The Practice of Enterprise Modelling

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Proceedings of

Short and Doctoral Consortium Papers

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PoEM 2015
Short and Doctoral Consortium Papers

Proceedings

This volume of CEUR-WS Proceedings contains 9 short and 5 doctoral consortium papers presented at the 8th IFIP WG 8.1 working conference on the Practice of Enterprise Modelling (PoEM 2015). The conference was held in Valencia, Spain, November 10-12, 2015.

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PoEM 2015 Short Papers Foreword

The 8th IFIP WG 8.1 working conference on the Practice of Enterprise Modelling (PoEM 2015) was held in Valencia, Spain, from 10 to 12 November 2015. Since its foundation in 2008, the PoEM conference series aims at understanding and improving the practice of Enterprise Modelling (EM) by offering a forum for sharing experiences and knowledge between the academic community and practitioners from industry and the public sector. It has traditionally covered topics such as EM and information system development, enterprise architecture, business and IT alignment, EM and business process improvement, Enterprise modelling tools and frameworks, quality issues in EM, change management and organizational transformation underpinned by information technology approaches.

This edition, PoEM received 72 submissions covering a large variety of EM topics. All submissions were subject to peer review and were assessed by at least 3 Programme Committee members, who provided constructive recommendations for further improvement. This CEUR Proceedings volume contains the accepted 9 short papers. Full papers are available in the PoEM 2015 Proceedings, published by Springer on the volume 235 of their Lecture Notes in Business Information Processing series. The authors of these short papers represent 8 countries: Brazil, Germany, Israel, Italy, Luxembourg, Norway, Sweden and Switzerland. The papers were presented in two sessions: Reflecting on Practice and Experiences, and Approaching Enterprise Modelling from New Angles.

We owe special thanks to the authors who submitted papers, for their trust in the relevance and rigour of this conference, and to the members of the international Program Committee and additional reviewers, for promoting the conference, as well as for providing valuable reviews for the submitted papers. We are also grateful to the PoEM Steering Committee Chairs for their continuous assistance and to the local organising team at the Universitat Politècnica de València for their hospitality and the organisation of the social events of the conference. Furthermore, we appreciate how the Session Chairs and audience contributed to experience lively Short Paper sessions.

October 2015

Sergio España
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PoEM 2015 Doctoral Consortium Foreword

PoEM 2015 has organised and held a Doctoral Consortium for the first time in this series of conferences. The ambition behind was to enrich the PoEM conference with a forum intended to bring together PhD students working on foundations, methods, tools and applications of Enterprise Modelling, and provide them with the opportunity to present and discuss their research with other academics.

In particular, the goals of the Doctoral Consortium were to provide fruitful feedback and advice to the selected PhD students on their research studies, to meet senior academics doing research on topics related to the Enterprise Modelling discipline, as well as to interact with other PhD students and stimulate exchange of ideas and suggestions among participants.

The PoEM 2015 Doctoral Consortium received 8 submissions from Belgium, Canada, France, Germany, Italy, Sweden, Tunisia and United Kingdom, 5 of which were accepted. Each paper was reviewed by two members of the Program Committee, and also assessed by the Doctoral Consortium Chairs.

The Doctoral Consortium included a tutorial by Prof. Paul Johannesson from Stockholm University, “Design Science - a Ritual for Legitimating Weak Research or a Tool for Making Research Relevant?” In addition the five accepted papers were presented and discussed.

We would like to express our gratitude to the mentors of the Doctoral Consortium, as well as to the members of the Program Committee for their efforts in providing very thorough evaluations of the submitted doctoral papers. We also wish to thank all PhD students who submitted papers for having shared their work with us. We owe special thanks to the Programme Chairs and the Local Organisation Committee of PoEM 2015 for their support.

October 2015

Pnina Soffer
Jelena Zdravkovic

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Participative Design of a Security Risk Reference Model: an Experience in the Healthcare Sector

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Abstract. In this paper, we propose a participative method to design a security risk reference model, composed of a domain model and a security risk model. We relate the application of the method to our attempt for a design of a national reference model of the medical laboratories in Luxembourg, for which we ran five participative workshops with domain experts to gather their knowledge. We validated the designed models with both the participating experts and non-participating experts. The design method and the structure of the participative workshops are described and results obtained are discussed.

Keywords: Participative Sector-specific Modelling, Enterprise Model, IS Security Risk Management, Healthcare Sector, Medical Laboratories

1 Introduction

The healthcare sector is undergoing profound changes that are triggered by diverse and opposite drivers [1]: a demographic shift leading to an increase in chronic diseases and a need for continuity of care, associated with increased patient expectations in terms of healthy living and quality of life; increasing costs of medication and medical devices generated by the pace of technological innovation (smart living, genetics, nano-medical universe) associated with an economic pressure to reduce social security spending. Healthcare providers have to cope with these challenges by leveraging multiple system integration solutions: the development of new collaborations (business process integration, organizations' merger, etc.); the sharing of medical and IT resources (technical integration); the development of electronic health records system (data integration). These integration points require information flowing beyond the classical healthcare organizations boundaries [2] and lead to increased risks in information security.

In order to address these increased information security risks, we propose sector-specific risk analysis approaches relying on a security risk model and a domain model of the sector [3]. This paper describes the approach we have developed to acquire and

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structure the knowledge of a sector in a participative way. It then gives insights on the experimentation of the method with medical laboratories.

1.1 Cooperative approach to improve enterprise model quality

According to Barijs [4], the quality of both the modelling process and modelling product is linked to collaboration, participation and interaction: completeness and accuracy of the enterprise model, as well as speed and efficiency of the modelling effort are positively impacted by (1) the collaboration of modellers, analysts and domain experts; (2) the participation of domain experts and employees to acquire shared knowledge; and (3) interactions' ease to capture the complexity of the system under observation. The integration of domain experts in the modelling activity can be envisaged from two perspectives [5]: first in the participatory approach to modelling, stakeholders meet in modelling sessions, led by a facilitator, to create models collaboratively; or in consultative participation, where an analyst creates the model and the domain experts are consulted to validate the outcomes.

Our approach is inspired by participatory modelling and has been built incrementally, along a path of experiments. In previous research [6], we experimented on participative knowledge gathering in the telecommunication sector. The interest of the domain experts' involvement was validated, however our approach was not structured enough to be easily repeated and continuously improved. In our healthcare case, we have structured a participative modelling method, inspired by existing approaches, and validated it in the design of a reference model for information security risks.

2 A participative modelling method

The sectorial demand in Luxembourg is important for the creation of national ISSRM models (professionals of the financial sector, telecommunications, e-archiving, and now, health sector). That is why we need to define a structured process to gather the essential information needed for the creation of national reference models, and also to make this method transferable to the market at a later moment. Our objective is to define a reproducible participative design method that satisfies participants in terms of collaboration, information sharing and results, and involving business experts of the addressed sector. Furthermore, the method should sufficiently support the modelling experts by gathering the right information at the right time.

2.1 Method description

The method we have developed combines activities from facilitated group modelling and consultative participation: (1) the domain experts participate in the knowledge acquisition; they however do not directly manipulate the model; (2) a facilitator leads the modelling session with techniques borrowed from the creativity domain; (3) the modelling experts participate in the modelling sessions, but also formalise the knowledge offline; (4) the domain experts are consulted to ensure that the shared knowledge is reflected in the final model.

The method is composed of a set of performed functions: (a) Domain Knowledge Acquaintance is performed by the Modelling Experts; (b) Co-Modelling Workshop Organisation is performed by the Modelling Facilitator, with the support of the Modelling Experts; (c) Knowledge Acquisition and Sharing are performed by all roles in participative workshops; (d) Sectorial Model Consolidation is performed by the Modelling Experts; (e) Sectorial Model Validation is performed by Domain Experts, with the support of the Modelling Experts.

The process is run iteratively and the reference model is built incrementally: each iteration focuses on a specific aspect of the model (environment of the system, processes and activities, technical architecture and infrastructure, security threats and vulnerabilities, information security risks) and is the object of a specific three hour workshop with all participants.

From an organisation perspective, the modelling experts' team is made up of four persons, two experts in Enterprise Modelling and ArchiMate [7], and two experts in ISSRM. We doubled the roles of modelers to ensure a completeness of the models: two persons capture more information than just one, and negotiation between them is a first step of validation. They all have previous experience in collaborative modelling. The facilitator is an expert in creativity techniques and focus group animation. None of the team members had any particular knowledge of healthcare.

2.2 Validating the method in a medical laboratories' ecosystem

We experimented with our participative modelling method in the context of the medical laboratories. The participative workshops were designed on the basis of the information we wished to collect to build the domain and security risk models. Five participative workshops were necessary.

Two private medical laboratories and one hospital laboratory composed the sectorial committee. One to three representatives of each actor attended the workshops. Different profiles were identified and required in order to smoothly run the workshops: biologists, software engineers and business intelligence experts.

During the Domain Knowledge Acquaintance, the modelling experts gathered some preliminary information on the sector: they identified industry standards and the legal framework relevant for the medical laboratory activities: ISO 15189 [8] and the Luxembourg National Public Health Code [9], as well as ISO 27799 [10] and the Guide to Information Security for the Health Care Sector [11] were analysed. During the Co-Modelling Workshops Organisation, the modelling experts and the facilitator planned the workshops according to the structure of the models that were to be designed. After each participative workshop, the modelling experts consolidated the knowledge (Sectorial Model Consolidation) in specific modelling language (ArchiMate models for the domain model and risk catalogues for the risk model). These models were validated with the domain experts (Sectorial Model Validation), to ensure that they actually reflect the outcomes of the participative modelling effort.

3 Participative workshops

The participative workshops and their associated results are presented below.

3.1 Workshops description

WS0: Objectives and approach. In the first meeting with the sectorial committee, we presented the detailed objectives of the project and the participative approach. We also took benefit of this first session to collect both the suggestions and potential objections. Some participants were particularly worried about exchanging potential confidential information with their competitors. We proposed a Non-Disclosure Agreement, and offered them the possibility to exchange sensitive information offline in private meetings or per email.

WS1: Identify the environment of medical laboratories. The objective of the first participative workshop was to draw a high-level view of the ecosystem: identify the types of medical laboratories; identify and classify the services; and identify the involved actors.

We identified the types of laboratories through a short brainstorming session and compared the outcomes with the literature. We only identified differences in naming.

To identify common delivered services we first proposed an interactive approach, but participants were still reluctant to "physically" participate. We continued with successive brainstorming and open discussions to identify the common delivered services, their categorization and the involved actors. The correlation between types of laboratory and the services was performed through an open discussion. We quickly observed a common approach between medical laboratories.

WS2: Business layer. During this workshop, the objectives were the validation of the first domain model built, and the description of processes and activities.

We presented the ArchiMate model built from WS1 and validated it with the participants.

Following this, the processes identified in the literature and the inputs gathered in the first workshop were presented to participants. For each process, we asked participants to detail the performed activities, as well as the entry and exit conditions (see Table 1-a). Each activity was then specified along the following dimensions: *who* (actors), *what* (objects and information manipulated), *where* (site) and *how* (systems used to perform the activity), see Table 1-b. We interactively built a matrix of the activities: the matrix was displayed on the wall, and we positioned sticky notes to model the multiple aspects of each activity. The colour of the sticky notes was associated with one of the specific dimensions. We prepared sticky notes in advance as an outcome of our Domain Knowledge Acquaintance activity; we were also adding new sticky notes on demand, based on the input of the participants.

Table 1. (a) Matrix displayed to support discussion on process definition. (b) Matrix displayed to support exchanges on the activities definition. Different colours were used for each concept. This is only an illustration of possible results.

Steps (a)	Step 1	Step 2	Step 3
Begin			
End			
Activitie s			

Functions	Step 1		Step 2		Step 3		Support functions	
(b)	Activity1	…	Activity i	…	Activity n	…	Activity x	…
Who								
What								
Where								
How								

WS3: Infrastructure layer. The third participative meeting was dedicated to the identification of the generic infrastructure.

First, we started with the usual validation of the consolidated domain model integrating the outcomes of the WS2. Participants proposed minor changes. We then switched to the modelling of the generic infrastructure supporting the business activities. For each activity, the participants detailed the involved supporting assets (hardware, software, network, people, facility and system). As they were quite reactive to the matrix presentation, we continued with a matrix displayed on a wall (see Table 2). Literature review and previous session allowed us to prepare a list of potential items of each category on sticky notes.

Table 2. Matrix displayed to support exchanges on the generic infrastructure definition. Different colours were used for each concept. This is only an illustration of possible results.

Functions		Step 1		Step 2		Step 3		Support	
		Activity1	…	Activity i	…	Activity n	…	Activity x	…
Supporting assets	Devices								
	Software								
	Networks								
	People								
	Facilities								
	Systems								

WS4: Generic infrastructure finalisation and security risk awareness. In this workshop we finalized the generic infrastructure and gave some introductory information security risk training to the participants. This was required to ensure a shared view on the concepts of information security risk, as the participants were not experts in this area.

The proposed scales (risks, threats, vulnerabilities and impacts) were presented and discussed. Only the impact scale required adaptation to the specific context, and we scoped the adaptation in the WS5. We observed a disengagement of some participants during this phase: the session was a lot less interactive than the others, and we were requesting participants to acquire a large set of new knowledge.

To finish in a participatory manner, a brainstorming allowed listing the generic threats identified by participants in their specific domain. After a check, we observed that the threats listed by participants are quite the same as the generic threats listed in literature.

WS5: Generic security threats and vulnerabilities. The last workshop was dedicated to the identification of threats and vulnerabilities, and the definition of the scales used in our information security risk model.

We asked the participants to state if the threats (identified in WS4) may concern the previous listed activities, and to identify generic vulnerabilities that can be exploited by these threats (see Table 3). We did this exercise by group of activities to avoid a too huge cognitive load. In this step it is important to remember the supporting assets: it helps to identify the vulnerabilities.

Finally, the propositions for risk, threat and vulnerability scales were quickly presented and validated. The impact scale required more attention. For each component of the impact (Availability, Integrity, Confidentiality and Non-repudiation) participants defined the extreme values, then the intermediate values, and finally, reformulated the definition of each value.

Table 3. Matrix displayed to support exchanges on threats and vulnerabilities elicitation.

Functions		Step 1		Step 2		Step 3		Support	
		Activity1	..	Activity i	..	Activity n	..	Activity x	…
Supporting assets	Devices	*Defined*		*Defined*		*Defined*		*Defined*	
	Software	*previously*		*previously*		*previously*		*previously*	
	Networks	*Defined*		*Defined*		*Defined*		*Defined*	
	People	*previously*		*previously*		*previously*		*previously*	
	Sites	*Defined*		*Defined*		*Defined*		*Defined*	
	Systems	*previously*		*previously*		*previously*		*previously*	
Threats	Threat 1			Vulnerability1 Vulnerability 2				Vulnerability 3	
	Threat 2	Vulnerability 4				Vulnerability 5			
	…								
	Threat n			Vulnerability 6		Vulnerability 7			

3.2 Model consolidation and continuous improvement

Between each workshop, the modellers worked on the modification of the different models to integrate the inputs of participants. In particular, between WS2 and WS3, the collected data was aligned to the literature findings on standard models in the healthcare sector. Between WS4 and WS5, the non-repudiation criterion was added to the basic impact scale at the request of domain experts, and the listed threats were compared to the generic threats from literature.

3.3 Results

Domain Model. The Domain Model has been built during the workshop sessions by addressing the multiple views on the system: (operating and support) functions and activities, localisation, roles, information, IT application and infrastructure.

Information System Security Risk Management (ISSRM) Model. The ISSRM model for healthcare has been built based on a generic ISSRM domain model [12] in which sector-specific generic concepts (i.e. assets, threats, vulnerabilities, security requirements, etc.) have been specialized and specified based on the initial review of the literature as well as based on the workshops results.

4 Validation

The main objective of the proposed method is to improve the way the information is collected from domain experts, i.e. the modelling process. The product of the process (the model) has also been validated: (1) A first internal check was done by modelling experts with regard to the national regulation and ISO standards. Then, each part of the produced models was validated by domain experts during specific steps of the participative workshops. (2) After the WS5 we validated the ISSRM model with external ISSRM experts. (3) As we identified several minimal differences between hospital and private medical laboratories, we plan to meet medical laboratory representatives from other hospitals and present the model to check the differences. If other differences appear, we will discuss the necessity to split the domain model into two specific sub-domain models. (4) The domain model will be presented to the specific instance regulating the healthcare sector for validation. (5) Finally, the use of the generic ISSRM model during risk analyses that will be done by laboratories in the future will enable to verify the completeness of the model.

4.1 Satisfaction of participants

In previous works, we had validated the value of a participative approach in the design of sector-specific ISSRM model. In order to improve the approach, we structured the activities in a method and experimented it in the medical laboratories' sector. We distributed a questionnaire to business experts at the end of the participative phase, to measure how they perceived the participatory aspect of the method, with a pair Likert scale from 1 (Not satisfied at all) to 4 (Very satisfied). We asked them how they perceived the consideration of their comments (M=4 SD=0.52), the diversity of exchanged points of views (M=4, SD=0.52), the possibility to express themselves (M=4, SD=0) and the listening and exchange between participants

(M=3.5, SD=0.55), see Fig. 1. With regard to these results, we checked the interactivity of the participative sessions. Furthermore, we achieved our goal of designing reference models: the modelling experts gathered the necessary information to build and check them with participants. We also identified room for further improvements; some of them will be implemented before running our next experiment, while others require additional research and development.

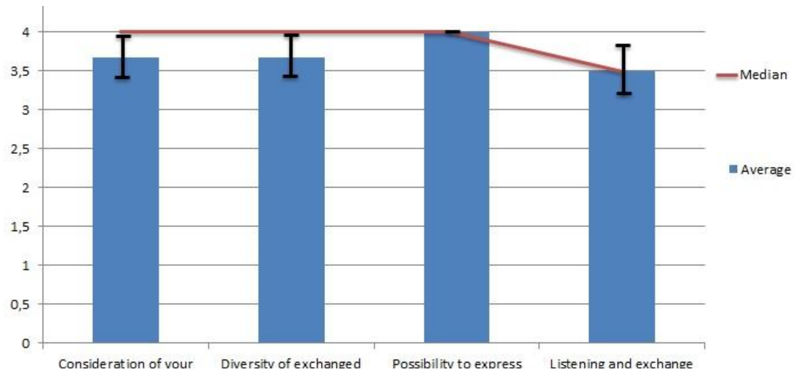

Fig. 1 Satisfaction of business experts on the participative aspect of the method

4.2 Advantages in modelling

The proposed method brings valuable improvements compared to our previous experience in the telecommunication sector, not only in terms of the experts' participation, but also in terms of produced artefacts. We actually structured the domain model in a (semi)formal modelling language: the collaboratively designed domain model represents the agreed common knowledge of the domain experts, and is a very useful input to drive the design of the associated ISSRM reference model.

The involvement of multiple medical laboratories' representatives in participative workshops enables to reduce the time needed to acquire knowledge from all of them. It also easily leads to consensus during the discussion itself, therefore also reduces time in negotiation: the composition of the domain experts' committee allowed us reviewing three visions and reaching consensus. This enabled to complete the information of each other directly and to negotiate on finding the more generic point of view when different possibilities were enumerated.

The quality of information provided by the participants permits us to quickly reach a high level of quality in the produced models, for both the domain and the information security risks sides. The model quality is checked by the fact that all experts in the domain understand it, and that it is useful for its purpose: the models are actually currently being exploited to support information security risk analysis.

Although we have given them the opportunity to adopt private sessions to protect confidential information, none of the involved laboratories have asked to share information offline, without their competitors. We can assume that the active participation of each laboratory created enough trust in the process, and also that we managed to adopt the right level of details in the design of the model.

The co-modelling workshops organisation activity also helped to share the same language between the modelling experts themselves and the modelling facilitator. This step facilitated the consolidation of the different models.

It may be noted that laboratories' representatives participated well and were involved throughout the workshops. That is a key factor of success for this method of participative modelling.

4.3 Issues in modelling

The quality of the model depends both on the modelling process and on the available knowledge. It was important to have representatives of each kind of laboratory in Luxembourg, i.e. private and public (hospital) laboratories were represented. Although the organization of their activities might differ a lot, they were able to build a common view on both the domain and the risks. This type of approach depends of the skills of participants, their openness and willingness, even though this can be improved by animations techniques. As a matter of fact, some participants prefer certain animations techniques over others; this required certain agility in the use of participative method and particularly of the proposed design method.

Our modelling approach covers the traceability aspect: what is the source of information of which of the model's elements. This is very useful when dealing with the evolution of the sources, such as a legal framework. It is relatively straightforward to implement when we face (semi-)structured information, such as reports, standards, or laws. However when dealing with participative discussion, it brings a new challenge in terms of information traceability.

5 Conclusions and future work

To build a national reference domain and an ISSRM model of the Luxembourg healthcare sector, we began to model the medical laboratories' activities. This step was realised thanks to five participative workshops involving representative domain experts (bio-analysts, IT and business intelligence profiles) from two of the three national private medical laboratories and one hospital laboratory. The participative workshops focused on several aspects of the system: processes, activities, IT infrastructure and information security risks of the laboratories. We observed a large part of commonality in these aspects among the participating laboratories, enabling us to quickly produce a complete generic domain model and an ISSRM model. These models are still under validation for some aspects, but, with regard to first checks, seem relatively complete and coherent.

The proposed participative method to collect, model and validate the information with domain experts was very useful. Based on this observation, the method will be reproduced soon with the Emergencies services and Radiology laboratories in order to incrementally design a reference national healthcare model. This will give us the opportunity to check the replicability of the method.

Some improvements have already been identified, notably to better support the traceability of information used to build the model. The consolidation of the models is also an area for improvement: we currently have to take the outcomes of the participative workshops in the form of flipcharts, pictures, sets of sticky notes, and transform these into elements of a modelling language. We worked on the semantic mapping and shared the same meta-model between any representation, (regardless of whether it is an ArchiMate model or a bunch of sticky notes). We now also envisage working on the infrastructure that will help us to digitalize the gathered information earlier in the process, but without losing the interactivity associated with the manipulation of the real objects, like reported by Ionita [13].

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Modeling As-is, Ought-to-be and To-be – Experiences from a Case Study in the Health Sector

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Abstract. In business process management (BPM) it is customary to differentiate between the current (as-is) situation, and the future (to-be) situation and develop models of these situations. In practice you never are able to implement the ideal to-be model, although it is still useful to represent this and update it as the situation changes. A finer distinction between the modelling of this ideal ought-to-be, as-is, and to-be is necessary, and we have in this paper provided an approach for combining top-down and bottom-up modelling to support the dynamic interplay between these models. The approach is exemplified through a case in the health sector where it has been tried out, reporting the learnings from supporting this in a contemporary enterprise architecture environment.

