are useless unless their solution holds a value. The value must be of sufficient significance in order for the customer to pay.

7 Comparison of Tools Used in the Models Reviewed

SD1 and Sakao use personas and scenarios in the development of PSS. Personas can be visual and anecdotal profiles. Personas benefit designers by allowing them to easily project them into diverse contexts and situations and make deductions about their prospective behavior [22]. Scenarios consist of settings, actors, objectives, and a sequence of actions and events that a persona will interact with. Personas and scenarios create clear images of target users and service flow for all team members and focus the value and requirements of the service. Personas are useful in considering the emotional needs and drivers of customers. Sakao utilizes questionnaires in order to build up information for personas.

Various methods of displaying the flow of the proposed service are used. Sakao's method breaks service creation into sub-models. These models take into account the network of agents needed to deliver the service, the range of service from the initial provider to the final receiver and the relationships between the receiver and the parameters of the function of the service. Although Sakao's main model is linear in form, these sub-models interconnect. This provides a clear structure while displaying the relationships between different aspects of service provision. Sakao has developed this approach into a software package which aids the creation of these models.

Similarly, SD1 and SD2 use blueprinting to display the flow and interactions of the proposed service. A service blueprint is essentially a flow chart that depicts every activity and step in the service-delivery process. Additionally, SD1 uses journey-mapping, depicting the stages undertaken by the customer. Blueprinting and journey-mapping can be used to identify any fail points within the service-delivery process which can significantly influence customer satisfaction. It can also be used as the basis for a service design that enables the service provider to shape the customer's emotional experience, and thus attain a competitive advantage [23].

SD1 emphasizes the importance of prototyping services. Based on the developed blueprints/ journey-maps (as discussed above) the proposed service is tested. This can be done on a minute scale with all elements quickly mocked up. For example a table in a meeting room can act as an airport check-in desk. Prototyping of services allows the service to be systemized. Systemizing highlights any problem areas and provides a clear series of steps and so eases the process of rollout on a larger scale. It also accentuates emotional elements of the service provision which may be overlooked if solely designed on paper. SD1 considers prototyping as an essential element of service design.

Similarly, Aurich emphasizes the systemization of service design as this method facilitates the integration of service design processes with existing product design processes. In order to systemize technical service design, Aurich utilizes a model which structures existing product design processes in relation to documentation and standardization of phases with coherent design activities and corresponding results. It aims to identify enterprise specific service characteristics and corresponding design activities to be implemented into the product design process.

It is clear from the above that the main aim of the tools discussed is to provide a clear understanding of the process form the service will take, that the proposed systems flow smoothly and that customer needs are being satisfied. Additionally, companies which provide services with a relatively higher level of customer co-creation use personas to determine the emotional requirements of customer. However it is interesting to note that, although SD1 and SD2 take into account pre-existing processes, only Aurich provides any tools with which to determine them. Company processes can be complex and high in number. A tool which provides an understanding of existing processes and their corresponding links to developing service processes could shorten development times.

8 Comparison of Customer Involvement in Models Reviewed

Customer or end user involvement is the level to which interested and affected parties are included or consulted in the development process. Although not always possible, SD1 encourages customer involvement in all stages of the service development process. Observation of customers using current products and services is used to determine any current problems and highlight any opportunities for improvements or new services. SD1 considers this firsthand observation essential. It finds secondary information such as questionnaires misleading due to lack of information on nuances of use and pre-existing assumptions of use within the supplying company. During the development process, customer feedback is used to tailor the service to requirements and create a smooth process flow. However, for B2B services, involvement of customers can be difficult due to IP issues. In this case, involvement is tailored to provide sufficient feedback while protecting the integrity of the proposed service.

SD2 and Aurich support limited customer involvement in the service development process in the same manner. Customers are involved in the initial stages. This is used in conjunction with market research and front line staff to determine unsatisfied needs and demands of the customer, and the readiness of the market for the new service proposal. This information is then used to specify the objectives and requirements of the proposed service. Customers are not involved in the development but are introduced for a controlled pilot run of the proposed service at later stages. This is used to determine bottlenecks and difficulties.

Alternatively, Sakao has no direct customer involvement in the service development process. Instead he uses marketing information concerning demographic and psychological information to generate personas (as discussed above). Additionally, customer surveys are used to identify parameters to determine the state of the receiver throughout the service provision. This is unusual as the interactive role of the customers in service delivery places an onus on service developers to interact with the customers during the development process of a new service [24]. This would seem especially true of a reference model which places particular emphasis on the changing state of the customer.

It can be reasoned that the level of customer interaction within the development process is dependent on the level of co-creation within the PSS provision. Aurich's model has a relatively low customer input, as does SD2's reference model. Alternatively, Sakao's and SD1's models have a higher level of customer co-creation. Therefore their input into the process carries more significance.

9 Post Launch Review

SD1 and SD2 include post launch reviews in their reference models. These can be used to establish if a project is delivering in terms of sales and revenue. Both advise companies to monitor and review usage patterns of the service. SD2 generates statistical analysis of any positive and negative affects the service is having on the business. This is then used as a basis to continue, improve or retire the service. Additionally, both companies use the data collected as a source for new service opportunities. Both note the importance of front line staff as sources of information concerning current products and services. Neither Aurich nor Sakao consider the service beyond development.

The use of post market reviews could be linked back to the financial emphasis needed by SD1 and SD2 in order to convince companies of the benefit of service provision. A review will ascertain if the service was financially beneficial. Additionally, the information gained from the review is implemented into the service development process, creating an innovation loop. This continual improvement and creation of innovative services aids in creating a competitive advantage, which drives revenue generation.

Table 1. Results of comparison of PSS models

Company	**Service Engineering Design Process Model [13]**	**Systemization of service design with a pre-existing product design process [14]**	**SD1**	**SD2**
Intended benefits	Financial gain; Customer added value; Economical; Social value	Financial gain; Customer added value; Economical;	Financial gain; Customer added value;	Financial gain; Customer added value;
Context of use	Considers current operations;	Considers all operators in the provision of the service.	Considers current operations;	Considers current operations
Service discovery/ identification			Unmet customer needs with sufficient potential financial gain	Unmet customer needs with sufficient potential financial gain; Emphasis on new/ existing technologies
Tools used in process	Flow models; Service Explorer Software	Systemization model;	Personas; Scenarios; Blueprinting; Journey mapping; Prototyping	Personas; Scenarios; Blueprinting;
Customer involvement in process		Initial stages; Pilot runs	Preferably involvement at all stages	Initial stages; Pilot runs
Post launch review			Monitor & review usage patterns; Source of innovation for new service proposals	Monitor & review usage patterns; Source of innovation for new service proposals

10 Conclusions

The importance of services is increasing within manufacturing companies and trends are moving towards a more product service approach to business, where both are combined to provide high customer value. However, many companies struggle to integrate the two effectively and do not successfully exploit the financial potential of an extended service business model. This paper discusses two research based models and two industrially based models designed to integrate product and service development processes.

All four models approached PSS systematically. The PSS models are aligned with traditional linear product development systems, which allow models to be approached through a logical step by step basis. This is an important aspect as it facilitates the application of the models. However, it is important to note that PSS models, unlike traditional product development systems which can be rigid in nature, must be adaptable to allow application to different company situations.

Research based models are less financially concerned at early stages of the development process. Alternatively, industry based models concentrate on potential financial cost and returns in early stages. This is to overcome reluctance to change due to unfamiliar processes, potential high cost of investment and potential financial risk. As research based models are validated on a smaller scale, this is of less concern. Also, it must be noted that SD1 and SD2 are viable businesses offering service development consultancy. They must convince companies of the value of service provision in addition to their own value as developers of those services. To achieve this, a greater emphasis on financial reward is required from several perspectives for industry based models. If a higher level of financial justification is required, emphasis on financial reward within the model must increase.