Keywords: Enterprise process modelling**,** case study

1 Introduction

The first process modelling language was described as early as 1921 [6], and process modeling has been performed in earnest relative to IT development and organizational development at least since the 70ties. The interest in process modelling has gone through phases with the introduction of different approaches, including Structured Analysis in the 70ties [5], Business Process Reengineering in the late eighties/early nineties [7], and Workflow Management in the 90ties [18]. Lately, with the proliferation of BPM (Business Process Management) [3, 8, 17], use of process modeling has increased also for large-scale usage [9, 10].

Models of work processes have long been utilized to learn about, guide and support practice also in other areas. In software process improvement [2], enterprise modeling [4] and quality management [9], process models describe methods and standard working

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procedures. Simulation and quantitative analyses are also performed to improve efficiency. In process centric software engineering environments [1] and workflow systems [18] model execution is automated.

A lot of research has been done in the field of enterprise process modelling [3, 11], as well as on the subject of how to judge the appropriateness of the models [12, 13]. Much work is done regarding the use and creation of models on a theoretical level, but in order to better understand the mechanisms at work in the application of enterprise process models, real-life cases can provide interesting insights. As we will report here, the traditional dichotomy between as-is and to-be models often found in BPM is too limited, and also other business process models, e.g. the ought-to-be model are important to capture and maintain. This paper presents some of the results from a case study on the use of process models in the health sector, using the Troux enterprise architecture tool-set.

A more detailed overview of types of process models are found in section 2. How the interplay in particular between as-is, ought-to-be and to-be models can be supported is illustrated in more detail in a case study reported in section 3. Discussion of results, concluding remarks and ideas on further work are found in section 4.

2 Modeling of Business Processes in Enterprise Development

According to general model theory [16] there are three common characteristics of models: *Representation, Simplification and Pragmatic orientation*: Thus a model is not just a representation of something else; it is a conscious construction to achieve a certain goal beyond the making of the model itself.

Process modeling is usually done in some organizational setting. An organization can be looked upon as being in a state (the current state, often represented as a descriptive 'as-is' model) that are to be evolved to some future wanted state (traditionally represented as a prescriptive 'to be' model). In practice only looking at as-is and to-be models is insufficient, one also need to have the possibility to experiment with could-Be's (different scenarios), and Ought-to-Be (the best scenario).

In table 1, we list relevant situations, along temporal and a contextual axes

Table 1. Types of models according to temporal aspects and purpose

Type of model	Past	Present	Future
Ideal model	Ideal model of the past	Reference model	**Ought-to-be model**
Simulated model (what-if)	Possible model of the past	Possible model	Could-be model
Model espoused	As-was model	As-is model	**To-be model**
Model in use	Actual as-was model	**Actual as-is model**	Workaround model
Motivational model	Past burning-platform model	Burning platform model	Burning platform model

We will below look in particular on the interplay between the actual as-is model, the ought-to-be (ideal) model, and to-be model. Process modeling starts with the company vision and business value, and shall contribute to long-term success. It is important to develop both corporate future goals and a target architecture. To achieve this, we need both a top-down and a bottom-up approach. Future state models are best done with a top-down approach while past and present state models are mostly done bottom-up. Future state models can also be referred to as future operating model (other terms are ought-to-be model and target architecture)

The future operating model is a top-down model describing best practice of how the most critical work ought to be done, and of how we want to operate in the future. There will always be a gap between the ambitions of an organization and the current or short term technical, methodical and organizational possibilities.

In order to get an overview, control and management of a business, it is important to get a common understanding what the business is doing or is supposed to do. One need an overall model of the main processes, information, systems, and skills necessary to produce products and services, that all stakeholders (owners, managers, employees, suppliers and customers) can agree upon. The model should also have a long perspective, 5-10 years or more, to be a “lighthouse” to guide the direction of the organization, thus the name “Future Operating Model”

This model is used for understanding and the planning of programs and projects. The Future Operating Model describes best practices which are derived from previous experience, expected technological development and regulatory requirements etc., and show the ambitions and plans. This model is a generic/conceptual/logical model, and is used for basic analyses and help answer questions like:

- "What is the enterprise doing?"
- "Is the enterprise doing the right things?"
- “How are the main processes and value chain performed?”
- "Could one redesign the basic processes?"

This is analysis that should be done before going into the details like:

- "Who / what does what?" (Human / machine).
- "Which IT systems used for what?"

Once these basic analyzes and decisions have been made, we can proceed with detailed workflow diagrams.

A unifying overall process model like this makes it possible for people with various backgrounds, coming from different organizational units and disciplines, and who has worked in different ways in the past - to agree on common work processes and value chains. This contributes to common terminology for processes, concepts and information objects. A generic overall model, also contributes to the standardization of the process-mapping so that the work processes are described the same way in the different departments and disciplines, which is important for communication and reuse.

In this model it is also important to focus on the customer/client and the customer interaction with the company is explicitly modeled.

Using a top-down generic model in IDEF0 [11] is best practice for logical/generic/conceptual process models. The model include a process breakdown structure with Inputs/Outputs as well as Controls and Mechanisms (ICOMs).

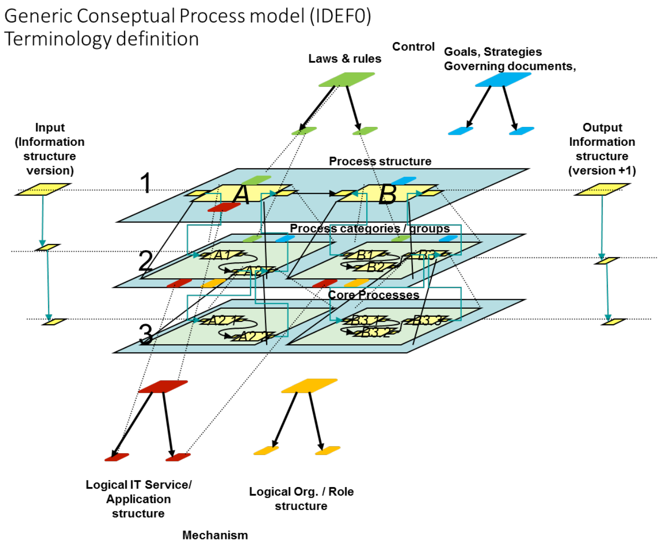

Figure 1: Generic conceptual model of IDEF0

As illustrated in Figure 1, this top-down model shows not only the process-breakdown, but also the breakdown of information-structure (input / output), the breakdown of logical applications and role and control structure.

This means we get a complete future operating model which is maintained independent of current technology and organizational implementations. It can live through technological innovations and organizational changes such as mergers or divisions.

The *workflow-model* describes detailed activities for each role and how the IT-systems are used for each activity. This gives detailed about which roles, information objects and applications functions that are used (as-is and to-be).

The workflow-model is a bottom-up implementation model, which shows the detailed workflow for defined parts of the value-chain.

Figure 2 illustrates how to combine top-down best practice with bottom-up implementation

1. On the left side a top-down process breakdown structure, from an "overall view" detailed in several levels down to "processes / activities".
2. The right side show a bottom-up workflow model which is built up from applications & roles, IT Services and procedures, used for implementation.

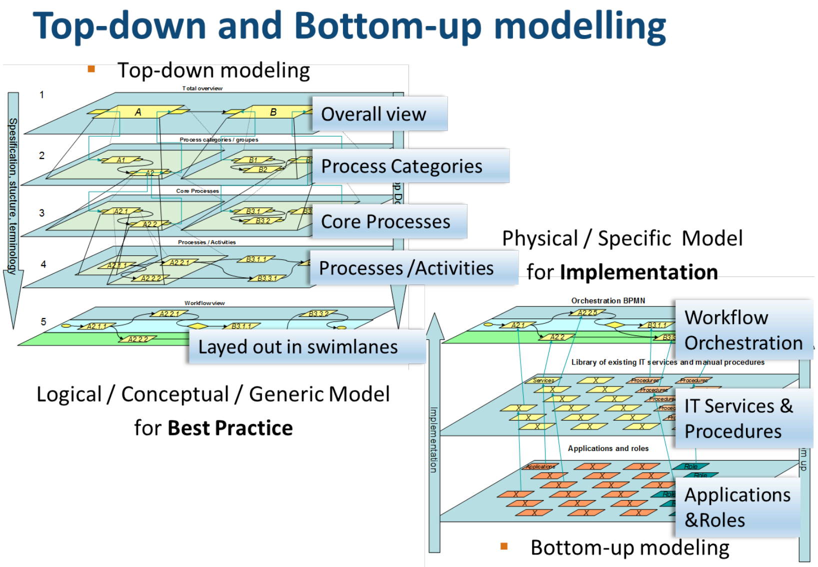

Figure 2: Illustrating the interplay between top-down and bottom-up modeling

As illustrated in Figure 3 process modelling with focus on a best practice top-down model, as well as detailed workflow diagrams, makes the process of going from current as-is to the next to-be that is easier, more structured and efficient.

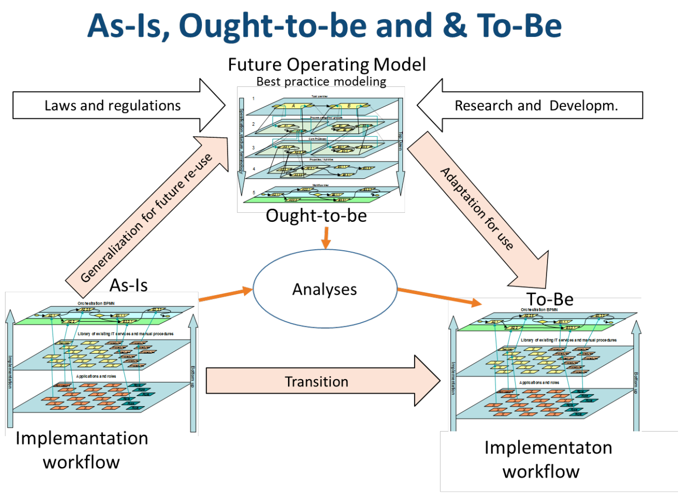

Figure 3: The interplay between as-is, ought-to-be, and to-be models

By linking best practice with as-is and to-be models, it will be possible to analyze how close (or far) the current and next practice is from best practice.

Often certain process steps are repeated several places in the value chain, and we want to standardize on ways of performing these processes. To make this more explicit in the model, we make stereotype-processes as indicated in Figure 4, which can be used as reference processes. These can be referenced from several places in the value-chain or in several value-chains and should be the basis for services and aligned with the service catalog and used as specification for the services. These stereotype processes will then represent the "layer" of common terms where the business meets IT.

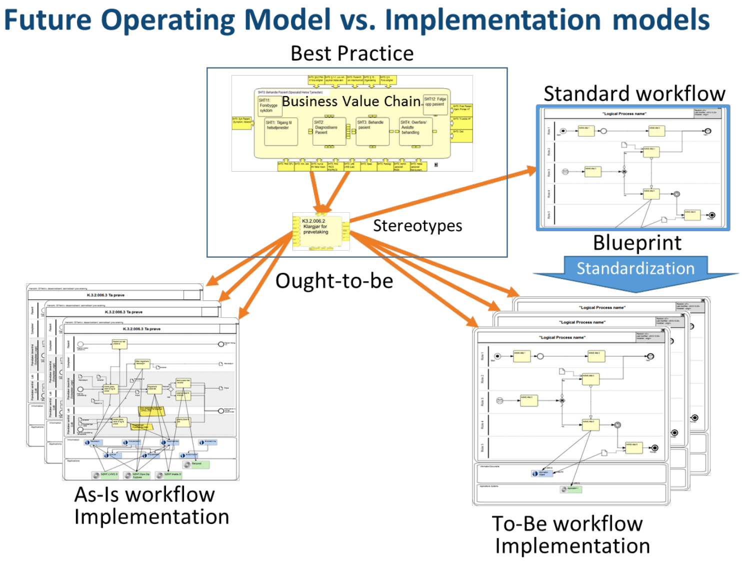

Figure 4: Stereotypes as reusable process definitions

3 Case Study

Health South East in Norway has been working with Clinical Pathway Processes for many years, using different methods and notations. In this case we used a combined approach using IDEF0 and BPMN.

- The future operating model is a top-down planning model (IDEF0) that can represent value-chains, but also value-shop and value-networks.
- The workflow model is a bottom-up implementation model (BPMN), that shows the detailed workflow for defined parts of the value-chain

The model(s) were created and maintained in a graphical tool (Troux Architect) with an underlying repository structure.

Based on this process modelling experience, and a reference model for clinical pathways used in the same organization a top-down process model was developed.

The process modelling project for a new hospital that was under construction, was adjusted to this reference model and below is some examples from this model

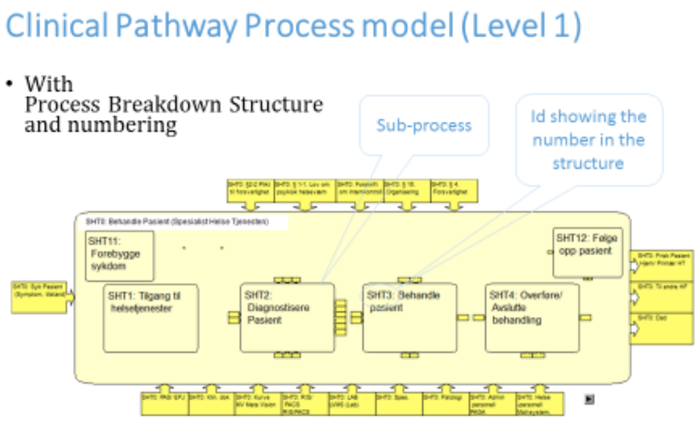

Figure 5: Top-level IDEF0 model in case study

The top level Hospital Clinical Pathway process modelled in IDEF0 illustrated in Figure 5 shows the sick patient as input and a cured patient as output. As controls on top the laws and regulations are shown and as mechanisms at the bottom the main roles/skills and logical application systems are shown.

On the next level we see the sub-processes in the pathway with more detailed inputs, controls, outputs and mechanisms (IDEF0 ICOM's). The processes and ICOM's are numbered according to the process breakdown structure.

This top down generic model can be broken down in several levels to an appropriate detailed level. It is also important to include the patient's own processes in the model in order to include a patient focus.

From this main process structure it is possible to make many different model views for various purposes and audiences. The processes can i.e. be presented in swimlanes representing main hospital units.

On the most detailed level it is also possible to present the processes with generic roles including the patient processes with focus on the interactions between the healthcare and the patient, highlighting the Line of Visibility (LoV) between the enterprise (hospital) and the customer (patient). This is illustrated in Figure 6.

These views can be made on several process levels, helping people from different professions with varying skills to get a common understanding of the enterprise processes.

When we get to a detailed level we often find standard processes that are used in several value-chains (pathways). To avoid making duplicates, we model these standard processes separate as Stereotypes and make a link (relationship) from the value-chain process to the Stereotype processes. The stereotypes should be aligned with the Service Catalog and might be seen as a specification for the services.

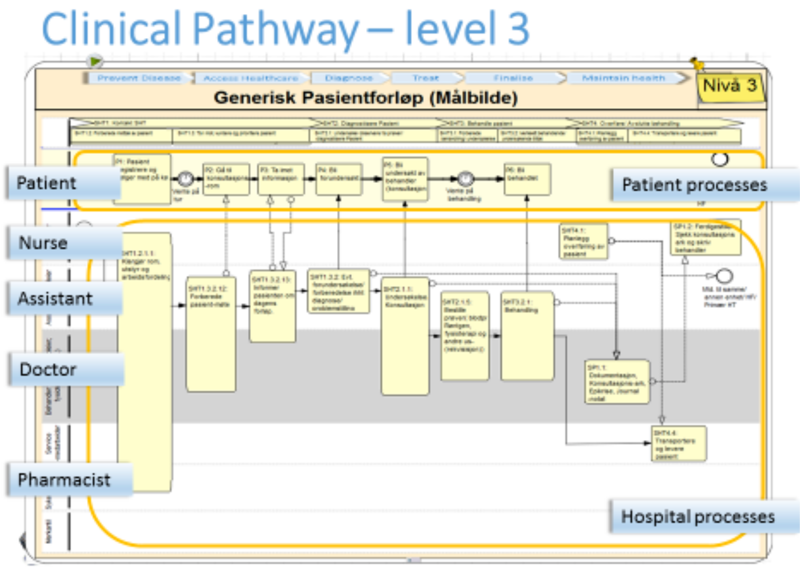

Figure 6 Inclusion of both hospital and patient processes

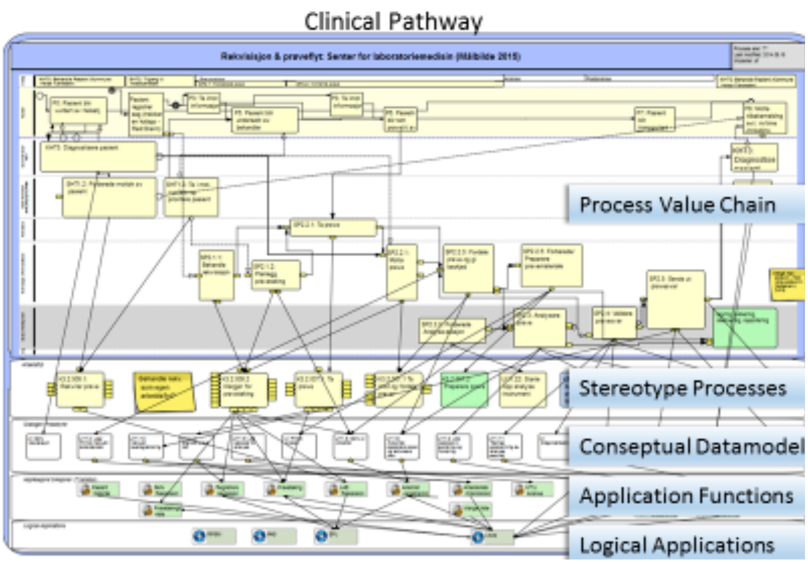

Figure 7: Process definition reuse through stereotypes

The use of stereotypes/standard processes as specifications for services is indicated in Figure 7, where they in the model are linked to application functions, the information model and to logical application objects. All the above are views from the best practice ought-to-be top-down generic model.

When we come to the implementation models (as-is or to-be) we have to go bottom up from implemented systems (applications, application functions, information model) up to activities in a workflow diagram (in the case using BPMN), often also called Orchestration as illustrated in Figure 8.

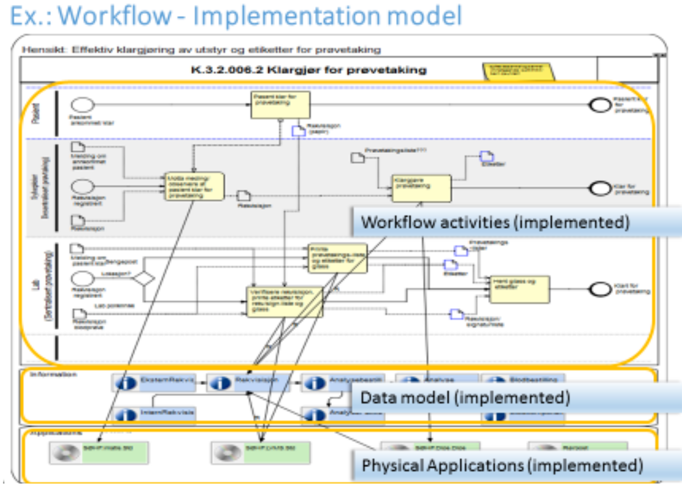

Figure 8: Example of bottom-up implementation models

This is a specific architecture model referring to specific activities, applications and information. One model might show the as-is situation with as-is activities and installed operative applications. Another model might show to-be with proposed activities and applications.

Going from as-is to to-be where guided by the best practice ought-to-be model in order to over time close the gap between the long-term ambitions and current technical and organizational capabilities.

This generic, conceptual process can also be applied and be valid outside a hospital unit. There will be several similar clinical pathways outside the hospital like municipal health service (local doctor), emergency units (Prehospital), and ambulance. It is important to see these similarities to be able to synchronize medical records information in the computer systems.

4 Conclusion and Further Work

We have in this paper looked upon how to enhance the traditional practice with as-is and to-be models with a ought-to-be model representing the best practice and future operating model – expressing also the long-term ambitions within the enterprise.

Working with this approach hopefully also will make it easier for the enterprise management and enterprise architects to express in more detail their ambitions, before the CIO and IT-architects brings in their systems and limitations from current technology. A main learning from the case is that the top-down ought-to-be models due to that they are not to be immediately implemented makes it possible to describe ideas and ambitions on a generic level, avoiding both organizational and technical limitations, but also terminological and conceptual constraints making it easier to be innovative and learn from others without being experienced as threatening to the current state of affairs.

As a case study this is limited to a certain phase of the specification and building of a new hospital in HSØ.

In the approach so far, we have used traditional process modelling such as IDEF0 and BPMN for the top-down and bottom-up modelling. In future work we will experiment with the use of approaches such as AKM [14] which are believe to be better for supporting the agile use of the enterprise process knowledge captured in the model.

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Insights from a Study on Decision Making in Enterprise Architecture

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Abstract. Although there are many frameworks for Enterprise Architecture (EA), they focus mainly on the holistic structure of an enterprise and rarely take decision making into account. This is surprising, given the large role that (design) decision making seems to play in EA. A lack of empirical work offering insight into decision making in practice might be the cause of this. To address this knowledge gap we report on some first insights from an empirical study on how the practice of decision making in EA is perceived by professional enterprise architects. We sketch an outline of designing and decision making in contemporary EA, including a high level of politicization, emotional decision making, and subordination to business management. We discuss the implications of these findings for further research and work centered around EA.

Keywords: Enterprise Architecture, professional practice, empirical study, practitioner perception, qualitative study

1 Introduction

Enterprise Architecture (EA) is not just about modeling static descriptions of an enterprise, but also about steering it towards a desired future state. This is reflected in The Open Group's description of EA in TOGAF [15], where a two-fold definition is given being: (1) "a formal description of a system, or a detailed plan of the system at the component level, to guide its implementation", and (2) "The structure of components, their inter-relationships, and the principles and guidelines governing their design and evolution over time". This second part describing normative principles and guidelines to affect an enterprise's design is where much of the architecting actually happens, as is reflected in the plethora of other EA definitions focused on it, such as Hoogervorst's view [5] of EA being "a consistent set of design principles and standards that guide design", and Lankhorst's view [8] describing it as the "realization of an enterprise's organizational structure, business processes, information systems, and infrastructure".

What is it *like* to actually work on decision making in EA? How do these high-level definitions translate to the actual decision making practice? There is work that focuses on what makes an architect a *good* architect – but those studies often still leave in the middle just what the investigated people do in a regular day's

S. España J. Ralyté, P. Soffer, J. Zdravkovic and Ó. Pastor (Eds.):
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work (cf. [13,4]). As such, while prescribing skills and characteristics architects ought to have, they offer little empirical insight into what architects currently do, especially in regards to decision making. Other studies do attempt to investigate how EA (or parts of it) is done, but are limited to understandings of the authors themselves from prior or concurrent industrial roles (cf. [7], or anecdotal evidence gathered in industrial cases (cf. [3]). Some studies are limited to specific literature (cf. [2]). Some studies investigate actual companies, but usually in limited scope, for example a single aspect of Federal Government [14], Czech companies [10]. Comparing the findings of such studies in order to gain a general understanding of the EA practice brings additional issues of interpretation along. Attempts at understanding how EA is perceived by those practicing it are for example Dankova [1] and Mentz *et al.* [9]. However, Dankova's work is limited in this regard by being essentially a corpus analysis of existing definitions. Mentz *et al.*'s more ambitious attempt incorporating hermeneutic phenomenology to compare understandings of EA between practitioners and researchers also only focuses on existing definitions and frameworks and does not actively investigate the views these people have themselves. Thus, investigating the perception of the EA decision making in practice remains an open topic.

1.1 The Use of Understanding Practitioner's Perceptions

Gaining a deeper insight on how EA practitioners are involved in decision making contributes to several aspects, both practice and research oriented:

1) *Understanding the way they make decisions.* First, an increased understanding of how practitioners make decisions and what they consider to be and not be part of their tasks can serve as an empirical grounding for other theory-backed efforts to improve the decision making process.

2) *Understanding the issues they have in decision making.* Second, both by explicitly asking what aspects practitioners perceive to be most critical during their decision making process and investigating the characteristics of that process, we can have a more empirically grounded list of focal points for research (and practical) efforts to address.

3) *Understanding what their experience is similar to.* Finally, by understanding practitioners' perceptions, we can also investigate how similar and different they perceive decision making in other related fields to be, like for example software or information architecture. For example, some decision capturing framework for EA bases themselves on theory and foundations from software architecture without rationalizing why they are applicable to EA. Other researchers continue to build in such frameworks (cf. [6,20]), without questioning that, leading to a continued lack of proper grounding (and potentially validity) of the design artifacts offered to practitioners. Insight into what software architects do, and feel they should do [12,11] can be used to compare how similar these fields are experienced to be.

Our research objective is to study these aspects and in doing so elicit data that gives insights into the general practice of EA as well. We will do so by performing qualitative work with a diverse amount of participants active as enterprise architects.

2 Method

2.1 Participants

We specifically targeted EA practitioners by posting an invitation to the study on several LinkedIn groups centered around (the use of) Enterprise Architecture, EA methods, or tools (e.g., groups such as Enterprise Architecture, EA Forum, EA Group, The EA Network, ArchiMate, TOGAF). Doing so we specifically attempted to target a diverse number of participants, from both geographical as professional background, attempting to prevent the limited professional context of earlier studies focusing on single companies or geographical areas. Participants were asked to fill out the questionnaire online, and were offered no reward except a copy of the research results, when available.

2.2 Procedure

The study consisted of a questionnaire with three main parts, building a professional profile of the participant, understanding the difficulties they face in EA decision making, and testing how they feel about certain aspects of the decision making process. The profile of the participants was built based upon the following questions.

- What are your main activities as an Enterprise Architect during the decision making process?
- What modeling languages and techniques do you use?
- Are you internal or external to the company you perform EA activities for?
- Do you have experience with other architecture fields such as software or information architecture? If so, to what degree do you find the decison making process to be different than in Enterprise Architecture?

These are followed by more specific open questions about the difficulties they face in their role as an architect, their involvement and views on design decisions, and what kind of data they use.

- To what degree are you involved in the process of making EA design decisions?
- What makes an EA design decision difficult for you?
- Related to the last question, what are the most important (or critical) aspects of an EA design decision for you?
- What kinds of input do you use for EA design decisions, and of those, do you favor qualitative or quantitative data to base your decisions on?

Finally, we asked participants to judge to what extent they agreed with a number of statements on a 5 point Likert scale (ranging from ‘strongly disagree’ to ‘strongly agree’). These were created to give insight into how participants feel about the decision making aspects detailed below.

- Where the authority resides: is there a difference between who *makes* (i.e., prepares) the decisions and who *takes* (i.e., is responsible for) them?

– Collaboration in decision making: is the decision making process a collaborative effort or not, and to what degree so?
– Decision refinement: are decisions iterated upon and refined before they are decided upon, and can they be reconsidered and revised afterwards?
– Data used to support decisions: is there a preference for particular types of data, and is the desired data available in the first place?

Table 1: Used Likert Scale Statements.

#	Group decision-making, Decision authory	Decision refinement	Supporting data
1	I take a decision by myself	Time constraints do not allow me to consider all decision alternatives	I prefer numerical data to base my decisions on
2	I take decisions after consulting others	I take a decision without knowing exactly what the outcome will be	I prefer discussions with people to base my decisions on
3	Decisions are taken by a committee	Decisions often have to be reconsidered, which also affects other decisions	It is easier to make decisions that are based on hard data
4	Decisions are taken by a group of architects	Decisions are often refined	In general there is sufficient numerical data available to make decisions
5	The final decision comes down to a single person	When I make a decision, it is final	Discussions with stakeholders offer more insight than numerical data

2.3 Analysis

The results from all open questions were gathered and classified per question. We then used progressive coding to identify common threads between participants, both on single word and phrase basis (e.g., multiple occurrences of the term 'time constraints' for the question what makes EA design decisions difficult). This coding was used to build an overview of the general trend for the answers. After doing so we went through the answers again to find answers that specifically conflicted with this trend, and use them to discuss the attitudes of the participants towards the questionnaire. To estimate the general tendency for each answer in the Likert scale we calculated the median of each question's answers (given the ordinal nature), which we used to determine whether the majority of participants had a polarized (i.e., strong agreement or disagreement) or neutral attitude towards them.

3 Results

We received **35** full responses to the questionnaire, with many more partial or empty responses discarded. The textual answers were analyzed and coded, and will be discussed in more detail in Sec. 4. There was no strong bias towards external or internal employees, with 17 indicating being external to the companies they provided EA services for, 15 being internal, and the remaining 3 gave no answer. The location of the participants was diverse, with many countries represented. A total of 18 participants were from (> 5) European countries, 9 from North America, 3 from South America, 2 from Australia, 1 from Africa, 1 from Middle East, and finally 1 from an unknown origin.

For the Likert scale, we selected the statements with strong responses (either positive and negative), and emphasized those with a low response variation in their responses (indicating consensus among the participants). These statements are not used as statistically generalizable findings, but as verification for the analysis of the qualitative data, and to ensure they both corroborate each other.

Table 2: Strongly polarized (≥ 4 and ≤ 2, pos and neg) Likert Scale Items. Statements in *emphasis* had particularly low variation and were thus most strongly (dis)agreed on.

Statement	Polarity
I take a decision by myself	
When I make a decision, it is final	Negative
In general there is sufficient numerical data available to make decisions	
I take decisions after consulting others	
Decisions are taken by a committee	
Time constraints do not allow me to consider all decision alternatives	
Decisions are often refined	Positive
I prefer discussions with people to base my decisions on	
It is easier to make decisions that are based on hard data	
Discussions with stakeholders offer more insight than numerical data	

4 A First Outline of Contemporary EA

In this section we give an outline of contemporary Enterprise Architecture as perceived by practitioners, describing the dominant views held by participants for the different aspects we studied. We will try as much as possible to let the participants speak for themselves, showing their actual responses.

4.1 Main Activities as an Enterprise Architect

Most participants indicate that the majority of their time is spent on working towards *future* states of the enterprise, less so on the current state (e.g., modeling it, analyzing it). This is in some contrast to the TOGAF definitions which give a clear two-fold interpretation of EA and imply equal importance of those parts. As stated, they spend a lot of time and effort to:

> "Seek the strategy, the strategic goals (qualitative) and objectives (quantitative) and then derive the information required to achieve them."

To make it clear that the future is of particular importance, many other participants stated similar foci:

> "... and then use those as inputs to model a set of potential courses of action."; "... providing a recommended course of action if possible"; "Helping investment decision makers consider alternative future change to their business, and monitoring the impact of the change as its being created and implemented."

This focus on future states can be explained by the answers of some participants where it is clear that models and data already exist, and need to be integrated and used towards the future state. The point of these artifacts needing to be harmonized into a form consumable for strategically responsible stakeholders brings forth the other main activity that architects seem to actually do while working on this future state: creating support and convincing management of the use of the design direction to go in.

> "Creating awareness and commitment at management (decision-makers level for a specific solution"; "Creating support within the enterprise for a specific solution or specific solution paradigm so that the decision-makers are confronted with this paradigm"

Already in describing their main activities it becomes clear that while Enterprise Architects work on the future state of an enterprise, there is a clear difference between those who propose (designs, decisions, strategies for) the future of the enterprise, and those who have the power to actually take it there, an aspect that will be explored more in Sec 4.5. See, for example:

> "Often I frame the decisions to be made and then propose various options with supporting data. Usually the option that I feel is the best is clear through that data. *However, the senior leaders who own the decisions need to be the ones who actually make it.*" (emphasis added)

4.2 Used Modeling Languages and Techniques

When asked about the modeling languages and techniques participants used in their daily work, the whole gamut of languages came by. The usual suspects such as UML, BPMN, ArchiMate (for Western European EAs, at least) were represented, as well as long existing techniques like Zachman, Flowcharts, IDEF languages, and so on, but just as well less known languages such as IBM and Oracle suites, ScIAM, SAINT, DNDAF, SCOR, RDF, Rummler-Brache, and so on. Multiple participants make a distinction between the audience of models and information, and that a distinct purpose followed from that: modeling to capture knowledge, and modeling to communicate knowledge. Practically speaking, very little formal or complicated modeling languages and techniques were actually shown to the business stakeholders when communicating with them:

> "Primary tool for communicating is PowerPoint."; "... but really powerpoint, excel and visio are more suitable for a non-technical audience."; "In dialogue with management I do not use modeling languages or techniques."

4.3 Data to be Used

Designing the future state of an Enterprise is considered a systematic activity by many, and as such useful data to base those designs on is needed. To do so, however, data is needed to base all those designs (and design decisions) on. This ranges from quantitative data about the operation of the enterprise, to qualitative data involving the actual people making up the enterprise. Both kinds of data are needed:

> "You need both sets of data. The challenge is introducing a disciplined process for capturing both types of input to align them for one decision and support dependent decisions in other areas."

4.4 Perceived Differences to Other Architecture Fields

Many participants had experience working in other digital architecture fields (e.g, software, information, data architecture). One participant argued that the primary difference between these fields arose simply from the professional culture of their domain. Going into detail on the differences between EA and those fields considered more technical like Software Architecture, participants generally found EA to have a broader focus and depth, with the scope and impact of design decisions potentially far greater in EA. These differences were often explained by EA having a much stronger business focus than comparable fields, from which also a higher abstraction level followed. While some participants state that software architecture is not fundamentally different from EA (at least in regards to the decision making process), they do showcase the different nature of achieving support for a future state or design, corroborating points made earlier by other participants that EA has many more human and 'soft' aspects that need to be dealt with:

> "EA decision making process has more political, personal etc. influences. Demands more communication and soft-skills. Software architecture decision making is (much) more straightforward fact based."

4.5 Involvement in the Decision Making Process

In the previous aspects we have already seen hints that while Enterprise Architects are consistently involved in designing and proposing future states of an enterprise, they are not necessarily the ones to take an enterprise there. Most architects seem to choose for future designs or (viable) future states in cooperation with business stakeholders, and then communicate those to management stakeholders who have the actual decision taking power:

> "An architect (EA or otherwise) is responsible for providing recommendations not decisions to the Board. The Board owns the accountability for decisions."

4.6 What makes EA Design Decisions Difficult?

As participants stated already in other aspects, EA design decisions are not simple to make, especially when compared to fields they perceive as more technical and rational like software architecture. The reasons for this are diverse, ranging from the involvement of a large number of stakeholders, difficulty communicating between people with different backgrounds, and dealing with conflicting goals and lack of information. However, besides all these aspects, a difficulty seemingly more specific to EA is shared by many participants, the politics involved in finding support for moving an enterprise to a particular future state:

> "The politics. Making a design decision based on principles and best practices is not difficult. Making it such that my stakeholders see the value in where I'm going, and see the benefit of going there with me, is much more difficult and interesting."

4.7 Most Critical Aspect(s) of EA Design Decisions

After understanding what aspects are most difficult about design decisions in EA, we also explicitly asked participants what aspects they found most critical to making decisions. The main response here is in line with the view of EA being highly politicized, as the most critical aspect to most EA design decisions, and thus to reaching a proposed future state of an enterprise were finding the right arguments to convince the right people at the right time, and keeping them convinced:

> "The most critical aspects of an EA design decision: having the right rational arguments for which conservative IT operators and managers are sensitive for, having the right emotional and business image/impact for the business, getting the right position in project planning"

5 Reflection

5.1 Implications for Research

From the outline that we have sketched, we see several things that research in EA can focus on to provide more support for the decision making process in EA:

Supporting the way they make decisions. Our results indicate that discussions between architects and business stakeholders play a large role in the EA decision making process. This supports the idea that dialogical skills are important for enterprise architects, so that they can "interact with those who are different, antagonistic, or even aggressive towards them". [4]. This is an important aspect that seems to set the decisions making process in EA apart from decision making in other domains such as SA. Recent EA decision rationalisation frameworks (e.g., [20,18], both theoretical frameworks based on formal logic) directly use insights from related domains such as SA (see more on this in point

3). Therefore, the discussions between stakeholders are not part of these framework. Given our results, we believe that in order to truthfully model the EA decision process, these framework would benefit from an extension such that the discussions between stakeholders are part of the rationalization of decisions as well. We report initial finding of applying argumentation to parts of enterprise architecture elsewhere [19], and we aim to further extend it in future work.

In a different direction, the finding that many EA practitioners make a distinction between capturing and documenting knowledge in models and communicating it to business stakeholders means that we can be clearer about the presumed users of modeling languages: they might be only used by experts. This has implications for the design of such languages, how complex they can be, how intuitive their interfaces should be, as novice users or non-IT literature users are, at least in an EA context, likely not active users. Instead, they are communicated the knowledge that architects captured in such models by different means such as Powerpoint slides, and informal drawings.

Dealing with the issues they have in decision making. Ensuring that all stakeholders have the same understandings, and keeping the 'buy-in' of stakeholders on those understandings is one of the critical aspects pointed out by our participants. On the one hand this offers support for such efforts like ArchiMate and other providers of complete and coherent EA approaches. On the other hand given the plethora of used modeling languages and techniques, it stresses the need of research investigating the different conceptual understandings that people have and how to best deal with and accommodate them [16,17]. Furthermore, as the most mentioned issue of day to day practice is the politics of dealing with all involved stakeholders, our study points out the need for more research into understanding the political processes involved in the EA process.

Realizing EA is not interchangeable with all other 'A'. How the decision making process differs from e.g., software architecture presents a number of implications for research, especially of a design nature, whether recommender systems, ontologies, or information capturing schemes. Given the perceived differences between EA and SA practice, frameworks created by researchers should not just assume the two are the same and use SA foundations to build EA frameworks. Such frameworks need to at least account for the perceived extra dimensions of political motivations in decisions, emotions that need to be addressed and the large part that discussions play in the decision making process.

6 Conclusion & Outlook

We have given an outline of the practice of design and decision making in contemporary EA based on an in-depth qualitative study of how enterprise architects perceive their professional work. This has led to a number of insights, namely that the practice of EA is fundamentally perceived as a consultancy service to business, with less rational decision making than other architecture fields, and a highly politicized working context.

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Initial Experiences in Developing a Reference Enterprise Architecture for Small and Medium-Sized Utilities

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Abstract. In the last decades, numerous developments and legal changes moved the utility industry towards a liberalized market. Utility enterprises have to stay competitive and reduce costs while managing more complex IT systems. The authors of this work see special demand for aligning business and IT for small and medium-sized enterprises (SME) in this industry and identify the development of a reference enterprise architecture (R-EA) as a key for this issue. This work investigates how to develop such a reference model, which comprises data acquisition as well as validation methods.

Keywords: Enterprise Architecture Management, Reference Modeling, Utility Industry, Small and Medium-Sized Enterprises, Reference Enterprise Architecture

1 Introduction

Enterprises need to be aware of the relations among their strategy, business processes, applications, information infrastructures and roles to be able to rapidly react on changing demands in the market and within their organization. Enterprise Architecture Management (EAM) contributes to this purpose by providing methods and tools to establish a more holistic perspective on enterprises [1, 2], which includes to systematically capture and develop the different architectural layers of an enterprise (e.g. business, application and technology architecture).

In recent decades, the European utility industry faced significant changes caused by developments and regulations like market liberalization and the diversification of energy sources [3]. Numerous new market roles and business opportunities created by changes in regulations resulted in an increased competition. Therefore, utility enterprises are forced to adapt their business models to the changing market situations, which also requires adaptation in the enterprise architecture. Especially SMEs have to overcome this increasing complexity by adjusting both their business and information systems [4].

In this context, EAM is expected to be important for supporting change processes and developing competitive business capabilities [5]. Current research lacks in

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investigating the exploitation of EAM in the frame of SMEs [6]. A survey within German SME utilities revealed that there is a demand for a reference EA. In the frame of the ECLORA Project such a R-EA is developed, which is configurable dependent on the respective application case. This work illustrates how to collect data in order to develop and validate such a reference EA. Therefore, the paper first points out developments in the utility industry, clarifies its understanding of SMEs, discusses the current state of EAM in this area as well as approaches how to develop reference models. Section 3 introduces the ECLORA project, its methodology and recent results, before the approach of data acquisition for R-EA development is presented in section 4. Finally, a conclusion and further outlook is given in section 5.

2 Theoretical Background

Over the last two decades, the European energy market has faced fundamental structural changes [3]. Next to increasing the energy efficiency, the European Union also aims to raise the share of renewable energy sources by 20%. The German government even steps further by intending to cover 35% of the electricity demand with renewables by 2020 and 80% by 2050 [7]. In addition, within the German EnWG law (Energy Industry Act) the industry transformed from a few monopolistic supply-side players to numerous supply-side enterprises, while customers gained more power in their role as an electricity consumer [8]. Next to this, also technical improvements increased competition, which forced utility enterprises to improve their efficiency and effectiveness [9, 10]. The Germany Federal Association of the Energy and Water Industry categorizes nine market roles such as energy retailer, balance grid coordinator or metering service provider [11]. Several roles can be taken by one utility enterprise. This development enabled the emergence of new business models combining several roles as well as offering new services.

The energy turnaround faces several major challenges according to [12]. The integration of renewable energy sources, whose generation is difficult to predict, faces a mismatch between times of supply and demand. Moreover, the production of these energy sources implicates unpopular energy storage installations and the transport of new plants for renewable energy brings along a massive expansion of the electricity grid. Also small energy producers with more flexible generation frequencies need to improve the energy production in comparison to the demanded energy in the grid [8].

The above stated developments and challenges have critical influences on utilities' operative and strategic business. Most of the public utilities in Germany can be categorized as small and medium-sized enterprises (SME). Thus, they are facing major obstacles these days restructuring their organizations while staying competitive and still complying with complex national and international regulations. According to [13] more than 99% of European enterprises operate as an SME, globally between 40% and 50% of gross domestic product is accounted to them. This paper uses the definition of the German institute for SME research, here enterprises are considered medium-sized with less than 500 employees [14].

2.1 Current State of EAM in SME Utilities

From information systems (IS) perspective today's utility enterprises have more complex requirements towards its information systems. In [10] the authors identified more than 80 different information sources that have to be used in order to develop an appropriate information system for the utility industry. Although there is a plethora of literature regarding the challenges in the utility industry, a paucity of literature with concrete focus on IS is identified. Additionally, most literature addresses the context of environmental sustainability but lacks in investigating the implications for utilities' IS and its role in the current developments [15].

The authors of this work determine EAM as an approach facilitating business and IT compliance on the one, and optimization of organizational structures on the other side. The emerging objectives to align business and IT, to overcome IT complexity, and to reduce costs for sustain competitiveness can be reached by implementing EAM [1]. An approach towards EAM initiatives has to be tailored to the context of SME utilities since their organizations models, decision processes as well as their understanding of the importance of strategic planning differ to more complex organizations [17]. So far there has been little research activity, which concretely addresses EAM as a mean to overcome the stated challenges in the utility industry. Most research focuses on parts of EAM's scope. For instance, [10] identified 11 reference models for information systems development in utility industry and proposed a catalogue for reference models in order to agree on a common terminology [18]. In the frame of an EU Mandate the Smart Grids Architecture Model framework was developed [19]. Within this framework the topic of smart metering emerges, addressing the enhancement of the Smart Grids' operational efficiency. Therefore, approaches to develop a smart metering architecture can be identified trying to manage the massive relevant data necessary to offer effective meter data management [20]. To cope the issue of complex and flexible energy input, load management and demand response are investigated [16] and customer-centric networks are created in order to reduce peak load by dint of dynamic tariff models utilities could use [21].

All these research activities address issues a utility enterprise nowadays has to consider not only in their business but also in their information systems. The stated literature investigates this at a relative granular level. A holistic approach like EAM cannot be identified. As a summary the authors derive a lack of current research regarding EAM initiatives in the utility industry [5].

2.2 Reference Modeling

This work identifies reference modeling as an approach capable of closing the gap of EAM within the utility industry. Reference models are information models developed for an abstract class of application and entitled to universality in this class. Thus, their purpose is to be reused by mechanisms of adjustment and extension according to a special application case. The reuse of a reference model is intended to increase both efficiency and effectivity of an enterprise's information systems and their change management [22]. The process of reference modeling comprises both the construction and the application of the model [23]. For both phases Schütte defines a procedure model defining certain modeling activities. The application phase is understood as an integrated process in the model construction since it may trigger the extension of the reference model [24]. Further, Schlagheck introduces the object-oriented paradigm into the construction and application of reference models. This enhances the models' reusability, configurability and comprehensibility [25]. Becker et al. identify a dilemma in reference modeling among the models general validity during construction and the effort of adjusting the model while its application. Their approach suggests solving this conflict by developing configurative reference models, which defines rules to determine model adjustments according to the problem class' characteristics. Each value of predefined configuration parameters triggers the instantiation of an appropriate model variant in a certain point of the reference model [26]. This approach integrates the application aspects into the construction phase of reference modeling.

3 ECLORA Project

ECLORA aims to develop a model description of complex enterprise architecture for the utility industry. This intention is facilitated by dint of reference modeling. The R-EA is developed and described based on specific architecture layers according to TOGAF (technical, applications, data and business) [29]. These architectural components can be used to refine and evaluate the usage of IT in utility enterprises in the context of their corporate strategies. Grounded on our experiences in EAM and a sound analysis of methods and techniques, we decided for a research design which comprises the use of the DSR approach as well as the Configurative Modeling.