The greater the importance of the financial returns of a service, the greater the importance of post-market review. Post-market review ascertains if a service is financially beneficial as it is used to establish if a project is delivering in terms of sales and revenue. Additionally, post-market review creates an opportunity for continual improvement and creation of innovative services through the collection of data on current operations and emerging customer requirements.

When determining a potential service, the solution of the problem must carry a value for the customer and generate sufficient financial gain to justify investment. Unsatisfied customer requirements are useless unless their solution holds a value. Therefore, particular care must be taken in uncovering and selecting customer requirements to progress to development and supply.

The main aim of the PSS tools used in conjunction with the reference models is to provide a clear understanding of the process form the product/service will take, to ensure that the proposed systems flow smoothly and that customer needs are being satisfied. Again, as PSS is a relatively new approach, this further justifies the alignment with traditional, familiar linear product development systems.

Companies which provide services with a relatively higher level of customer co-creation use tools such as personas to determine the emotional requirements of customer. Additionally, the higher the level co-creation in the supplied product/service, the higher the level of customer interaction within the development process. This is essential if customer requirements are to be met through a smoothly operating product service system.

11 Future Work

It can be seen that the main difference between research and industry developed methodology concerns the financial elements of the process. Significantly more emphasis is placed on financial elements for industry developed models as they are used to justify the potential high cost of investment and potential financial risk. Alternatively, research based models concentrate on the process of product service generation and supply.

Further research is needed to assess the relative merits of the two approaches. Are industry led models progressive enough to increase current service revenue and create new product service systems? Are research based models significantly grounded to allow large scale industry application? Future research is required in order to answer these questions.

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Impact Analysis of Process Improvement on IT Service Quality

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Abstract. Process improvement focuses primarily on the improvement of process management and not explicitly on the improvement of the intrinsic qualities of a service or a product. Similarly to the lack of studies concerning calculations of ROI in process improvement, there is a lack of studies evaluating the impact of process improvement on the intrinsic qualities of products and/or services. The customers are more interested in the quality of the product or service and less in the speed of development or automation of processes. This paper highlights why it is necessary to investigate the impact of process improvement on IT service qualityand describes how the listed research questions will be addressed.

Keywords: Process Improvement, IT Service Management, IT Service Quality, and ImpactAnalysis.

1 Introduction

Process improvement approaches are means to develop an organization's processes to more effectively meet its business goals. Process assessments are used to find out the capability of the process to reach this goal [1]. Although an increasing number of articles about the benefits of process improvement have been published [2-5], there is still resistance against process improvement in industry. As Jones points out[6], it is not wise to start process improvement work if managers do not calculate the return on investment or collect the data to demonstrate the progress. Unfortunately, there are almost no reliable statistical studies carried out that would help companies become aware of the benefits of process improvement [7].

Our research aims to evaluate the impact of process improvement on IT service quality by conducting a series of studies in IT service industry.In this paper, we describe the research objectives, the related work, and the next steps that we will take to reach the aim of our study.

2 Related Work

Process models of ISO/IEC 15504 and CMMI, used for process assessment, have first and foremost been applied in software industry. This trend is currently changing with

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the growing need of objectively evaluating and improving processes in various fields, including IT Service Management. IT Service Management has popular descriptive models of best practices like ITIL® and ISO/IEC 20000. ITIL was combined with the measurement framework of ISO/IEC 15504 resulting in anAssessment Model for IT Service Management Processes(TIPA) that allows the IT Service Management processes to be assessed and consequently improved in an objective and continuous manner [8].