3.1 Research Design

The research method used for ECLORA is design science for information systems research proposed by Hevner et al. [27]. Design science is a problem-solving paradigm that reacts on an identified organizational problem by creating and analyzing IT artifacts. In the case of ECLORA the resulting artifact is the reference EA for small and medium-sized public utility enterprises. ECLORA applies DSR using technical action research approach by Wieringa and Moralı as validation design [28]. This serves as a methodological framework, illustrated in Fig. 1.

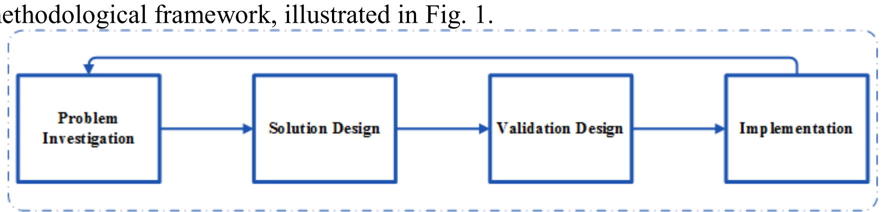

Fig. 1. Instantiating Design Science in ECLORA

As depicted the Configurative Reference Modeling approach is utilized for Solution Design within ECLORA. This approach proposed by Becker et al. addresses the reference modeling's dilemma among general validity and effort of adjustments.

3.2 Recent Results and Implications

As stated before, current research does not address industrial needs in terms of managing a flexible IT architecture utility SMEs. A survey with stakeholders from the public utility sector was conducted ascertaining industry's attitude, experience and need for EAM. The examination of the survey revealed several findings that are listed below and can be found in [4].

1. *High Diversification of Market Roles*: 25 combinations of market roles were identified. This implies that utility's EA depends on the market roles it takes.
2. *EA Frameworks too complex and expensive*: Although numerous EA Frameworks are available, there is a lack of frameworks tailored to SME utilities. They do not feel supported by them.
3. *Validation of the demand for a Reference EA*: The survey identified factors that let utilities' EA grow complex. Next to fusions and outsourcing strategies, especially rules and regulations require an advanced flexibility.
4. *Optimization of Communication between IT and business*: Although the identified core processes were supported, the majority of respondents neither felt sufficiently delivered with information nor was satisfied with the IT support. This reveals insufficient Business-IT-Alignment.
5. *Business Process Outsourcing in Utility Industry*: Especially in Energy Data Management and Billing the enterprises utilized outsourcing strategies.

These results of this survey have special implications for the ECLORA project regarding its reference enterprise architecture. The findings listed above will also influence the way ECLORA defines how to apply the reference EA to a SME utility.

3.3 Development of an initial R-EA

In order to develop an initial R-EA, data was collected by means of quantitative and qualitative methods. A survey was conducted to analyze the current situation and identify common practices and needs for improvements in utility enterprises [4]. For the development of our initial reference architecture, we merged the findings from a literature analysis, branch literature, expert interviews and the survey's analysis.

The development of the initial R-EA bases on The Open Group Architecture Framework (TOGAF), which comprises three layers: business architecture, information architecture, technical architecture [29]. Since this approach is primarily addressed towards big enterprises, an objective was to tailor the concepts of TOGAF towards SME utilities. Therefore, several perspectives for a R-EA were developed, e.g. the cooperation of actors and roles, which considers the branch-specific influences of federal agencies and EU authorities. Initial stakeholders and dependencies were identified and depicted. Specific elements were figured out, especially for the business architecture (BA). The BA consists of five functional divisions of utilities with several hierarchical levels. Fig. 2 shows the breakdown for *Energy Data Management*, which is one of the functional divisions and a characteristic part of utility industries. Roles and dependencies are pictured as well. The developed architecture layer and business processes were validated by branch experts within an internal workshop.

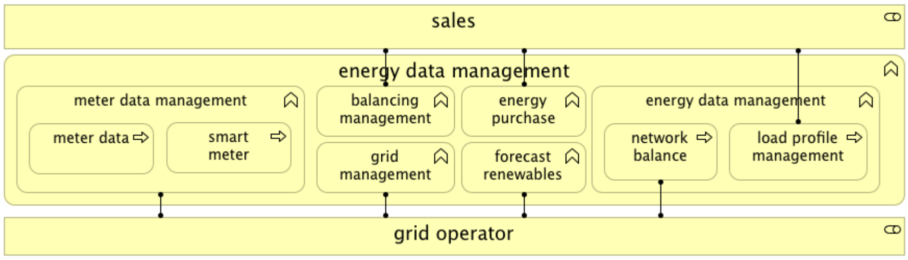

Fig. 2: Business Architecture of Energy Data Management

4 Preparing the Validation Cycle

4.1 Capturing the R-EA at the Utility's

The initial R-EA serves as a basis for conducting workshops at the utility SMEs. As the implications from the survey show, the awareness of EAM's importance in utility industry increases in conformity with one's knowledge of this discipline. Still, the results of the survey reveal that the majority of the consulted utilities is inexperienced in the field of EAM [4]. Since it cannot be assumed that the utilities' participants at the workshops understand the concepts and views of EAM, it seems inappropriate to it as a means to collect all relevant data during the workshops.

Thus, the obstacle was to elaborate means how to collect data in the workshops without the necessity to train participants in terms of EAM. Concluding the results of the survey, practitioners are not supposed to understand modeling notation and hence, would not be able to add value to the models with their domain expertise. For this reason, illustrations with a higher level of abstraction were developed to compress the information relevant for the workshop. Hence, the presentation of the R-EA only contains functional divisions and first subsections as well as related roles. This seemed to be a reasonable approach to drive discussions with the domain experts, which was validated by the experts of the industrial project partner.

A next issue was to capture the information and technology perspective on the utilities, their interrelations between each other and with the business architecture. It was decided to use business processes typical for the utility industry. Furthermore, the right participants and workshop design had to be discussed as well as tools and auxiliaries used during the workshops. Decisions and experiences regarding these issues are discussed in the following sections.

4.2 Business Processes to Capture the Current State

Business processes are used, which are known by the participants and which are representative for the utility industry. While the processes *meter data collection* and *consumption billing* are of a standardized nature, utilities differ in the performance of the *customer acquisition* process as well as *domestic connection*. The decision to use these processes was taken in collaboration with the experts from the industrial partner. They were assessed appropriate in order to gather information for developing a R-EA.

Analyzing these business processes intends to gather information according to different process realizations and contributes to understand the interactions between the different architectural layers. Therefore, *meter data collection* is used here for illustration purposes. It focuses on the data transfer from a meter to the processing system of the utility industry and therewith contains elements of data architecture, information flows as well as integrated technology like smart meter. Despite that, the process itself is easy to understand because it might be reasonably assumed that every employee of the utility industry is a client of this industry as well. The process starts with the order to collect meter data, placed by the supplier. Even though there are different reasons for triggering this action, the subsequent activities are the same. This order is settled by a network operator, by either remote meter reading or on-side reading. Meter data are transferred to the supplier, who imports and validates the incoming data in his IT and therewith generates accounting data. Even though this handling is expected to be similar within the utility industry, it permits little variations like the usage of smart metering or the on-side reading executed by clients itself and affects all layers of the reference architecture. The process illustrated in Fig. 3. is validated by experts of the industrial partner.

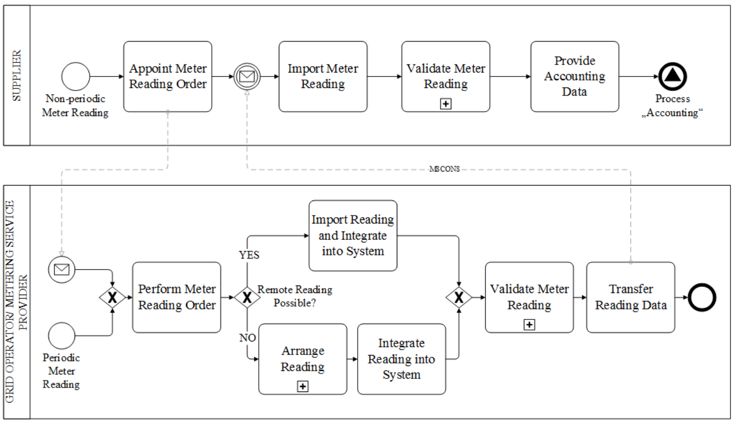

Fig. 3 Meter Data Collection

Regarding the data collection at the utilities’ there are some aspect to be considered beforehand. We want to develop the remaining processes from the scratch together with the participants, only specifying the beginning and end point. This procedure minimizes the risk of merely nodding through fully pictured processes. Participants shall reflect their everyday activities without being influenced by our predefined elements.

4.3 Workshop Design

This work presents an approach to collect data regarding the several TOGAF layers presented, taking into account that domain experts may not be familiar with EAM. Table 1 depicts the schedule that serves as a proposal and contains information about the timescales, main parts, their assumed duration as well as brief description of the topics. The workshop lasts two days, with a maximum of eight hours a day.

Table 1. Workshop Agenda

Duration	Focus	Topic
7-8 hours (Day 1)	Enterprise Architecture	Comprises all TOGAF layers, whereby **business layer** is the baseline of consideration. E.g. energy data management, technical network operation.
	Business Process I *Meter Data Collection*	Meter Data is transferred into your system. By whom, how, when and why?
7-8 hours (Day 2)	**Business Process II** *Customer Acquisition*	When a potential customer becomes a customer: What tasks have to be accomplished when a customer enquires a contract with the energy supplier?
	Business Process III *Domestic Connection*	A new property was built: Which information is required and what actions have to be performed in order to integrate the consumption point?
	Business Process IV *Consumption Billing*	All data for billing are in your system: What has to be done in order to send the invoice to the customer?

After introducing the team, topic and goals, the R-EA is presented. Further, each layer and its content is explained by dint of the meter data collection example. A simplified R-EA model is used. To gain more insights into the information and technology layer and to validate the business architecture layer as well, we predefine purposeful questions, open-ended questions and ask for improvement suggestions. This ensures to systematically extend the R-EA within every workshop. At the end of the day, the R-EA is discussed and probably enriched or adjusted with information, objects or links between existing elements.

The second day focuses on the business processes. They will be created by using the approach of participatory modeling [30]. To create them we determine the beginning and end point wherein the participants are tagging each step they have to do to achieve the end. Using different shapes of cards allows specifying if there is an activity (rectangular card) or an object, e.g. a document (oval shape) requested. All members of the ECLORA-team will document the workshop, except the moderator. This ensures the maximum perception of information, which will be compared and compiled afterwards. During the reworking new objects are reflected upon the R-EA. New insights and their generalizability will be discussed before adjusting the architecture, bearing in mind that those workshops are company-specific, whereas deviating steps within the processes will be integrated for covering a wide spectrum of variants.

5 Conclusion

The aim of EAM is to master the complexity of IT and to align it to the enterprise's objectives, its business and other aspects like laws or regulations [1]. Especially utility industry is expected to be a beneficiary of the integration of EAM since laws such as market liberalization require utilities to act competitive [12]. In the frame of the

ECLORA project, a R-EA is developed, which applies reference modelling in order to provide a universal solution for EAM integration in utility industry. Therefore, this work examined how a R-EA is developed in the frame of the project by conducting workshops with several German utilities. In advance, a survey was conducted in order to validate the industry's needs towards such a reference model and to develop an initial R-EA. Although the respondents assess EAM as a mean to handle current challenges for utilities in the changing industry, the general approach and its terms are unknown to the majority [4]. This challenges the elicitation of appropriate data for the stated project ECLORA.

This paper proposes how to conduct workshops at the utilities' in order to gather this relevant data necessary for developing a R-EA. The authors understand a first focus on the business architecture as an appropriate mean to get an overview about the enterprise at hand. The remaining EA layers can be captured by taking typical business processes of the utility industry as a base of discussion, i.e. the meter data collection. Having the domain experts participating at the workshop ensures the correctness of the collected data. Pointed questions enable the processes' relation to information and technology architecture of the utility. The final outcome is a workshop design, which will be applied in future actions of ECLORA.

The workshop design presented is a suggestion that was developed in cooperation with both academic and industrial partners of the project. It will be validated and further enhanced by applying at several German utilities'. At the moment the authors see room for improvement regarding the level of details of the information presented during the workshop as well as the concrete scheduling and documentation of the results. Nevertheless, a first test run revealed that the current design helps to gather promising information and seems to deliver its intended outcome.

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Adapting an Enterprise Architecture for Business Intelligence

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Abstract. Business intelligence (BI) projects have the goal to implement suitable tools for decision support and to integrate them with existing data sources in a company. They have therefore been on CIOs agendas for several years and there are still a lot of BI projects to come. Despite this fact, however, still the majority of BI projects fail to deliver the full benefit for the business that was expected. One factor why such projects are likely to fail is the lack of communication and common understanding of the project by the BI project team and the business departments. In this research, a modelling technique has been implemented that allows to model both the BI project elements as well as the business model in one comprehensive and easily understandable model, which can help to facilitate the communication between the stakeholders of a BI project. The modelling notation has been evaluated against real-world case studies by conducting interviews, which have shown that the implemented modelling technique could indeed improve the project results. An extended version of this paper is available under [1].

Keywords: Business Intelligence, Business Motivation Model, data warehouse, business modelling, enterprise architecture, meta-model

1 Introduction

In recent years, the area of Business Intelligence (BI) has become a crucial part in the decision making process for companies in order to increase the value of the company. The expansion of existing or the introduction of new BI systems is still an important point on many CIOs' agendas. A recent study, however, has unveiled that not even 30% of the BI projects conducted have completely delivered the expected benefit for the business, even though the discipline of BI has been around for nearly two decades [2]. Among other reasons, one of the most important success factors when creating a BI system is the alignment of the project with the company's business strategy, goals and objectives [2], [3]. In order to provide valuable insights into the company's performance and to create a benefit for the business it is of great importance to understand e.g. which key performance indicators (KPIs) are relevant for the business in pursuit of the company's goals. Defining these KPIs and their underlying measures without a holistic view on the business strategy may result in

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missing answers to crucial business questions and, in the worst case, might lead to a decrease of business value due to missed opportunities or wrong decisions. The alignment of a BI project with the company's strategy has already been named as an inevitable prerequisite for project success by several authors [2], [4], [5].

Modelling techniques and frameworks which allow the modelling of certain aspects of the business strategy, objectives or goals as well as the architecture of a BI system exist and provide tools to create models of their respective topics, for example the Business Motivation Model (BMM) from OMG. However, the modelling techniques that have been identified and analyzed are all limited to their respective areas. No modelling technique could be identified which provides the possibilities to model both the technical as well as the business aspects of a BI project which would greatly support the alignment of the BI project and the business strategy by graphical means. The goal of this study is to identify which elements are necessary for the mentioned alignment and to develop a modelling notation that allows the people involved in the project to facilitate communication and understanding and thus to support them in designing BI solutions that truly create a business value.

2 Related Work

BI Fundamentals

The term "Business Intelligence" (BI) was initially shaped by the Gartner Group in the 1990s. It is a technique to access and analyse information by the means of information technology which supports the management of a company to take business decisions based on quantitative business information coming from a variety of sources [6]. The Data Warehouse Institute defines the term as "*The processes, technologies, and tools needed to turn data into information, information into knowledge, and knowledge into plans that drive profitable business actions.*" [7, p. 7], which is the definition used throughout this research paper.

BI Architecture

A BI system not only consists of one tool or software, instead it contains several systems, which are connected over several layers. The base of all BI systems are the data sources, which supply the data. This data is gathered from the different sources and integrated into a single database called data warehouse (DWH). Based on the DWH, one or several data marts are fed with data and store it in a structure optimized for analytical queries. The most commonly used structure is the dimensional modelling technique, introduced by Ralph Kimball in the 1990s. The idea behind the dimensional data model is to separate the measured data from the context. The measurements, also called facts, usually yield values (called fact measures) which are captured during the execution of a business process [8]. This whole structure can be modelled using a bus-matrix, which logically connects business processes with analytics dimensions. On top of these data marts, reports are created which contain relevant information for business users.

BI projects

Avanade identified that 91% of all companies are using BI tools for analysing and managing their data [9]. According to a Gartner report, BI will continue to be an important topic with most company's CIOs until 2017 and the adoption of BI tools within companies will continue to grow [3]. Despite the high awareness of BI, still less than 30% of all BI projects deliver the intended value for the business. Focusing on metrics which are not relevant for the operational or strategic control of the business is one of the major fail factors in BI projects [2]. This makes it necessary that the BI initiative is driven by the business in order to create a benefit [5]

Enterprise Architecture

Gartner Inc. [10] defines an Enterprise Architecture (EA) as a "discipline for proactively and holistically leading enterprise responses to disruptive forces by identifying and analysing the execution of change toward desired business vision and outcomes". Lankhorst [11, p. 10] adds that the alignment of business and IT leads to lower costs and other benefits and that a good enterprise architecture helps to translate the corporate strategy to daily operations which is one of the key points in achieving business success [11, p. 3]. To support Enterprise Architecture design, several frameworks have been developed by different authors with different purposes, like the Zachman Enterprise Architecture Framework or The Open Group Architecture Framework (TOGAF). Existing tools allow the modelling of relations between business goals, KPIs and processes, however, no tool has been found which provides a holistic view on the company and bridges the gap between enterprise architecture and BI.

Business Modelling

In the last 15 years business people are becoming increasingly aware of the importance of a model and start to create models of their processes, goals, strategies, rules or policies. One of the drivers why business modelling became popular is the changing economics of corporate information technology and the need to better align IT activities with business needs. However, there are several kinds of business modelling techniques, each supporting its specific purpose [12, pp. 1–4]. Creating a model of the business and aligning it with IT or BI initiatives can facilitate the communication between these worlds and thus lead to better understanding and more sustainable results. Orr et al. [13] add that business modelling is a very important task and can bring a huge benefit on communicating the strategy as well as strategy definition and allow a more thorough analysis of the business. An example for a modelling notation that allows business modelling is BMM, which provides a meta-model for developing, communicating and managing business plans in an organised and systematic way.

4 Case analysis

We performed case analyses of BI projects to understand how an alignment of the projects with the enterprise architecture was done and how the quality of that alignment impacted the success of the projects. We analyzed two real-world BI projects, a successful one and one that can be regarded as failed, based on project documentation, follow-up documents as well as interviews with involved people.

The goal is to identify which artefacts were generated during the projects and how well they supported the communication between the project's stakeholders and hence the generation of business value.

The first case focuses on the development of a new BI system for multiple departments of a Swiss health insurance company. The scope of the project was to replace the existing manual reporting process with a flexible and easy-to-maintain BI system, thus minimizing the effort and at the same time the quality of reporting. In the initial phase, the relevant core processes were analysed and measurements were defined. Then, the company's balanced scorecard was reviewed and KPIs were defined and specified, including the data sources, dimensions and periodicity. A bus-matrix was defined as a documentation and guide for the subsequent implementation. Several changes to the initial requirements were necessary during the project, however, due to the close involvement of the senior management and their understanding of the technical implications, the impact of the changes could always be made visible to the sponsors. The system was accepted without restrictions and was made available to the users. Besides the initially defined project goals, the company experienced further advantages that were enabled by the use of the system.

The second case is about a rather big BI project carried out for the financial department of a transportation company. Since years, the company was relying on dozens of different reports, based on data gathered from various sources across departments, to steer its business activities and track its financials. The goal was to implement a standardised/harmonised, yet flexible and easy-to-use solution that would increase the transparency, efficiency and reporting functionality. After the requirements engineering phase, the solution architecture was defined and the project team started to work on the project according to the initial specification. Eventually, after two years, a completely new BI system was introduced that was implemented according to the initial specification. However, within weeks the newly developed system was withdrawn since the business strategy had changed and the previously defined KPIs and reports were no longer relevant.

Although both cases were initially aligned to the company's goals by the use of balanced scorecards and KPI mapping tables, the way these tools were used was very different. While in the second case, the senior management was only involved during the initial phase of the requirements engineering, the involvement of the senior management in the first case was much closer, including a certain understanding of how the technical solutions supported the project goals.

In the second case, however, the senior management had no understanding of the technical relationships as they were not involved during the system's design phase. Obviously, becoming familiar with the artefacts produced by the project team (bus matrix, KPI definitions) was too cumbersome for the management in this case. We hypothesise that artefacts with a significantly lower complexity might have increased the management's commitment by reducing the communication barrier. Possibly, that would also have made it possible to understand the effect of potentially small changes in requirements to the overall BI.

5 The BI Project Model (BIPM)

The BI Project Model (BIPM) extends the already existing BMM with aspects relevant for modelling and aligning BI projects. This extension was implemented using the ADOxx meta-modelling platform[1], but it should be easily transferable to other modelling environments. Figure 1 shows an extract of the BMM class diagram with the most relevant BMM classes colored in blue and the BIPM extensions colored in orange as well as the proposed relations between these classes. These additional classes were identified based on both the elements relevant for a BI system as well as the commonly used structure within a BI system suggested by the literature [14]. The class "Source System" represents a transactional system like a cash system or a production control system which are the systems that generate the data used for analysis. The "Fact" class represents the fact table where the relevant transactions of the executed business process are stored, based on Kimball's dimensional design model [14].

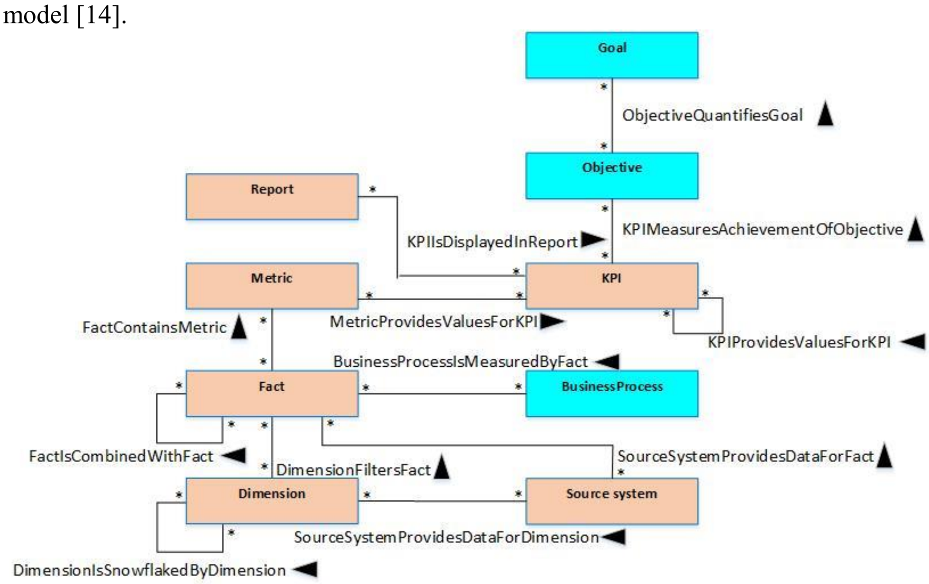

Figure 1: BMM class diagram with BIPM extension

The class "Dimension" represents a dimension in a BI data model which is necessary to provide a meaning for the analyses of the measures captured in the fact table and allow the measure to be put into a specific context. The "Metric" class represents a numerical value, which is stored in the fact table and can be used for

[1] http://www.adoxx.org/live/home

measurements. The "KPI" class represents a numerical value that is calculated based on one or several metrics and is used for measuring the achievement of an objective. Therefore, a KPI is very closely related to the "Objective" concept as well as the "Metric" concept and cannot only store a specific value but also target values or thresholds. The class "Report" could be used to visualize in which report which KPIs are used and can therefore be of help especially in follow-on projects to identify which reports are impacted when a KPI is changed. All these classes contain one or multiple attributes, like the name of the element or the containing data fields, which can be used to specify the purpose and the content of a class in more detail.