Although there have been case studies conducted in software industry about the higher capability levels of process models increasing the performance of the software companies [2, 9-12], little can be found on process improvement effects in IT service management on service quality. There is also an extensive amount of literature about the key success factors of process improvement (e.g., [13-17]),but still a lot of improvements are not yet implemented or their benefits are unclear. This study aims to evaluate the impact of process improvement extending on various works describing different approaches to measure process improvement and innovation [18-23]. The aim is attained through international surveys and multiple case studies in IT Service Management area.

3 Research Objectives

Process improvement aims to support organizational business goals and should increase organization's performance. Processes are often improved in organizations with their impact notbeing measured. In the field of IT Service Management, there are many descriptive models that suggest best practices for IT Service Management, ITIL and ISO/IEC 20000 being the most popular ones. These best practices together with a measurement framework describe an improvement roadmap. Organizations' managers want to see benefits of process improvement fast and it is therefore important that the impact of each process improvement implementation can be measured. We aim to analyze the benefits IT Service Management process improvement has on service quality and how quickly the IT service providers might receive feedback from their customers about the increased quality of their provided services.

Our hypothesis is that the model-based IT Service Management process improvement has a positive impact on the intrinsicIT service quality indicators.In order to tackle this broad question, we need to establish IT service quality measures and understand process improvement in IT service management domain. In other words, we have many sub-questions to answer: what are the IT service quality measures and indicators; how relevant is the IT service best practice guidance to IT service industry and to the quality of the IT services provided; how do managers justify investments into process improvement; what is a successful process improvement for top managers, operational managers, customers, and users; and how are process improvements measured?

4 Discussion and Future Work

Since one cannot improve what he cannot measure, we will first define the IT service quality measures that will form the basis of data gathering in industry. The IT service quality measures will be derived from ITIL V3 [24], ISO/IEC 20000[25], and SERVQUAL [26] and classified based on ISO/IEC 25010 (SQuaRE) [27] and the Practical Software and Systems Measurement framework (PSM) [28].

Since software engineering is a domain where measurement has played an important role for a long time, we will apply this insight into IT service management domain. SQuaRE is an international standard of software product quality requirements and evaluation describing four different kinds of product quality measures – process measures, internal measures, external measures,and quality in use measures.We will adapt these measures to IT services and map them to the PSM framework that is widely used in the practice of software and systems measurement.

Quality of service refers to the extent to which the service fulfills the requirements and expectations of the customer [25]. The quality attributes will be derived from ITIL, ISO/IEC 20000, and SERVQUAL. While ITIL and ISO/IEC 20000 are mostly addressing process measures, SERVQUAL targets various customer satisfaction measures.

Once we have defined the IT service quality measures, the next step will be to find out the relationship between the process measures and the other IT service quality measures. For that we will construct a survey to gather data from industry, focusing on the most critical processes that industry prioritizes for improvement like incident management, change management, problem management, and service level management[29].

The survey will have a non-probability sampling focusing on two groups of respondents: a) companies who have used the model-based approach for assessing their IT Service Management processes and b) companies who have improved their processes based on descriptive ITSM best practice model like ITIL. The non-probability sampling will differentiate the results of formal process improvement and the process improvements based on alternative process measurement approaches.

As a result of the study we will be able to see how process improvement influences the IT service quality measuresand how relevant the IT service best practice guidance is to industry.

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Profile-Based Security Assurances for Service Software*

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Abstract. In service software, it is highly desirable to have a service composition mechanism that supports automatic reasoning about the security assurances of services. Service consumers such as human, machine, even application software may have their specific security requirements for services they consume. The requirements vary from consumers to consumers. This paper outlines a framework focusing on the selection of service software consistent with the security requirements of various consumers, and compatibility checking of the assurances provided by services. We use profile-based compatibility analysis techniques to form an essential building block towards assuring security of service software.

1 Introduction

A service software is a self-contained, modular application deployed over standard computing platforms, and readily accessible by users within or across organization boundaries. cross-organizational transactions can be carried out instantaneously, and virtual organizations can be formed dynamically through automated integration of service software. There is a great desire from the business community for the Web to become an open global computing platform that would facilitate secure service software creation, integration and provision. There is an expectation that the specific security requirements of the consumer are addressed by the service software. Let me clarify this with an example.

Imagine a scenario in where a consumer would like to use a service software for reservations. How can she know that the level of security assurances provided by the selected service software would meet her specific security requirements, so that the transactions can have desired security outcomes? More specifically, Carol, a consumer, likes to book an item such as a hotel room, a car, or a flight. The normal sequence of steps in a service-based application includes: (i) Carol searches (a searching service) for her preferred reservation item, and select the item; then provides her details (another service to make the reservation); makes online payment (a service too), and finally receives a bar-coded digital receipt (a service) of reservation.

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In this journey of moving from one service to another in an integrated system environment (composed of multiple services), Carol may have different security requirements for each service she uses. For example, she wants her search parameters should not be used by any one to link with her identity –a security property called *non-linkability*. She also prefers her name, phone number, email and home address kept confidential. She does not care if her suburb and street names are disclosed provided that none could identify her or her home address with these two pieces of information (*non-deducibility*). She also likes to have a guarantee that her credit card number is kept secret (*confidentiality*), and no one should be able to alter the amount she paid (*integrity*). Carol also wants that no unauthorized entities are able to see (*privacy*) and make a copy of her receipt (*authorization*). Finally, she needs an assurance that none could observe her activities in the Internet (*non-observability*). We can see that Carol has a very specific set of security requirements for different services in this scenario. Likewise, another consumer John, may have different security requirements from Carol for the same reservation services he consumes.

How do we handle these types of diverse security requirements? To best of our knowledge, these types of different security requirements of various consumers for the same service cannot be handled with the current technologies. In this context, the challenge is: how could we design service software focusing on the end consumers specific security requirements, and provide assurances to the individual security needs more effectively?

Most service design methods emphasize on the functionality (service) and build *one-size-fits-all* security solutions around the functionality. In addition to functionality, we need a model that would provide multiple choices of security assurances of a service, and at the same time it is secure too. The model would enable service consumers to select service software based on their preferred security properties consistent with their expectations and requirements. It is essential that a service software provides assurances that could be tuned to the consumers requirements so that the design of the service is harmonious [4] with the consumers' security needs, and provides desired assurances.

2 Challenges

Most of the current practices focus on providing security-related middleware platform support and language facilities (e.g., encryption, digital signature etc.) for implementing into service software. Various security standards and mechanisms (such as WS-Security, WS-SecurityPolicy) are being used to facilitate interoperability between Web services. Although standards are important, they do not address the specific security needs at higher-level business processes. The key issue is to ensure that the composed services are in accordance with the local security policy of consumers. The current approaches take a defensive line of thinking in dealing with service integration in respect to security issues. That is, they tend to treat security as an 'after-thought' or 'add-on' in system development without considering consumers' actual needs.

A key consideration missing from the current practices is how to profile the implemented security properties of a service from a consumer's perspective, so that they could inspect the service's security properties, and be able to analyze the service security compatibility with their requirements. A fine-grain security markup of service parameters in OWL-S has been proposed in [1]. It represents the annotations about the security in a logic-based language. Another work reported in [2] also develops security ontology and matching algorithm to reason about security requirements of services. Although these are the most closest work to our framework, these lack the end-users perspectives. These papers do not provide techniques on how the security properties would be transparently expressed to end-uses, and how they could select their security choices.

No matter how sophisticated the security techniques used in service software, it presents unacceptable risk if the security properties of services that the user's system relies on are unknown, incompatible with the consumer's local security policy, or even cannot be examined by the consumer. Our work attempts to address three challenges in this research project: (i) how to make security assurances of service software transparent to consumers; (ii) how to enable consumers select their security choices; and (iii) how to check the security compatibility of the selected security for services.