Since a major goal of the BIPM is the facilitation of the communication between stakeholders, especially between IT and business, a graphical representation of the meta-model was developed, which is easily understandable by both parties.

In order to facilitate the readability and clarity of the model, each class has its dedicated graphical representation, which makes it easier to understand, especially for people not familiar with BI projects, which elements are part of the BI project and how they are related to one another as well as to the company's business model. Possible relations between the elements are visible in Figure 1 and examples of the relations can be found in Figure 3. The following table shows the different graphical representations as well as their meaning.

				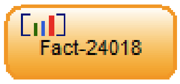	
Report	KPI	Metric	Dimension	Fact	Source System

Table 1: Concepts of BIPM

The modelling procedure for BIPM is visualized in Figure 2 by showing the steps necessary to create a BIPM from scratch.

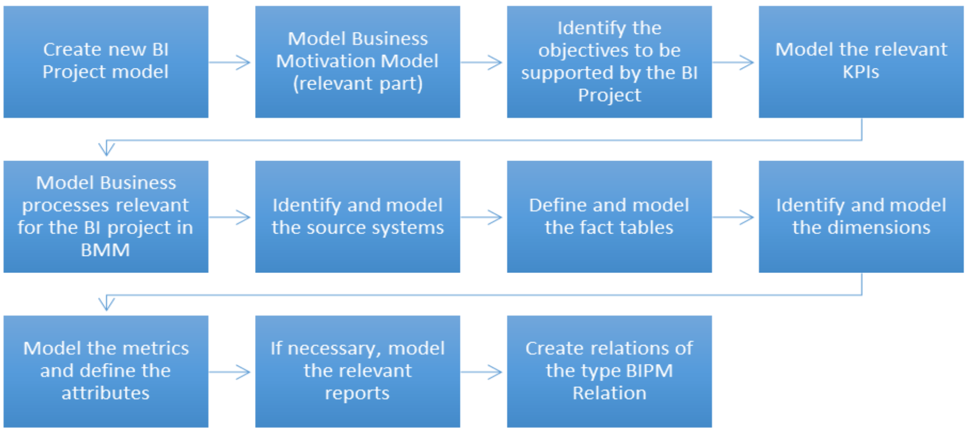

Figure 2: Procedure for creating a BI Project Model

According to Karagiannis & Kühn [15, p. 2] a modelling technique consists of two main components, the modelling language and the modelling procedure. They define the modelling procedure as a description of the necessary steps for applying the modelling language in order to create a result. The steps and their order of execution are based on both the logical order for creating a BIPM model as well as Kimball's four-step dimensional design process [14, pp. 246–248] in a slightly adapted way.

Figure 3 depicts the structure of a BI project modelled in BIPM.

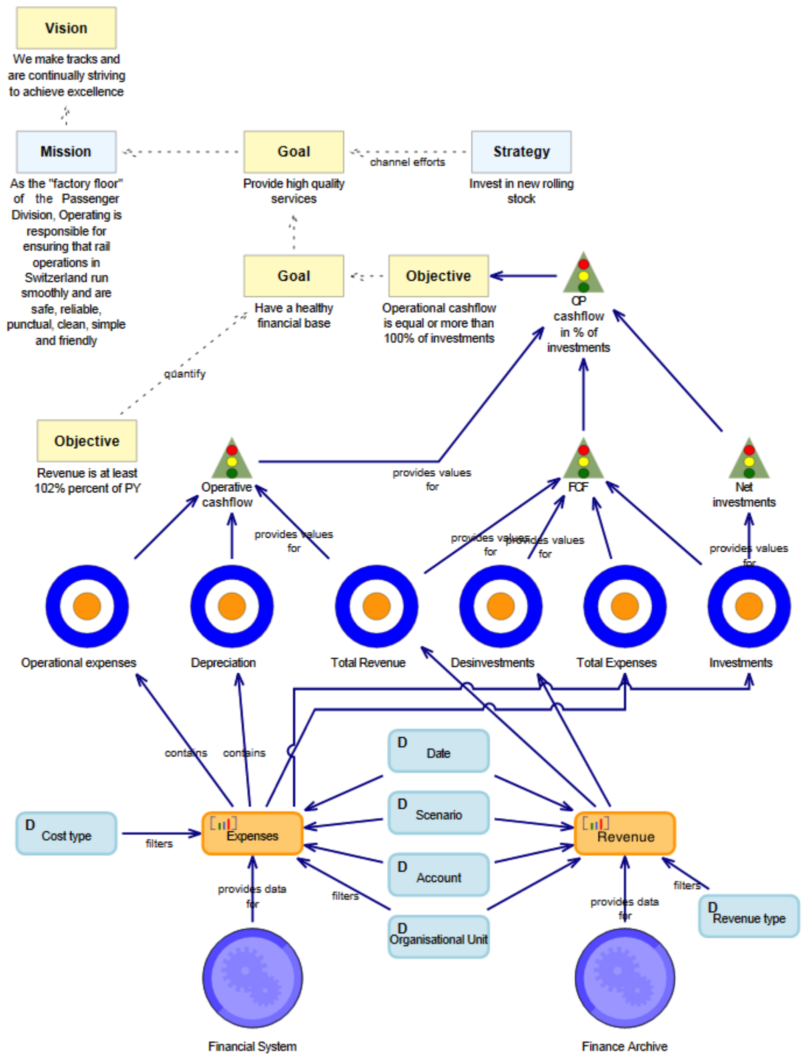

Figure 3: A small BI project modelled using BIPM

The upper part of the picture shows the business motivation containing the company's vision, strategy and goals. The lower part contains the BI project using the

BIPM extension. Both parts are connected via the relation between the BMM's "Objective" class and BIPM's "KPI" class. This relation allows the modeler to specify, which objective of the company's business model is supported by which KPI – the starting point of a top-down modelled BI project. By following the relations between the class instances, the data lineage can clearly be identified, from the KPI down to the involved source systems or vice-versa.

6 Evaluation

The goal of the evaluation was to evaluate whether the use of the BI project model as a modelling notation for BI projects would be helpful and whether it provides a significant benefit over the use of already existing and applied tools like the dimensional design model or the bus-matrix with regards to the communication aspect. This evaluation was done by remodeling a real-world case and conducting sets of interviews with several pairs of persons who are unfamiliar with the specific case. Each interview set contains two individual interviews with people having a similar educational and professional background, Table 2 presents a summary of the interview results:

Questions	Interview set 1		Interview set 2	
	without BIPM	with BIPM	without BIPM	with BIPM
Time until a statement about the project can be made	approx. 13 min	approx. 4 min	approx. 15 min	approx. 3 min
Identified number of company goals supported by the project	0 of 2	2 of 2	0 of 2	2 of 2
Number of correct namings of metrics	0 of 5	5 of 5	0 of 5	5 of 5
Steps performed to name the metrics	-	1	-	1
Time needed to identify the table to add attributes to the insurant	Less than 1 min	Less than 1 min	approx. 5 min	approx. 2 min
Correctly identified source systems	9 of 9	9 of 9	9 of 9	9 of 9
Correctly named business processes relevant for the project	0 of 2	1 of 2	0 of 2	2 of 2
Time needed for identifying the source system for comparing premium calculation data	2 min	approx. 1 min	-	approx. 1 min
Total time needed to answer all the questions	approx. 36 min	approx. 22 min	approx. 42 min	approx. 19 min

Table 2: Summary of evaluation interviews

Both interviewees had to answer several questions about the project – short versions of these questions are presented in the leftmost column of Table 2. These questions were chosen to cover important aspects from various layers – from strategic goals down to source systems – of a BI project. To help them find the answers, one of the interviewees was provided with the BI project model of the case and the other one with the traditional documentation. A total of two interview sets – four individual interviews - were conducted. From the summary of the interviews in Table 2, it becomes clear that the interviewees who answered the interview questions only with the help of a BIPM model were able to answer the questions in about half the time compared to the interviewees with the traditional information. Further, the answers were more accurate and they could identify several elements which were not identifiable at all using the traditional documentation. The interview partners with BIPM both agreed that such a model could be of great help as it is more easily understandable and is especially helpful when trying to identify the interdependencies between the elements. However, they suggested that the visual representation of the objects could still be enhanced.

7 Conclusion

The result of our research is a holistic modelling technique consisting of both a modelling notation as well as a modelling procedure to create graphical models of BI projects. A meta-model library was implemented using the ADOxx meta-modelling platform (www.adoxx.org) which allows the creation of specific BIPM models.

The evaluation, described in section 6, has shown that the BIPM models were clearly preferred by the interviewees and they were able to provide better answers to the questions in less time. Although the existing project documentation provided a more detailed insight into the project than the BIPM models did, the latter allowed the interviewees to get a clear and holistic picture of the project in a much shorter time and gain a better understanding of the main project elements. What they particularly liked in the BIPM models were the visible relations between the elements of the BI project as well as the relation to specific business objectives.

One can therefore conclude that in these cases the BIPM models provide a representation of the BI project which is easier and quicker to understand for people who are not closely involved in the project or who have little to time to get familiar with it. Given these results, and looking back at the findings about the failed BI project in Section 4, it is reasonable to assume that BIPM would be an important step in facilitating management understanding of BI projects and hence increase their commitment. This, in turn, will make it possible to avoid project failures as the one described in Section 4. In a further research step, the modelling technique should be evaluated during real BI projects.

Since the modelling-technique is neither industry nor technology specific, it can be assumed that it can also be applied in BI projects conducted in different industry sectors. This proof, however, has to be done in a subsequent research project.

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From Visual Language to Ontology Representation: Using OWL for Transitivity Analysis in 4EM

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Abstract. Usually, enterprise models consider different aspects and include different abstraction levels of enterprises. The application of ontologies as conceptual bases that can clarify relations within and between these abstraction levels is believed to be helpful. This paper investigates the use of ontologies for formalizing enterprise modelling languages and enriching their semantics. The aim is to transform enterprise models into ontologies based on a mapping of the enterprise models' meta-model into a semantically corresponding ontology. The ontology representation then is used to check logical consistency and to infer new facts regarding the implications of the model beyond what would be possible with a visual modelling language. In order to check feasibility and pertinence of our approach, we selected the goal modelling part of the 4EM method. This paper provides (1) a formal OWL representation of the 4EM goals meta-model; (2) a systematization of transitive goal properties; (3) a set of SWRL rules expressing these transitivity; and (4) an analysis of exemplary goals model instances.

Keywords: 4EM, OWL, Enterprise Architecture, Enterprise Modelling, Goal Modelling, SWRL, Enterprise Model Analysis, Meta-Modelling.

1 Introduction

In general terms, enterprise modelling is addressing the systematic analysis and modelling of processes, organization structures, products, IT-systems or other perspectives relevant for the modelling purpose [1]. Usually, enterprise models consider different enterprise aspects and include different abstraction levels induced by refinements of, e.g., processes into sub-processes or goals into sub-goals. Ontologies are content theories about the sorts of objects, properties of objects and relations between objects possible in a specified knowledge domain [2]. The application of ontologies as conceptual bases that can clarify relations within and between different abstraction levels in enterprise models is believed to be helpful. Ontologies have shown their usability for this type of tasks. They provide a way of knowledge representation, which is widely used today for intelligent analysis of

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knowledge. As a consequence of this, ontologies will also have the power to clarify the relations between focal areas and the constructs within a focal area [3].

This paper investigates the use of ontologies for formalizing enterprise modelling languages and enriching their semantics. The focus in this context is on visual languages which have the advantage to be better understandable by non-experts in enterprises but which in most cases lack operational semantics (see [4] for an overview). More concrete, we aim at transforming enterprise models into ontologies based on a mapping of the enterprise models' meta-model into a semantically corresponding ontology. From the existing ontology representations, we will use the W3C recommendation ontology language OWL (Web Ontology language) in its version OWL2 to represent the ontology. An OWL ontology consists of Individuals, Properties and Classes.

The ontology representation then is used to check logical consistency and to infer new facts regarding the implications of the model beyond what would be possible with a visual modelling language. In order to check feasibility and pertinence of our approach, we selected one modelling language (4EM; see section 2) and focused within 4EM on the goal modelling part.

This paper provides (1) a formal OWL representation of the 4EM Goals meta-model; (2) a systematization of transitive goal properties; (3) a set of SWRL rules expressing this transitivity; and (4) an analysis of exemplary goals model instances.

The remainder of the paper is structured as follows: Section 2 describes the construction of an ontology representing the 4EM meta-model for goal modelling. Section 3 shows how this ontology can be enriched by adding transitivity rules. Section 4 provides a validation of the formalized meta-model by instantiating an example model coming with the 4EM specification in [5]. Section 5 summarizes the work and discusses future activities.

2 4EM Goal Modelling Ontology

Experience reports on Enterprise Modelling indicate both, the usefulness of ontology representations [6] and the inclusion of goals [7]. Ontologies have been used for many years for representing enterprise models. The most popular examples are probably Uschold et al.'s "The Enterprise Ontology" [8] and Dietz's DEMO approach [9]. Although the Enterprise Ontology aims at representing business objectives, an appropriate concept structure for representing goal relations is not available. In DEMO, goals could be represented by using the "agendum" concept, but this concept has a wider meaning than just goals. The DIO ontology provides representation of the ArchiMate meta-model [10]. ArchiMate's motivation extension allows for the representation of goals. However, structured goal hierarchies and relations for other perspectives in enterprise models are not developed in ArchiMate to the same extent as in 4EM.

From the existing EM methods, the „For Enterprise Modelling (4EM)" [4] has been selected for this paper because of the expressive goal modelling possibilities and the publicly available documentation including an informal meta-model. 4EM uses six interrelated sub-models which complement each other and capture different views of the enterprise, i.e. each of the sub-models represents some aspect of the enterprise.

These sub-models are: (1) Goals Model, (2) Business Rule Model , (3) Concepts Model, (4) Business Processes Model, (5) Actors and Resources Model, and (6) Technical Components Model.

The Goals Model focuses on describing the goals of the enterprise. This model captures what the enterprise and its employees want to achieve, or to avoid. Goals Models usually clarify questions, such as:

- Are there conflict/support relationships between goals?
- Are there constraints/problems that hinder the achievement of a goal?
- What sub-goals have to be achieved in order to achieve a goal?
- What generally hinders/supports the achievement of a goal?

These so called Competency Questions (QC) can be used as a requirements specification for an ontology on the domain of enterprise goals [11].

Especially in complex models visual analysis of these aspects is error prone. If a sub-goal is in a conflict or underlies some constraints, these circumstances should also be considered at top-level. Furthermore, inherent inconsistencies like supporting top-level goals having conflicting sub-goals need attention. Ontology-based reasoning provides a tool to assess these issues stemming from transitive relationships in goal modelling.

In the following, the ontological representation of the 4EM Goals meta-model will be constructed according to the 4EM method description in [5, pp. 87-101]. First the taxonomy of goals model component types (classes) is constructed. In a second step, the construction of binary and n-ary relationship types follows. Relationship transitivity is discussed separately in section 3 because it is not specified in [5]

2.1 Goal Model Component Types

The model component types are represented as classes in OWL. All goals model component types are represented as specializations of the abstract class `GM_ModellingComponent`. The `Goal` class represents goals or objectives respectively. The 4EM method describes priority and criticality as optional attributes for goals. These have not been considered in the meta-model so far. This is kept for later work. Problems symbolize environmental circumstances that hinder the achievement of goals. Problems can be described more specifically as weaknesses (internal factors) and threats (external factors. Problems are represented in OWL with the `Goal` class and its sub-classes `Threat` and `Weakness`. A cause expresses explanations or reasons for problems (`Cause` class). Apart from causes, constraints (`Constraint` class) express business restrictions, laws or external policies that affect components of the goals model. The last component type are opportunities (`Opportunity` class) which symbolize resources supporting the achievement of certain goals.

2.2 Goal Model Binary Relationship Types

Relationship types are represented as object properties in OWL. Object properties are directed binary relationships. Further semantics can be added to object properties by defining characteristics like transitivity and relations to other object properties, including specialization/generalization.

The 4EM goals model describes four binary relationship types. First, the `supports` relationship shows that fulfilling one goal also supports the achievement of another. Furthermore, the relationship is used to relate opportunities to goals. The `contradicts` relationship in contrast shows that the achievement of one goal is in conflict with another. This relationship is considered to be symmetric. Hence, if goal A contradicts goal B also goal B contradicts goal A. The `hinders` relationship is less strict. It can be used between model components to show negative influences. This relationship is not considered symmetric but can also be used to link goals. The last binary relationship is the `causes` relationship. It is used to link causes to problems.

Experience from ontology engineering shows that inverse relationships should be included in an ontology in order to fully specify concept relationships. For example, a problem can be linked to one of its causes by a `caused_by` relationship. These inverse relationships are automatically added to instances by OWL reasoning if defined in the meta-model. Table 1 shows the specification of the binary relationships.

Table 1. Goals Model Object Properties

Object Property	Domain	Range	Inverse	Characteristics
supports	Supporter	Goal	supported_by	transitive
contradicts	Goal	Goal	-	symmetric
hinders	Hinderer	Goal	hindered_by	-
causes	Cause	Problem	caused_by	-

Two additional abstract classes have been added. `Supporter` for goals model element types that can support the achievement of a goal (sub-classes `Goal` and Opportunity) and `Hinderer` for element types that can have a negative influence on the achievement of a goal (sub-classes `Goal`, `Problem`, and `Constraint`). The supports relationship is considered to be transitive. Hence, if A supports B and B supports C, A also supports C. Similar assumptions cannot be made for the other binary relationships.

2.3 Goal Model N-ary Relationship Types

N-ary relationships define semantics of goal decomposition in the 4EM goals model. The AND-relationship decomposes a top-goal into a set of sub-goals that have to be fulfilled each in order to achieve the top-goal. The OR-relationship defines a set of sub-goals where it is sufficient to fulfill one of the alternatives. Finally the AND/OR-relationship needs a combination of some of the sub-goals to be fulfilled. N-ary relationships are not directly supported in OWL. Logical Ontology Design Patterns can be used in order to model cases where the ontology language does not provide appropriate constructs [12]. The catalogue of the NeON-projects provides the n-ary relationship pattern for modelling such relationship types in OWL [13]. A class for the relationship type is created and appropriate object properties are associated. For goals modelling, the abstract class `GoalComposition` is used to represent decomposition of goals. The respective sub-classes are `ANDGoals`, `ORGoals`, and

ANDORGoals. Accordingly, object properties have been defined. The compositionTopGoal property assigns the goal to be decomposed and the compositionSubGoal property assigns the sub-goals. topGoalComposedBy and SubGoalComposedIn are the respective inverse properties. According to the 4EM method, goal composition structures are special cases of the supports relationship. Therefore, the chain of composition object properties is defined as a sub-property of supports (subGoalComposedIn o compositionTopGoal SubPropertyOf supports). Fig. 1 shows the complete OWL class hierarchy that is used to represent the 4EM goals meta-model.

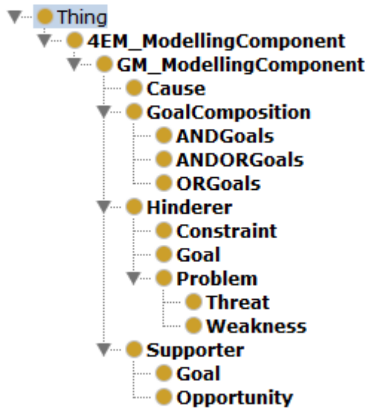

Fig. 1. Extended Class Hierarchy of the 4EM Goals Meta-Model

3 Transitivity Rules

After modelling the 4EM goals meta-model, the possibility of formal statements regarding transitivity of goal properties is investigated. In a first step a systematic analysis of possible property propagations between goals is performed (section 3.1) . In a second step, the formalization of found transitivity is discussed (section 3.2).

3.1 Transitivity of Goal Properties

By systematically investigating transitivity we analyse which object properties are shared between goals based on the possible goal-to-goal relationships. In addition, we also ask which object properties may be assumed for a goal at the target of a goal-to-goal relationship based on the object properties of the goal at the origin. Table 2 shows all possible combinations and the assumptions made for transitivity. The columns contain the goal-to-goal relationships. Considering the direction of these relationships, the direction of property propagation is set. Relationship semantics do not allow property propagation along the inverse relationships defined in section 2.

For example, if goal A is hindered by some hinderer H and supported by goal B no assumptions can be made for the relationship between B and H.

The rows contain the object properties to be propagated. Referring to the discussion in section 2, these include the relationships originally defined by the 4EM method and their inverse properties as well. For example, a goal can hinder another goal and can be hindered by some Hinderer as well.

A first decision made for transitivity specification is the exclusion of property propagation via goal conflicts and hinders relationships. For example, if goal B hinders goal A and goal B is hindered by goal C no assumption can be made that goal C supports goal A (double negation). The same applies for the contradiction relationship. Influences like constraints and problems that pose difficulties for the achievement of a goal may not influence the achievement of another goal at all or may also have a negative influence on it. Furthermore, goals are desired future states. Conflicts between goals need to be solved by a decision in favor of one of the goals or by relating the degree of goal fulfillment. The focus should be on the goals not on relating the context of one goal to the other.

The situation is different for supports relationships between goals. The semantics of these relationships means that a sub-goal is a more specified part of the top-goal (cf. [5]). Thus, the context of the sub-goals is also part of the top-goals' context. This is also true for goal compositions. As described in section 2, goal compositions form specializations of the supports relationship. Thus, their semantics are generally the same. This is also true for object property propagation. However, the AND-composition requiring all sub-goals to be fulfilled allows for the definition of more strict (specialized) semantics for object property propagation. In consequence, table 3 has just two columns: for the supports relationship and for the AND-composition.

Propagating hinders, supports and contradicts via supports relationships is not considered. In contrast to the AND composition, the sub-goal is not required to be fulfilled in order to achieve the supported top-goal. For example, if goal A supports goal B and goal A hinders goal C, it cannot be concluded that the fulfillment of goal A also hinders goal C.

Table 2. Object Property Transitivity by Goal-to-Goal Relationships

	supports	**AND composed in**
hindered by	hindered by	hindered by
supported by	supported by	supported by
contradicts	hindered by	contradicts
AND composed by	supported by	AND composed by
OR composed by	supported by	supported by
AND/OR composed by	supported by	supported by
hinders	-	hinders
supports	-	supports
contradicts	-	contradicts

3.2 Formalization

After clarifying which object property propagation semantics should be supported, a formalization of these semantics is required. Generally, there are two possibilities to add such object property related semantics for inference mechanisms. First, the OWL language can be used. Here, object property axioms provide means to infer object property assertions (relationships between instances) based on existing object property assertions. Second, a rule language like SWRL can be used. Here, new facts are inferred based on a test of freely defined OWL statements against the ontology. If the body of a rule is found to be true its head is considered true as well and a new fact can be added to the ontology.

Transitivity of the supports relationship has already been defined in section 2 and can be expressed in OWL. However, property chains as introduced in section 2 are not fully supported by current OWL reasoning tools (Hermit 1.3.8). Thus, only SWRL rules are used to address the transitivity along property chains and n-ary relations. Table 4 shows the resulting formalization of the transitivity rules discussed in section 3.1. An ontology containing the instances of the example from section 4 can be found here: http://win.informatik.uni-rostock.de/uploads/media/4EM_GM.owl

Table 3. OWL/SWRL Formalization of Object Property Transitivity

supports	
hindered by	hinders(?c,?SubGoal),supports(?SubGoal,?TopGoal) -> hinders(?c,?TopGoal)
supported by	supports is defined transitive
contradicts	supports(?SubGoal, ?TopGoal), contradicts(?h, ?SubGoal) -> hinders(?h, ?TopGoal)
AND composed by OR composed by	subGoalComposedIn(?SubGoal,?Comp), compositionTopGoal(?Comp,?TopGoal) -> supports(?SubGoal,?TopGoal)
AND/OR composed by	supports is defined transitive
AND composed in	
hindered by	subGoalComposedIn(?SubGoal,?Comp), compositionTopGoal(?Comp,?TopGoal) -> supports(?SubGoal,?TopGoal) hinders(?c,?SubGoal),supports(?SubGoal,?TopGoal) -> hinders(?c,?TopGoal)
supported by	subGoalComposedIn(?SubGoal,?Comp), compositionTopGoal(?Comp,?TopGoal) -> supports(?SubGoal,?TopGoal) supports is defined transitive
contradicts	ANDGoals(?ANDComp), compositionSubGoal(?ANDComp, ?SubGoal), compositionTopGoal(?ANDComp,?TopGoal),contradicts(?c,?SubGoal) -> contradicts(?c, ?TopGoal)
AND composed by	ANDGoals(?ANDComp), compositionSubGoal(?ANDComp, ?SubGoal), compositionTopGoal(?ANDComp,?TopGoal), ANDGoals(?ANDSubComp), compositionSubGoal(?ANDSubComp, ?SubSubGoal), compositionTopGoal(?ANDSubComp,?SubGoal) -> compositionSubGoal(?ANDComp, ?SubSubGoal)
OR composed by AND/OR	subGoalComposedIn(?SubGoal,?Comp), compositionTopGoal(?Comp,?TopGoal) -> supports(?SubGoal,?TopGoal)

composed by	`supports` is defined transitive
hinders	`ANDGoals(?ANDComp), compositionSubGoal(?ANDComp, ?SubGoal), compositionTopGoal(?ANDComp, ?TopGoal), hinders(?SubGoal, ?c) -> hinders(?TopGoal, ?c)`
supports	`ANDGoals(?ANDComp), compositionSubGoal(?ANDComp, ?SubGoal), compositionTopGoal(?ANDComp, ?TopGoal), supports(?SubGoal,?c) -> supports(?TopGoal, ?c)`
contradicts	`contradicts` is defined symmetric

4 Exemplary Model Analysis

In order to assess the applicability of the ontology to 4EM Goals models and the benefits of OWL reasoning, we have adopted the exemplary A4Y case from [5]. Some minor changes have been made in order to add complexity and to simulate a less systematic modelling. The hinders relationship between Goal 2 and 3 in [5] has been removed in favor of a sub-goal (Goal 10) of Goal 2 hindering Goal 3. Furthermore, Goal 10 has been split into 2 two goals (9 and 10).

It was possible to instantiate the complete model using the ontology. Furthermore, inference with the Hermit 1.3.8 reasoner added new facts to the model. No logical errors have been found. Regarding the relationship between Goal2 and Goal 3 it was inferred that Goal 2 hinders Goal 3 because Goal 10 is necessary to achieve Goal 2 and hinders Goal 3 at the same time (see Fig. 3). Thus, even if those hidden relationships are not modelled directly they reveal by reasoning using the proposed ontology schema and rules. Furthermore, the complete context is constructed automatically for a goal. All hindering and supporting influences are assigned to the goals for detailed analysis. Thus the Competency Questions formulated in section 2 can be answered by the ontology. The ontology allows for inferring hidden contradictions and hinders relations as described for the case of Goal 2 and Goal 3. These could be missed when relying on visual analysis only. Additionally, ontology based queries can be performed for further analysis. For example, goals that have hinders and supports relationships to each other at the same time need special attention and can be identified (G2 supports and hinders G1 in Fig. 3). Reasons may be conflicting sub-goals.

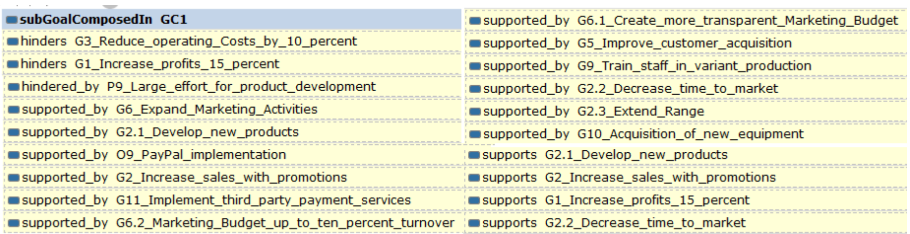

Fig. 2. Inferred Relations for Goal 2 "Increase Sales with Promotions"

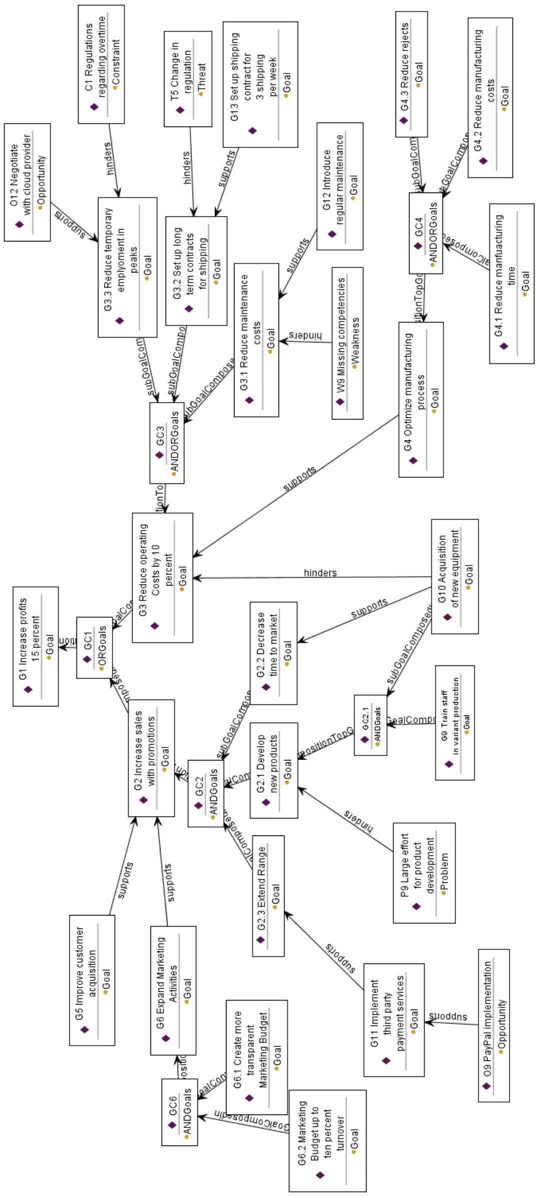

Fig. 3. Exemplary Goals Model Instance

5 Summary and Outlook

Based on the example of 4EM goal modelling, this paper investigated the possibility to transform meta-models of existing enterprise modelling languages into ontologies.

The purpose of this transformation was to further specify the relations between focal areas and the constructs within a focal area, to check logical consistency, and to infer new facts regarding the implications of the model beyond what would be possible with a visual modelling language.
Our work showed that the developed ontology is applicable and the implemented reasoning provides support for analysis of the goal model.

Future work will have to investigate the implications of an ontology-based formalization for 4EM and the transferability of results to other enterprise modelling languages. In order to understand the implications for 4EM we started to capture the complete meta-model of 4EM in an ontology, i.e. to extend the goal modelling ontology to all perspectives of 4EM. This overall 4EM ontology will have to be used to check inconsistencies and clarification needs in 4EM. We expect that more transitivity rules and reverse relationships will have to be added. Regarding transferability to other enterprise modelling languages, we do not expect general problems as long as the language in question does not define operational semantics.

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Ontology-based Modeling of Cloud Services: Challenges and Perspectives

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Abstract. Cloud services (CCS) are a crucial element in the service sector, but there are still challenges left in their design, implementation, operation and dismissal, due to issues such as the integration of physical and technical components, interaction of social and technical aspects, dynamic and elastic reconfiguration. In modelling service systems, ontologies have been recognized as a useful instrument for reducing conceptual ambiguities and inconsistencies. However, none of the general approaches proposed in literature have addressed the specific aspects of CCS. In this perspective, we explore how the UFO-S core ontology can be used to describe IT services and, in particular, CCS. A case study and the challenges deriving by CCS are discussed.

Key words: Cloud services, Service ontology, Core ontology

1 Introduction and Motivations

For many years, services have been investigated from the economic, financial and juridical viewpoints due to their socio-economic relevance. More recently, IT services have become a very active field of study, due to the complex interplay among the above-mentioned aspects and the peculiar features of the digital milieu (e.g. ubiquity, mobility, context-awareness). Cloud computing services (CCSs) differ from traditional IT services for some characteristics, such as abstraction from the underlying hardware/software infrastructure, multi-platform accessibility, on-demand service provisioning, pay-per-use-based business models, dynamic quality of service (QoS) management, scalability and flexibility. These peculiarities, which are responsible for the rapid emergence of a large number of CCSs, motivate the importance of a specific analysis.

From the customer perspective, “the great amount of CCSs makes it hard to compare the offers and to find the right service” [11, p. 81]. The customer needs

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to evaluate service features and expected outcomes, their correspondence to his needs, the risks associated to the service (e.g., lock in, security) and the opportunities (e.g., integration with other services). Starting from these considerations, the customer can choose which service to buy. This information is also useful to the provider for strategic purposes; for instance in order to evaluate possible service compositions, service pricing, or the dynamic allocation of resources [23].

It seems clear that a proper analysis of CCS from the conceptual perspective requires a holistic approach, taking the whole *service system* into account. This means understanding target customers, relations among actors, and the specific ways of value co-creation. In turn, this demands understanding the way in which actors operate, interact and use resources to co-create value.

In modelling service systems, ontologies have been recognized as a useful instrument for reducing conceptual ambiguities and inconsistencies [5, 17, **?**, 16]. None of these general approaches, however, have addressed the peculiarities of CCS. In this paper we would like to explore how a general ontology of services – the core ontology of services developed in [16], named UFO-S – can be used to describe IT services, and in particular CCS. The choice of UFO-S for our analysis is due to some of its peculiarities with respect to other service ontologies [16]: (a) by communicating commitment-related aspects, it reinforces the importance of what "contract" and "policy" elements represent in service relations; (b) it clearly defines the roles of target customer, service customer, service provider, and so on, important for understanding the dynamics of service relations; (c) it incorporates the notion of commitments into dynamics of behavior in service provisioning; (d) taking a foundational ontology, UFO [8], as a basis, UFO-S incorporates a clear distinction between capabilities, their application, and resources; (e) it offers means for characterizing service specifications in terms of service commitments, often neglected in computational approaches.

Our aim is to identify which are the changes needed to UFO-S in order to account for CCS and which are the aspects that can be already modelled using the existing primitives. This will be based on the application of UFO-S to a specific case study, which – besides the immediate relevance to the cloud computing domain – represents a particularly complex domain.

The remainder of the paper is structured as follows. In Sec. 2, we outline the peculiarities of CCS, thus setting the groundwork on why these services pose more challenges than other IT services. In Sec. 3 we shortly recap UFO-S, which we use to model a case study (Sec. 4). Finally, based on the previous sections, we outline the main modeling challenges for IT services (Sec. 5).

2 Cloud Services

Cloud services are based on the cloud computing technology, which has been defined by the National Institute of Standards and Technology (NIST) as "*a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources [. . .]*" ([14], p. 3).

The heterogeneity in CCSs is so significant [11] that they can hardly be classified in a simple way. Among the most relevant classification factors proposed in the literature [14, 12, 11, 10, 18, 19] we can mention the service model, the underlying architecture, the license type, the pricing policy and other aspects. Based on these various aspects of CCS, a few taxonomies [10, 11, 19] and ontologies [22, 15] have been proposed. In the following, we address some of these aspects relevant for the ideas discussed in this pape

Service deployment is a complex process that undergoes several phases (collectively known as service lifecycle), such as service design, service implementation, service offering, service negotiation and agreement, service delivery, service support and service end-of-life management [13, 16].

On a first approximation, there are four main roles involved, namely service provider, service producer, service customer and service consumer [6] (or end-user [13]). A service provider is the agent who commits to have the service executed, while the service producer is the agent that actually performs the core service actions. These two roles may be played by the same actor, but this is not always the case. Furthermore, the service customer is the one that requests the service and then negotiates for its customized delivery, while the consumer is its direct beneficiary. Customer and consumer may or may not coincide. In the case of CCS, eight roles have been identified [2], as outlined in the following.

Providers can be either application providers, platform providers or infrastructure providers. The application provider provides applications to customers and is responsible for overall service monitoring and quality assurance. The platform provider offers "*an environment to develop, run and test applications*" ([2], p. 6). Finally, the infrastructure provider is concerned with the offering of virtual hardware and network connections.

Intermediate roles are played by consultants, aggregators and integrators. Consultants offer expertise on cloud computing and on the customer's business processes and requirements. Aggregators assemble CCS in order to provide more complex solutions. Integrators intervene when there is not a previous aggregation of CCS, but it is the customer that decide which services to integrate. Finally, consumers are the direct beneficiaries of the service.

Cloud services are characterised by high dynamicity from different points of view. We can distinguish the requirement layer (from the customer/consumer perspective), the resource layer, the value layer and the legal layer. From the customer perspective, requirements towards service functionalities – based on customers' goals, which can rapidly change – are the basis for choosing among services and differs based on the user community, which may have different needs. From the provider perspective, the dinamicity in the demand of the service brings to the dinamicity at the resource layer, in terms of capabilities required to design, develop and deploy the service. In accordance with with the resource-based view theory [21], resources and competences affects products value. Consequently the dinamicity at the resource layer creates value dinamicity, which affects both customers and providers. The resource dinamicity is also affected by the legal one, which concerns all the terms established in the SLA or the constraints set by law, which gains more importance due to the issue of service contracts that cross multiple jurisdictions. For what regards CCS, the resource dinamicity is the most critical factor, since cloud computing implies by definition a dynamic allocation of resources. This issue needs to be faced starting from service design, i.e. the service needs to be highly user-adjustableIndeed. More in general, the provider has to guarantee the contractually defined levels of service, allocating "*limited resources among competing users*" ([1], p. 16) in order to satisfy the agreed service levels while still minimizing the operational costs [23] and maximize potential revenues and perceived value. In this sense, the dynamism of user requirements, legal constraints and allocated resources, implies a dynamism of both the value proposition of the provider and the customer expected and perceived value. These considerations should also constitute the basis for adequate pricing policies and for setting QoS levels (e.g., the cost email loss is higher for managers than for other employees and it may change over time).

Based on CCS characteristics and their dynamism, it is necessary to account for: (a) the different roles that actors can assume (e.g., an organization is a customer of a company and provider of another one); (b) the characteristics of the actors involved, the external environment (e.g., competitors) and the internal structure and dynamics of the organizations, also in terms of resources used.

3 Unified Foundational Ontology for Services

UFO-S, a core reference ontology for services, is able to explain a number of perspectives on services, including those that emphasize services as value co-creation, as capabilities and as application of competences [16]. UFO-S establishes the basis for the service phenomena along the service lifecycle considering the notion of commitment as foundationally necessary, in agreement with [5].

As a core ontology [20], UFO-S refines concepts of a foundational ontology – the Unified Foundational Ontology (UFO) [8, 9] – by providing a conceptualization for services that is independent of a particular application domain. From a modelling point of view, UFO-S is based upon the usage of OntoUML language [8], an ontological extension of UML that incorporates the foundational directions in UFO. We now list the stereotypes that we will adopt for the case study, while forwarding the interested readers to [8, 16] for a thorough description.

First of all, each object is considered as an instance of a *kind*, which is a substantial sortal universal. Each entity can assume a *role* depending on the context. An entity capable of covering many other concepts with different principles of identity is considered as a *mixin*. Other kinds of types can be highlighted: *phases* represent possible stages in the history of a substance sortal (e.g., for a living thing, alive and deceased). In the same way, *modes* are individuals existentially dependent on other individuals.Other basic concepts include: *agents* (e.g., person, organization); physical or social *objects*, i.e., non-agentive substantial particulars; *actions*, which stand for intentional events whose existence depends on their own participants; *resources*, i.e., objects participating in an action. In addition, a crucial role in UFO-S is played by *relators*, which can be seen as reified relationship. More exactly, relators, whose ontological nature and significance for the practice of conceptual modelling has been recently revisited in [7] can be seen as aggregations of qualities (*modes*, in UFO) inhering in related entities, accounting for the way the related entities are involved in the relationship.

The UFO stereotypes sketched so far allow us to understand how service lifecycle phases have been modelled in [16]. For explanatory purposes, let us consider here only the service negotiation phase. This phase is an *event* involving a service provider – a *physical agent* (i.e., a person) or *social agent* (e.g., enterprise) – and a target customer community, i.e., a collective referring to the group of agents to whom the service is being offered and whose *role* is target customer. The successful outcome of a service negotiation is a service agreement, which mediates the social relations between provider and customer. Similarly, the agents involved in service lifecycle phases perform specific *actions* depending on the phase they are involved into. We forward the interested reader to [16] for a thorough description of those aspects.

In this paper, we focus on two phases of the service life-cycle according to the formalization proposed in [16]. More specifically: (i) service negotiation, when provider and customer(s) negotiate in order to establish an agreement about specific aspects that drive the service delivery, and (ii) service delivery, when actions are performed in order to fulfil a service agreement.

4 Applying UFO-S: a Case Study

Let us see now how a reference ontology of services, UFO-S, can be applied to develop a service ontology concerning a concrete example of a cloud service, coming from a real case study. The case study pertains an email service internally delivered to an Italian company with more than 5000 employees spread out into more than 100 offices all over the country. The IT Department of such company was responsible for procuring this service. After a public call, two service providers were selected for the mailbox service and the networking service.

The model we developed resulting from the application of UFO-S to our case study is reported in Fig. 1. To better understand the scenario, we have divided our model in two parts, representing what happens at the *contractual level* (upper yellow layer) and at the *delivery level* (bottom green layer). The central entities in these two parts are respectively the *IT Service Contractual Relationship* and the *IT Service Factual Relationship*. This structure reflects a peculiarity of our domain, and in particular of CCS: during the service delivery phase the actual resources allocated by the provider are dynamically adjusted, and contractual aspects keep being dynamically re-negotiated while the service delivery evolve. So we have two relationships that evolve more or less at the same time: a *contractual* relationship and a *factual* relationship. Thanks to the relator construct we can account for both. In particular, as we have shown in the model, we can account for different *phases* of the contractual relationship, such as, for example, a test phase where the optimal resources to be allocated are estimated, a normal phase, and an emergency phase where for some reasons there is a scarcity of resources, and some priority policies need to be adopted on the basis of the customer's needs. Concerning the customer's needs, we can see that they are represented as a *mode* inhering in the customer, but which depends on a specific department inside the customer's organization, namely the IT department. Together with the customer's and the providers' commitments, customer's needs are part of the bundle that constitute the factual relationships, whilst only the first two are relevant for the contractual relationship.

Both relationships involve the *Hired ICT Provider*, specialized in the *network* and *mailbox* service provider, and the *Business Customer*. It is important to highlight that although it is the business customer who is bound to the contractual and factual relationships, it is the *IT Department* who participates in the *Initial Service Negotiation*. Thus, it establishes commitments and claims on behalf of the business customer. As a consequence, the commitments and claims established by the IT Department "belongs" to the business customer.

It is worth noticing that the core action in the service delivery, namely the *Single Mail Action*, is not performed by the providers but rather from the *User* (see Sec. 5). The user is, at the same time, the beneficiary of the service, though is not the one that can choose which providers to hire or under which conditions the service is delivered (i.e., the IT department), nor the one who actually pays for the service (business customer). Thus, the user is the consumer of the service. The *Hired Network Service Provider* performs the action of providing the Internet connection, by allocating the required *Internet Bandwidth*.

We must observe that, despite we have tried to use UFO-S as much as possible, the peculiarity of our case study has forced us to deviate from it in many respects. One aspect concerns the relation between the provider's commitment and the action that constitutes what the provider commits on, that is, in our case, a mail sending/receiving action, or a mailbox management action. This action is *guaranteed* by the provider, but it is actually executed by the user, which is in this case a customer's employee. In this particular case, the action on which the mailbox provider commits presupposes another action, namely some kind of internet transport (or internet connection), which is guaranteed by another provider: the network provider.

5 Lesson learned: modeling challenges and perspectives

As we have seen, conceptual modelling of CCS poses several challenges, parts of which can be addressed with the current version of UFO-S and parts of which require its extension. Let us recap them.

The analysis of the CCS characteristics and of the case study brings to light how the corresponding models need to reflect dynamism and flexibility of CCS, in terms of both service structure and governance choices based on a cost-benefit analysis. The relational dynamic aspects can be modeled by means of relators since they are bundles of qualities – in this case, commitments and claims – that account for the way in which the related entities are involved in the relationship.