3 Our Framework

We envision a security profile based compatibility checking. A service composition is the mechanism of interconnection between a service and the service consuming application or human. In service composition, we view services in a architectural layout which shows the interconnecting service software along with their security parameters reflecting the security assurances of services. We call these parameters *security profile* of the services. In this high level of abstraction, we define the profile of the services as security attributes and define some operations that perform on the profile. The examples of the operations are change the profile, selection of profile etc.

Our proposed framework focuses more on automatic analysis of security compatibility using formal analysis techniques of security properties of the services. To provide satisfactory solutions to the problems of security concerns outlined earlier, our approach has three main building blocks as shown in Fig. 1: (i) *Reflection of security assurances*; (ii) *Selection of preferred assurances*; and (iii) *Checking of security compatibility.*

3.1 Reflection of Security Assurances

As services software are usually developed for others to use, the security provisions and requirements are published together with their service descriptions. The reflection capability enables the user to understand the security properties of the service. It is necessary that the semantics of the security properties [3] are communicated to the service consumer.

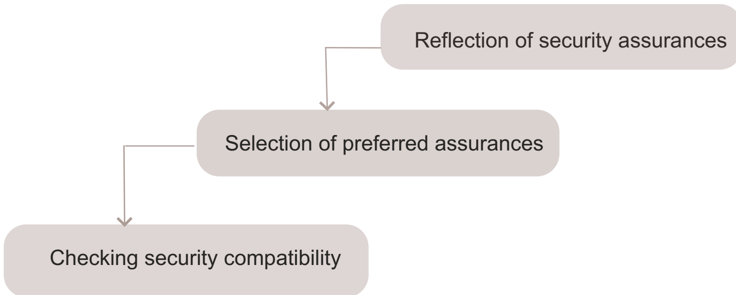

Fig. 1. Building blocks of the Profile-based Assurance Framework

3.2 Selection of Preferred Assurances

This provision enables the consumer to select their preferred security properties if the service provides a choice of security assurances. The service publishes a set of security properties supported by it. The list shows the security provisions as well as the required properties that the consumer is ensured and it needs to satisfy respectively. In our framework, the list could have choices in both categories.

3.3 Checking of Security Compatibility

At the time of composition, the security compatibility between interacting services are automatically analysed so that they satisfy each other's security requirements. This is to ensure that the selected security properties work without compromising service security provisions.

Our framework has three significant innovative aspects. The first innovative aspect is that we approach security from a (service-based) software engineering perspective, and adopt a proactive and predicative line of thinking. We emphasize on the consumer's understanding and selection capabilities of service security properties along with an ability to check security compatibility of services. The second innovative aspect is that the framework provides a semantic model that is essential to reason about the effectiveness of the selected security assurances. The formal analysis techniques for security compatibility allow us to check automatically if the services in a composition are compatible in terms of security features, leading to compatible security-aware composition. This is critical to providing assurance to system users about the systems security behavior, nurture confidence and trust in the business community about service-based system security.

4 Conclusion

For businesses to open up their applications for interaction/integration with other service software, a fundamental requirement is that there has to be sufficient choices for security provisions allowing consumers to select and verify the actual security assurances of the services. Clearly, our vision and research for service security based on profile based compatibility analysis will form an essential building block towards realising the full potential of service oriented computing. We foresee that the provision of the proposed scheme for Web service security profiling and compatibility analysis will significantly advance the state of practice in service oriented computing. At the same time, its development represents a new and highly challenging research target in the area. Our research results will be equally applicable to other distributed computing platforms such as cloud computing.

This work is of great significance to the development of future computing systems that facilitate security-aware cross-organizational business activities. The envisioned capability to integrate service software across-organizational boundaries that meets the security requirements of all parties involved represents a significant technological advance in enabling practical business-to-business (B2B) computing, leading to new business opportunities. At the same time, the approach will make significant scientific advancement in understanding the problem of application-level system security in a service oriented computing setting.

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