Indeed, it is necessary to distinguish among what is defined contractually, i.e. the contractual relation, and what is actually done, i.e., the factual relation.

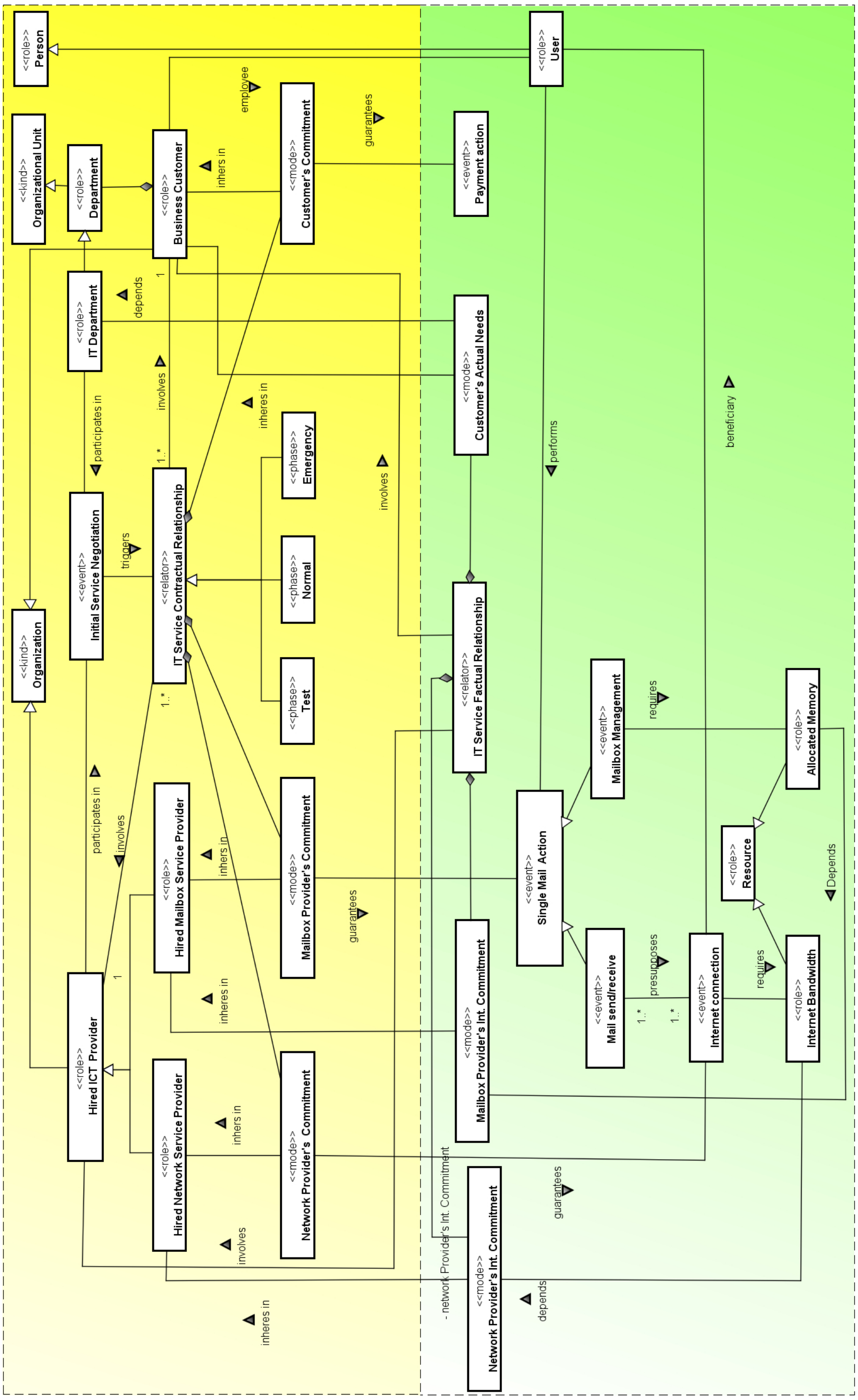

Fig. 1. Service Agreement Sub-Ontology and the Service Delivery Sub-Ontology

As previously stated, in the service delivery phase it may be necessary to dynamically re-negotiate contractual conditions and allocate resources. The former aspect concerns the redefinition of the contract based on the actual commitment of the providers and on the customer needs expressed by the IT department. The contractual relation is accounted for in UFO-S, while the factual relation is not yet factored in. The latter trait, together with the dynamic optimization of resources, is one of the key aspects of cloud services. This peculiarity requires to account for both the resources and the value of the service, in order to face the trade-off between costs, QoS, potential revenues and penalties. A change in the allocation of the resources, may bring to the payment of penalties or to revenue loss. The potential revenues can be analyzed by understanding how value is perceived by the target customers, thus more effectively tailoring the price to the context in which the service is sold and on the characteristics of the target customers. In this sense, it should be possible to model organizations, societal aspects, target customers, high-level preferences. Among the aspects that may affect customers' preferences , there are the lock-in risk, software license type, privacy and security concerns, which can be modeled with resources, besides the more common considerations of the actions needed to buy or use the service.

The dynamic allocation of resources affects also the relevance of the notion of *commitment*, on which UFO-S is built. Indeed, the customer pays for having the provider committed to procure the amount of resources needed by the user in order to benefit from the service [16, 5]. UFO-S does not specifically tailor resources and value aspects, although the notions concerning resources and, more in general, organizations are considered in the Enterprise Ontology Pattern Language [3] and taking UFO as a basis, UFO-S incorporates a clear distinction between capabilities, application of capabilities, and resources. Such concepts are clarified, respectively, in terms of dispositions (as intrinsic moments), manifestation of dispositions, and individuals that bear such dispositions.

To consider also the aspects related to value propositions and contractual issues, the different phases of the service lifecycle have to be analyzed and extended, from the service design to the offering, the delivery and, finally, the termination phase. In the latter phase, data storage issues gain particular importance for CCS, since the provider is in charge of deleting all customer-related data after service termination. The concept of *commitment* is useful to model this traits, as well as all other obligations assumed by the provider towards the customer. These aspects affect value as well, as customers evaluate potential data breaches, penalties in case of cancellation of the contract and several other aspects to decide how valuable the service can be for itself or for its company.

Moreover, it is important to tackle role changes for a given actor, especially in service chain scenarios. If we refer to the proposed case study, we have that a given company buys two services from two different external providers in order to integrate them and offer them to its employees. Thus, the company offers the integrated IT service to its employees, without being responsible for the quality of these services (QoS) or being able to intervene on the delivered QoS. In this sense, the company is not only a customer but rather a service aggregator that, from the employees' point of view, behaves as a service provider, thus denoting the modelling need of role changes for actors.In addition, another issue related to roles has to be mentioned as well. As highlighted in Sections **??** and 4, besides the roles of service provider and customer, other ones should be accounted for, such as service consumer and service aggregator.

Finally, IT services – and in particular CCS – are seldom *instrumental services*. With instrumental service we mean that the offer of the provider does not consist of an action (e.g., cutting your hair), but rather of allowing the user to perform a given action, which constitute the *core action* of the service. In our case study, the providers offer the Internet connection and the mailbox application, with whom they guarantee to the users that they can send/receive or manage emails. In this frame, the provider performs *supporting actions* apt at enabling the core service consumption [4]. In other words, although the actions are guaranteed by the provider, they are executed by the user.

6 Conclusions

This work investigate whether cloud services can be represented by means of the core ontology for services, namely Unified Foundational Ontology for Services (UFO-S). In order to do so, we outline CCS peculiarities, e.g., dinamicity, and the roles of the actors involved in their deployment and usage. Thus, we apply UFO-S to a case study concerning the external provisioning and internal delivery of an email service in a big company.

Through the modeling of the case study, we outline the main benefits of UFO-S and the extension required to model CCS, focusing on the necessity of representing dynamism, value, roles and actions . Besides the previously described general advantages of the adoption of UFO-S, we analyze the relavance of relators for CCS modeling. Relators are a bundle of qualities, through which it is possible to represent dynamic relationships among providers and customers in the lifecycle phases e.g. contractual and factual relationships. In the current version of UFO-S only the initial agreement relationships is factored in, while there is no account, e.g. for the factual relationship. Thus, an extension is needed.

We also show that in order to account for value, value propositions and contractual aspects the phases of the service lifecycle need to be expanded, so to include the service design and termination phases. The complexity of CCS requires for an in-depth analysis of roles, which can be multiple for the same actor. At the moment, it is not possible to represent this with UFO-S. The complexity of CSS requires for an in-depth analysis of roles. Thus, the number of service participant roles should be extended in UFO-S in order to include also the ones defined in cloud computing literature. Finally, we highlight how the analysis of the notions of *core* and supporting actions is necessary in order caractherize instrumental services.

Future work will be directed at the integration of these aspects in UFO-S, with the aim of providing a new version of the core ontology.

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Agile Design of Sustainable Networked Enterprises

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Abstract. This paper reports on new agile approaches and methods for design modelling of collaborative networked enterprises, ranging from small manufacturing supply-chains to major public service organizations. Use-cases in selected fields have been implemented by agile modelling and holistic design of collaborative networking capabilities, and active knowledge architecture driven solutions. The active knowledge architecture is the knowledge base for collaborative planning, execution, validation, enhancement and reuse. Use-case projects are transformed from horizontally sliced, sequential activities supported by information flows to collaborative workspaces and knowledge-driven processes. Novel concepts, agile approaches, adaptive methods, open platforms, and emergent knowledge architecture-driven solutions are built and validated. The realization of agile workplaces and sustainable capabilities for collaborative networking open up for novel approaches to computing solutions. Use-case digital models to enhance human mental models and enable collaborative innovation and learning and competence transfer are implemented.

Keywords: Agile approach, Active knowledge architecture, Holistic design, Model-based, architecture-driven work environments, Sustainable solutions.

1 Introduction

Novel enterprise knowledge concepts, agile approaches, holistic design methods and digital technologies are now having disruptive impacts on most application areas. Improving the business and service delivery processes, capturing and visualizing information contents and flows, and supporting strategic decisions in IT governance have so far been the major focus of enterprise modelling and architecture frameworks.

Our focus has included holistic thinking, novel business models, and enhanced human capabilities and values, supported by emergent context-rich knowledge-bases, and implemented as Active Knowledge Architectures (AKA) [7, 9, 10]. User involvement in building application capabilities is supported by design modelling applying the Active Knowledge Modelling (AKM) technology rather than prescribing and programming applications and common data models and information sources [6].

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The reasons why most sectors are slow in absorbing novel approaches, methods and platforms are mostly due to the size of the organizations and the lack of practitioner and entrepreneur involvement in planning and design [1]. The fact that strategic and business objectives and values to be delivered are not visible to the developers of project platforms and methods are also barriers that must be removed. Users, stakeholders, designers and suppliers, and people responsible for operations and maintenance must be involved in design modelling across the entire life-cycle.

Enterprise modelling phases are redesigned as collaborative knowledge spaces and are now presented as agile approaches, adaptive methods, modelling principles and emergent platforms. The paper is composed of six sections:

Section 2, Towards the knowledge-driven society, summarizes the challenges facing Enterprise Modelling and Architecture. Section 3, Use-case pilots implemented, describes the use-cases implemented, the main objectives, and the capabilities demonstrated in these use-cases. Section 4, Novel paradigm-shifting concepts, describes the eight paradigm-shifting concepts discovered, implemented and validated in the use-cases. Section 5, Experiences and lessons-learned, summarizes the experiences and lessons-learned across all industrial and public use-cases. Section 6, Summary and future projects, describes business potentials and possible paradigm-shifts in ICT and digital technologies and human sciences.

2 Towards the Knowledge-Driven Society

Societies and public service organizations currently perform research and innovation based on traditional ways of working and organizing work and information flows.

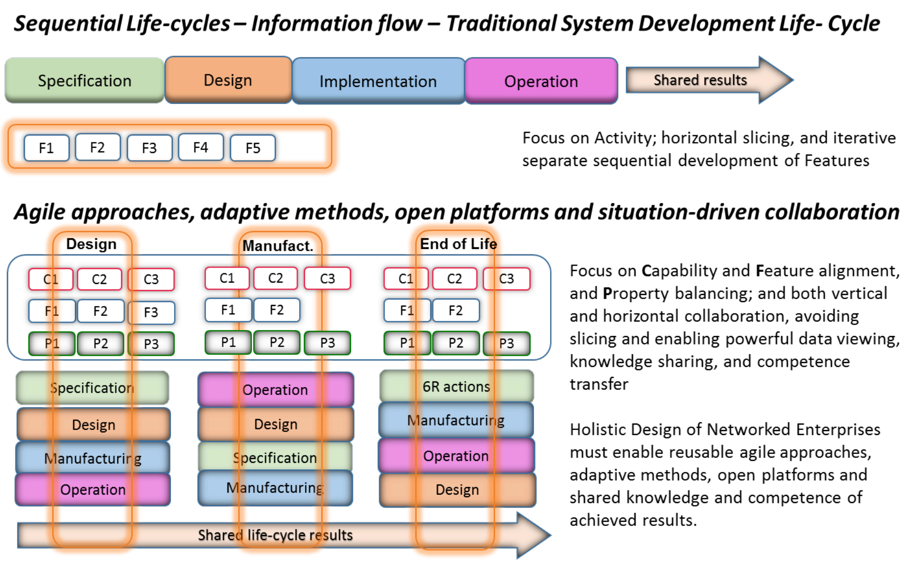

Figure 1 Emergent networked enterprises will be based on knowledge sharing.

How this traditional thinking have to change to let us relax hierarchic organizations and remove collaborative planning and design barriers is illustrated in Figure 1.

2.1 The Modern Networked Enterprise

Future enterprises must be able to participate in multiple simultaneous networks, ranging from research to collaborative partnering and customer delivery. Transforming data and information to knowledge by linking sources to role-specific workspaces, and eventually to architectures to drive collaborative innovation and learning across life-cycles must be supported. Practical approaches, work environments, and pragmatic learning must get much more attention from research programs and academia [1].

Capturing data and information sources, turning data into knowledge, linking it to workspaces for training and work execution will aggregate experiences and drive new methods, and feed continuous innovation and learning. Continuously enriched workspaces constitute what we call the pragmatic learning process. Collaborative networking will simplify work planning and execution and support continuous innovation and learning.

2.2 Capitalizing on Enterprise Knowledge Spaces

The discovery of enterprise knowledge spaces and workspaces [6, 8] has introduced a third organizational structure, the role-based organization, complementing the hierarchy and networking teams. Roles and their workspaces enable us to easily create data- and situation-driven collaboration and continuously capture and update data, information and knowledge from local context-rich work environments and situations.

Enterprise knowledge should be modelled in role-oriented workspaces and knowledge spaces composed of reflective views, repetitive task-patterns, repeating sources, and reusable models [7, 9]. Practitioner participation in project planning and design are challenges to be focussed on as they are important for our democratic services. The ultimate goal of sustainability is that the knowledge expressed in the design and production of a product or service can be replicated and adapted to new environments.

3 Use-Case Pilots Implemented

Present enterprise practices and management solutions are developed by consultants, ICT people and vendors focusing on data capture and document flows, and are not taking advantage of the AKM discoveries and technologies to capture practical workspaces and knowledge spaces [9]. Paradigm-shifting pilots were implemented in EU projects Athena, MAPPER and Co-Spaces, building aerospace and automotive use-cases, in projects for the oil and gas industry, and in public projects for the Norwegian Road Authority, and the Health-care Services.

3.1 Road Planning and Building

The Norwegian Road Authority (NRA) is responsible for all road planning, building and maintenance in Norway. Projects are based on 153 handbooks of road building principles, best practices, and experiences collected by the NRA planners involved.

A specific section of the E6 Motorway was selected as use-case for modelling a first road knowledge architecture [10]. An overview of the modelled architectures is shown in Figure 2. The left hand side of the model contains generic information that applies to all roads. This information was obtained from the relevant handbooks and discussions with NRA planners and experts. The right hand side of the model contains the actual road-case, i.e. contents specific to the particular part of the E6 Motorway.

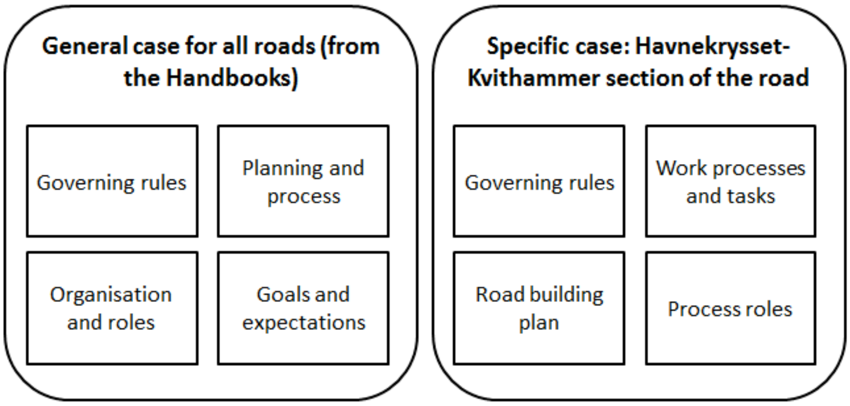

Figure 2 Modelling the planning and building knowledge architectures of roads.

The planning architecture and the specific use-case architecture, depicted in Figure 2, are composed of reflective knowledge dimensions, aspects and views. Design modelling to exploit visualization and the capabilities enabled give the planning and building projects ground-breaking new collaborative capabilities and benefits.

3.2 Healthcare Process Design Modelling

Current projects are based on business process and management activities. Best practices and experiences from treating patients are not yet included in the planning and operational architectures. There are many gaps between the ambition and planned services and solutions that present technology and methods are not able to close.

The Future Operating Model [13] must capture best practices derived from experiences, technological development and regulatory requirements etc., and show the ambitions and plans - on a general level. Knowledge models and architectures will be improved and used for future planning and operation.

3.3 Oil & Gas Production Planning

The major pilot project in the oil and gas industry was performed in 2009. A more detailed description is found in [9]. The intention was to fulfil these major objectives:

- Enable continuous supplier work planning and follow-up of production
- Improving collaboration and knowledge sharing and reuse across projects

The core active knowledge architecture contains models of many product and organizational aspects and process capabilities. Models of roles and responsibilities, the business, work processes, methods and results exchanged, and of the platform configuration are added. Model-Based Architecture-Driven (MBAD) workplaces enable agile approaches, collaboration and autonomous knowledge processing.

4 Novel Paradigm-Shifting Concepts

The experiences from the use-case pilots have lead us to eight paradigm-shifting concepts that will enable the generation of collaborative platforms for all life-cycle actors to design novel approaches, methods, platform capabilities, and solutions to meet growing needs and challenges, but also to pursue new business opportunities. The most important concepts enabling agile approaches and emergent solutions supporting concurrent enterprise design and operations are:

1. *Role-oriented Organizations - capturing work-centric contexts*
2. *Enterprise Knowledge Spaces - multi-dimensional spaces simplify modelling, collaboration and property parameter management*
3. *Context-rich Workspaces – enabling simultaneous model-based workplace design and execution*
4. *Active Knowledge Architecture (AKA)- integrating approaches, methods, services and platforms*
5. *Model-based, Architecture-driven (MBAD) Workplaces - configuring agile solutions*
6. *Holistic Design Methodology– working top-down, bottom-up and middle-out*
7. *Concurrent Modelling and Operation – close the gaps in design and execution*
8. *Visual Work Environment – simplifying networked collaboration*

The major concepts, their properties, enabling capabilities and business impacts will be briefly explained in the following sub-sections.

4.1 Role-Oriented Organizations

Existing organizations, composed of hierarchies, networks or static collaborating teams, were never designed to fit the design, manufacturing, customer usability and life-cycle support services of products and operational services for future demand. The people assigned to roles must be supported by agile MBAD workplaces, allowing them to perform at-the-workplace design modelling and task execution, closing the gaps between planning, design and execution.

4.2 Enterprise Knowledge Spaces and Context-Rich Workspaces

Smart networked enterprises cannot be built by application software systems alone, and adaptive services cannot be delivered by current methods. Future development, use and value of ICT will be managed by externalizing and sharing situated enterprise knowledge and reusing role-oriented workspaces, knowledge models, emergent networking architectures, and architecture-driven workplaces. The nature of practical knowledge spaces and workspaces must be exploited by users applying graphical modelling to capture work-centric local context. Graphic modelling of work-sensitive data and context enable humans to express their tacit knowledge as workspace models, enhancing their mental models for improved local work execution, coordination, collaboration and work management [3,4, 6].

4.3 Active Knowledge Architecture

An agile holistic design approach, based on the AKM discoveries, concepts and methods, will provide practitioners with model-based workplaces, the required adaptive visual working environment, and the methods and capabilities needed. The Active Knowledge Architecture (AKA) is based on holistic design, agile approaches, novel design principles, and active models of enterprise knowledge spaces and role-oriented workspaces. Visual modelling and new design methodologies enable new approaches to application solutions, whatever the application is.

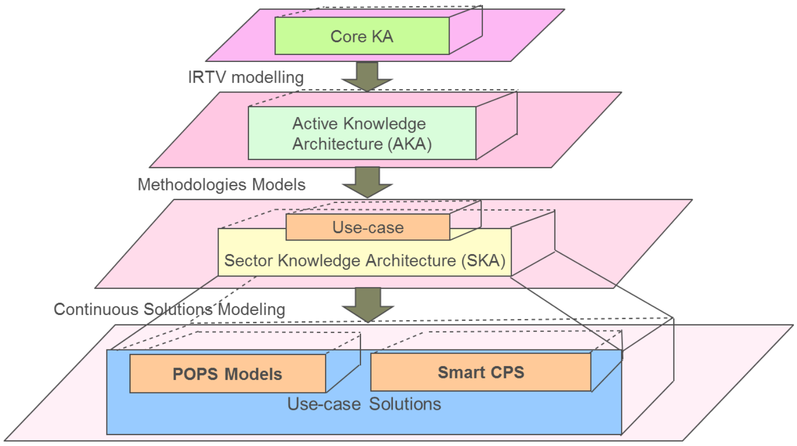

Figure 3 Levels of AKA development, operation and management

The Core Knowledge Architecture (CKA) is common to all knowledge architectures across sectors, methodologies and platforms, see Figure 3. By graphic modelling of knowledge spaces, applying the Information, Role, Task, and View (IRTV) language, the design of sector specific AKA is supported. Adding active models implementing agile approaches, adaptive methods and core roles and their workspaces, builds networked enterprise reference architectures.

4.4 Holistic Design

Holistic design is more than a simple move from the modern to the post-modern, as it represents both an ontological change in the consideration of organizations and an epistemological shift in our understanding based on Cyber-Physical Systems (CPS) and emergence. The people involved in enterprise design and management must adopt holistic design thinking, and become familiar with the AKM concepts, modelling principles and the collaborative product and process design methods.

Holistic design implies separate modelling of properties and their domain parameters. Modelling top-down to support planning and control, bottom up to capture work-sensitive data and context, and middle-out modelling to balance property parameters and capabilities across disciplines and partners, see Figure 1. Supporting conceptual design and design embodiment require novel fine-grained graphic modelling and support for novel IRTV modelling principles and constructs.

4.5 Concurrent Modelling and Operation

Capturing role-specific workspaces and knowledge spaces, applying holistic design methods, is performed by teams interacting and collaborating to influence the shared active models of approaches, methods, application domains and aspects [3]. Modelling for design will create conceptual objects, properties and domain parameters, capabilities, features and collected data in separate views, supporting design embodiment and creation of designed configuration and collaboration rules. Building and operating classes and categories of knowledge assets will be facilitated. So current gaps in life-cycles, modelling and execution, and in design and operation can be closed, and users can experiment with variants and families of solutions.

4.6 Visual Work Environments

Visual work environments allow users to observe and monitor status of work at related human and digital roles. Traceability, decision-support, predictability and assessment of trends and situations will give users enhanced capabilities to deal with uncertainties and risks. Powerful architecture-driven viewing of task-specific and common business situations provide effective support for collaborative design and execution, knowledge elicitation and overall knowledge and asset management.

5 Experiences and Lessons Learned

Many experiences, pragmatic methods and design modelling principles enhancing enterprise design and operation are derived from extensive collaboration between practitioners, engineers and modelling experts. The most important experiences and lessons-learned are described in the following. The discovery of enterprise knowledge spaces and design modelling of active knowledge architectures of kinds of enterprises has been the main contributions from the use-cases so far implemented.

5.1 Business and Organizational Challenges

Current hierarchic and networked organizations are not able to capture local work-centric context and pragmatics, such as considerations for environmental changes, method adaptations and overall enhancements. This is dependent on role-oriented organization structures and their workspaces, enabling holistic design and support of reflective views, repetitive task-patterns, reference templates and reusable models. This has high potentials for improved business models.

5.2 Human and Innovation Challenges

Configuring, adapting and reusing workspaces and knowledge spaces for training, learning and experimentation will enable students and researchers at any age to learn from the best practitioners. The knowledge assets of enterprises must be modelled and used to support execution to provide the capabilities demanded. Workspaces are the most context-rich work environments, where properties, capabilities and services are designed. In order to express the contents and the dependencies between them or dependencies and rules designed by users we must provide users with fine-grained graphic modelling tools and methods [2, 3, and 4]. Agile enterprise architecture, enterprise knowledge spaces and workspaces are described in more detail in [2, 6].

6 Summary and Future Projects

Future industrial collaborative networking applications should be based on visual modelling of roles, work environments and emergent knowledge architectures, involving stakeholders and users. A pilot AKA is the first target for any networked enterprise initiative. The scope of the pilot, core knowledge to be captured, roles affected, and competence and skills of teams involved must be captured to enable new tasks and local knowledge modelling. Stakeholder perspectives of capabilities, services, concerns and performance parameters may be needed, and are easily included in holistic design modelling of workspaces. This emergent agile approach enables users to build and adapt their own workplaces and ICT applications.

Practical work logic, parameter dependencies and working contexts cannot be prescribed and coded, so software applications have limited life-cycle flexibility and support for collaboration and harmonizing design solutions. The AKM approach uses software components to implement generic and easily adapted capabilities. Data- and knowledge-driven application domains must be captured by collaborative modelling using the IRTV language, supported by software components as generic enablers.

Visual work environments, models and knowledge architecture elements, are key assets for the coming knowledge and digital economy. All networked enterprises will eventually need to be proactively designed, and in this vein, continuous learning and innovation will be a decisive factor for commercial and technical success, but so will also classes of standardized proven knowledge elements that can be referenced and reused whenever required. Present approaches to emergent Enterprise Architectures (eEA) and building of sustainable product life-cycles, will greatly benefit from enhancing the present EA frameworks by adopting the AKM approach and methods.

6.1 Exploiting Visual Collaborative Landscapes

Visual landscapes, supported by active knowledge architecture, facilitate concurrent distributed team composition, competence transfer, knowledge management as well as capability and services composition. The MBAD agile approach will remove interoperability barriers and have revolutionary impacts on existing approaches, methodologies and solutions to product, organization, process and platform design and operations across industries and public domains. People involved in networked enterprise design, development, operation and management must adopt holistic thinking, and become familiar with the AKM approach, methods, concepts and practices. The limitations of natural language, document flows and current systems development must and can be removed. The MADONE network, see http://www.MADONE-network.org is established to help build collaboration environments, methods and demonstrators to support projects.

6.2 Design Modelling Principles

Thirty-six modelling principles have been proposed and tested for validity across the implemented use-cases [6]. The majority of these principles were discovered in the MAPPER project, and are published [6]. We are working to redesign, extend and validate the components of the methodologies previously developed and the design modelling principles supported by an open modelling and execution platform.

6.3 Future Projects

The success of future projects will depend on the capabilities and methods implemented in extensible, architecture-driven collaboration platforms, and on use-cases built by and involving leading competence and skills. Capabilities are needed to allow projects to build their own knowledge models of products and processes, organizational roles, and business and work environments. Visual knowledge models of these aspects must be built by involving users modelling their own graphic symbols and enhancing the IRTV modelling language. Our experiences regarding role-orientation and user participation are supported by other researchers [1, 11, 12], for example, in their experience reports using agile enterprise modelling methods. The importance of a clearly stated mission, of team composition and in particular the role of the facilitator, and the importance of adequate tool support is emphasized. Furthermore, the need for combining modelling language and adequate modelling principles are underlined, which fits our view that meta-models and modelling capabilities and processes should be adjustable before and during use-case modelling.

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Modeling Authorization in Enterprise-wide Contexts

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Summary. Authorization and its enforcement, access control, has stood at the beginning of the art and science of information security, and remains being a crucial pillar of secure operation of IT. Dozens of different models of access control have been proposed. Although enterprise architecture as a discipline strives to support the management of IT, support for modeling authorization in enterprises is lacking, both in terms of supporting the variety of individual models nowadays used, and in terms of providing a unified metamodel capable of flexibly expressing configurations of all or most of the models. This study summarizes a number of existing models of access control, proposes an unified metamodel mapped to ArchiMate, and illustrates its use on a selection of simple cases.

1 Introduction and related work

Authorization and its enforcement (access control) has been a crucially important pillar of enterprise IT security, both on technical levels (in computer systems, databases, networks etc.) and organizational levels (access policy and its human enforcement). Yet, major enterprise architecture (EA) modeling languages such as ArchiMate [1] do not currently support modeling access control, nor provide extensions, which would enable practitioners to do so in an elegant, defined and generic manner.

A plethora of different access control models have been proposed (a subset is listed in table 1). Several of them have become widely adopted in a variety of IT systems. For example, discretionary access control (DAC) implemented using access control lists (ACLs) and role based access control (RBAC) resound most, their origin dating back to 70's and 80's, respectively. While these and a few more models have been employed extensively, there are some fresh candidates on the verge of larger-scale adoption, such as the attribute based access control (ABAC), not to mention their more recent and sophisticated risk-adaptive variants.

Access control models are typically modeled formally (e.g., [3, 7, 8, 11, 13]), and a subset of them even freely conceptually (e.g., [10, 11, 13, 17]). However, the analysis of access control in enterprise IT landscapes calls for a middle way

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PoEM 2015 Short and Doctoral Consortium Papers, pp. 81-90, 2015.

Table 1. Summary of access control models, policies and mechanisms studied

Name	Character	Property	Domains	Policy	References
Access matrix	Mechanism	*any*	*any*	DAC*	[2]
Access control list (ACL)	Mechanism	*any*	*any*	DAC*	[3] (p. 35)
Protection bits	Mechanism	*any*	OS	DAC*	[4] (p. 14)
Capability ticket	Mechanism	*any*	*any*	DAC*	[5] (p. 134)
Protection ring/domain	Mechanism	*any*	*any*	MAC*	[3]
Lattice model	Model	*any*	*any*	MAC	[3, 6]
Bell LaPadula (BLP)	Model, policy	Conf:ty	*any*	MAC	[7]
Biba	Model, policy	Integrity	*any*	MAC	[3]
Brewer-Nash (Chinese wall)	Model, policy	Integrity	*any*	MAC	[8, 9]
Role-based access control (RBAC)	Model	*any*	*any*	*any*	[10, 11]
Attribute-based access control (ABAC)	Model	*any*	*any*	*any*	[12–15]
Usage control model (UCON)	Model	*any*	*any*	*any*	[16]
Risk-adaptive access control (RAdAC)	Model	*any*	*any*	*any*	[17, 18]
Token-based access control (TBAC)	Model	*any*	*any*	*any*	[19]

* *denotes typically, however not exclusively*; OS *denotes operating systems*

between these approaches – conceptual modeling according to a defined, unified language.

This study addresses the challenge of flexibly modeling scenarios of authorization according to the most well-known access control models, in terms of EA. The purpose is to enable EA practitioners easily capturing authorization relations in enterprise architectures. The study presents a number of existing access control models in terms of conceptual modeling, and proposes a unified metamodel (seen as an ontology or modeling grammar) for describing their configurations. The proposed unified metamodel is formed as a prospective extension of the popular EA modeling language ArchiMate. Subsequently, four illustrative examples are presented, to exemplify several different ways of modeling authorization, and to demonstrate the applicability of the metamodel. Similar approach has also been adopted by Basin et al. [20], proposing an approach titled “model driven security”, building on an extended metamodel of RBAC [10] called SecureUML [21], and providing a semantically well-founded modeling language and code generation process. Somewhat similarly, the work of Gaaloul & Proper [22] and Gaaloul et al. [23] propose an access control model for use in EA modeling. However, the approaches are exclusively based on RBAC, which makes them inapplicable for modeling a number of other commonly used models. Slimani et al. [24] and Muñante et al. [25] propose approaches for modeling access control in a more generic manner, however, both fall short of being able to express an arbitrary ABAC configuration, not to mention the more recent models. This study treats the most well-known and widely adopted models of access control, as well as

Table 2. Common vocabulary of access control

Term	Description
Subject/ requestor	An entity capable of performing actions in a system under consideration (SUC). For example, a program running on an operating system.
Object/ resource	An entity within a SUC, which is in need of protection from unauthorized access. For example, an object can be a document or a system operation.
Mode of access	The way, in which a subject can access an object within a SUC. Examples are read, write, execute, delete, create, search, or list contents.
Access rule/ permission/ prohibition/ access right	A rule specifying a specific mode of access for a subject to an object – either permitting it (more common), or by prohibiting it. In a yet more generic sense, a single access rule may also specify multiple modes of access for multiple subjects to multiple objects.
User	A user can be a subject, often having the privilege to further create subjects in a SUC (e.g., run programs). A non-subject user might only be allowed to manipulate subjects, however, not itself access objects directly.
Session	A temporally constrained window of usage, typically authenticated (e.g., by a log-in procedure), in which a user can act within a SUC via subjects.
Classification	A security designation of an object (e.g., a document), which indicates e.g. the highest secrecy of information contained therein, according to a predefined scheme (e.g., a mathematical lattice defining a partially ordered set of security labels, or simpler, a full order such as in figure 3b.
Clearance	A security designation of the eligibility of a subject to access object having a certain level of classification, in a certain access mode. Specifics depend on the model of access control under consideration.
Security label	A mark associated with an object or a subject, which carries a specific security meaning. A security label typically denotes a specific classification (of an object) or clearance (of an object).
Attribute	A characteristic of an entity such as a subject (e.g., organizational affiliation or business role), an object (e.g., minimum amount of credits needed for access or classification), or the environment (e.g., time of day, threat level or other environmental condition). It can be seen as a function that takes as input an entity (e.g., a subject, object or the environment), and returns a specific value based on the properties/state of the entity.
Token	An attribute extended through its possible dependence on volatile, dynamic properties or items such as cryptographic tokens (e.g., a Kerberos token), devices (e.g., a smart card), biometric tokens, or risk tokens, which change based on subject behavior and/or other conditions.

some prospectively powerful newcomers, and proposes a unifying metamodel mapped to ArchiMate.

2 Access control: concepts and models

This section introduces the terms specific to access control used throughout the paper (table 2), and briefly describes the models of access control treated.

A distinction between an access control model, policy, and mechanism should be made. While the first describes an access control system, the second describes

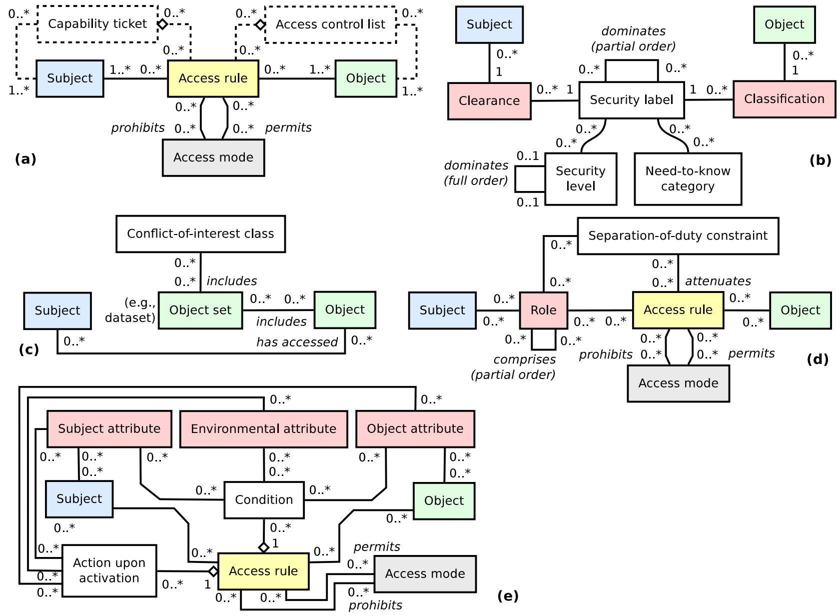

Fig. 1. Generic metamodels for expressing configurations of (a) DAC; (b) BLP and Biba; (c) Brewer-Nash (Chinese wall); (d) $\text{RBAC}_{0,1,2,3}$; and (e) ABAC. In (a), the dashed items describe implementation aspects/alternatives.

a set of requirements for the system, and the third describes a part of an implementation of the system. Table 1 summarizes the access control models, policies and mechanisms treated within this study.

Discretionary access control (DAC, figure 1a) models are based on the identity of subjects and access rules stating what the subject can and/or shall not do. Subjects can decide over other subjects' permissions (access rules) [5]. DAC is likely the most prevalent access control model today, thanks to its simplicity and extensive legacy. An example of DAC can be found in a typical Windows or UNIX filesystem. The most common representation of a DAC configuration is an access control matrix [2], which is in practice typically represented by multiple access control lists (ACL) (see [3], p. 35) or capability tickets [5].

Mandatory access control (MAC, figure 1b) models have largely become synonymous with the term *lattice-based access control* [6], the security levels of which are structured as a lattice. The Bell-LaPadula (BLP) model [7] and Biba model [3] use need-to-know categories (e.g, project numbers) for regulating access to objects in a DAC-like fashion, and security labels denoting security levels for classification of objects and clearance of subjects. Both models consider two modes of access – reading and modification. Biba additionally considers invocation (i.e., calling upon another subject) which can consequentially be viewed as modification under the invoked subject's clearance. However, while BLP addresses confidentiality, Biba addresses integrity. In BLP, reading an object is allowed to a subject if the subject's clearance is equal or higher than the object's classification, and writing it allowed if it is equal or lower. In Biba, reading an object is allowed if the subject's clearance is equal or lower than the object's classification, and writing (and invocation) is allowed if it is equal or higher. Although the difference between BLP and Biba makes the two policies conflicting, they can be combined given separate labels for confidentiality and integrity [6]. The Brewer-Nash model [8] (Chinese wall, figure 1c) differs in that its configuration changes dynamically according to the history of each subject's access. The model defines a term *conflict-of-interest class*, which groups datasets, or rather *object sets* (e.g., data of different banks), and regulates access as follows. A subject can read an object only if the object is in the same object set as an object already accessed by the subject, or if the object belongs to an entirely different conflict-of-interest class. A subject can write [to] an object only if it also can read the object, and if no such object can be read that is in a different object set from the one for which write access is requested and which at the same time contains unsanitized (i.e., not anonymized) information.

Role-based access control (RBAC, figure 1d) [10,11] is technically a non-discretionary model, in which subjects are granted access based on the roles they take on themselves for a specific session (e.g., Jane can take on herself the role of a system administrator, a financial analyst, or a teller). Several types of RBAC have been identified [11] according to their features. $RBAC_0$ denotes a minimal version, in which a subject can only take on itself a single role for a session, and there are no constraints for separation of duty. $RBAC_1$ augments $RBAC_0$ with hierarchies of role inclusion, in form of a partially ordered set. $RBAC_2$ augments $RBAC_0$ with constraints (e.g., expressing that a subject must not be assigned two specific roles at the same time). $RBAC_3$ combines $RBAC_1$ and $RBAC_2$, which also enables constraining for dynamic separation of duty (e.g., a subject must not take on itself two specific roles within a single session).

Attribute-based access control (ABAC, figure 1e) [10, 13] is one of the more recent models, which, although being the fastest growing one [14] and seemingly on the verge of a large-scale adoption [15, 26], is not yet as widely known as RBAC. Its major advantages over DAC, MAC and RBAC, are far greater expressiveness, richness, greater precision and flexibility. In fact, ABAC no longer requires specifying individual relationships between subjects and objects [14]. On top of ABAC, UCON [16] proposes *mutable attributes* (changeable as a consequence of access in addition to administrative actions), predicates that have to be evaluated prior to a usage decision (*authorizations*), and predicates that verify mandatory requirements for access (*obligations*). The invention of ABAC has been preceded by numerous extensions to RBAC (e.g., by spatial, temporal, task-, organization- and decision-related aspects), however, this study does not treat them in favor of the more generic ABAC.

Risk-adaptive and token-based access control (RAdAC [17,18], TBAC [19]) have been proposed in the recent years. On top of ABAC, RAdAC considers measures of risk related to access decisions, which can be arbitrary (e.g., based on subjects' behavior and trust; ways, probabilities and consequences of misusing

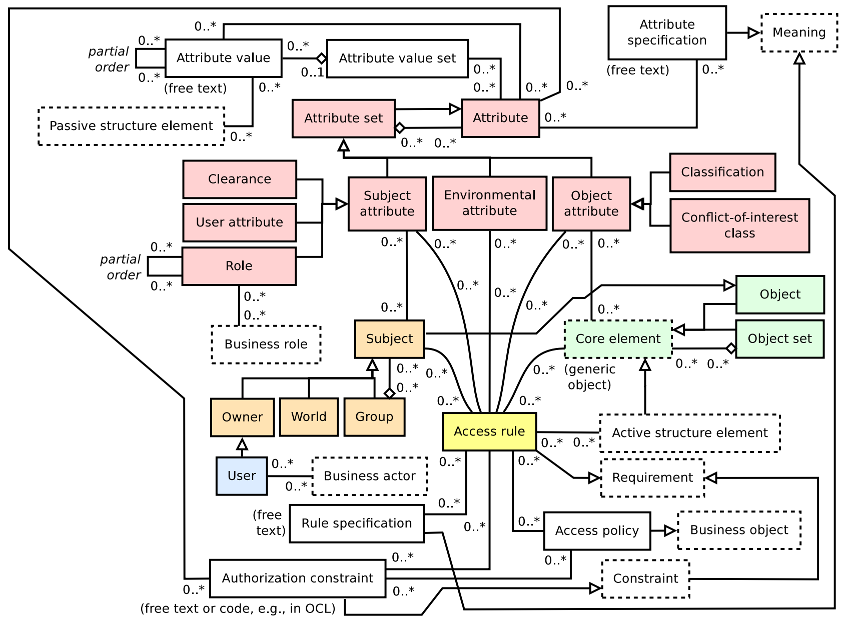

Fig. 2. Proposed unified metamodel for modeling authorization. The dashed entities are defined by ArchiMate [1].

objects; environmental conditions). TBAC, although not having received academic attention, broadens the perspectives of application and implementation of ABAC and RAdAC in a way highly relevant for EA practice and modeling. Example tokens are listed in [19].

3 Metamodel for modeling authorization

The unified metamodel for modeling authorization is depicted in figure 2. Below, this section first describes the metamodel, motivating certain features of its design, and later provides a set of illustrative examples, each showing the use of the metamodel through a corresponding model of a concrete configuration of a certain access control model.

Structurally and syntactically, the unified metamodel mostly resembles that of ABAC (cf. figure 1e), thank to ABAC's ability to encompass or emulate most of the other access control models' function. For structural simplicity however, the entity `Attribute` semantically comprises both *attribute* from ABAC and *token* as used in TBAC. Also, items such as *role* or *clearance* can be modeled simply as an *attribute*. For more clarity however, the unified metamodel retains a number of such entities, namely `Role`, `User attribute`, `Clearance`, `Classification` and `Conflict-of-interest class`, since those are expected to occur commonly. Less generally common such entities (e.g., *predetermined* *explicit authorization* or *location*) can be instantiated from the closest fitting child class of `Attribute` rather than having a separate class. `Role`, unlike other children of `Attribute`, allows the modeler to define arbitrary partial orders, to capture configurations of $RBAC_{1,3}$ [11]. Since the name of a modeled attribute might not suffice to capture its full nature and its range of values, the modeler can further specify attributes textually (e.g., by free text or references), using `Attribute specification`. At the same time, the modeler can specify partial orders (e.g., lattices) of attribute values using `Attribute value` and group them into sets (e.g., for security levels and need-to-know categories), using `Attribute value set`. Moreover, attribute values can be linked to instances of ArchiMate's `Passive structure element`, to denote values that might already be modeled using ArchiMate. An `Object` can group arbitrary sets of ArchiMate's `Core elements`. `Subject` figures as a child of `Object`, since a subject itself can be an object. `Subject`, much like `Attribute`, is also further categorized into the commonly occurring `Owner`, `Group`, `World` (i.e., anyone), and even `User` denoting a an intelligent actor (e.g., human), for the case its distinction from `Subject` is desirable to model. `Access rule` can connect to a `Subject` and an `Object`, although it is not necessary, e.g., in case of ABAC. `Access rule` can relate to `Attribute`s of any kind, also multiple ones. It can also relate to ArchiMate's `Active structure element`, e.g., to denote dependency on a system that realizes its enforcement etc. As with `Attribute specification`, `Rule specification` can help further specify an `Access rule`. Finally, an `Access rule` might be a part of a specific `Access policy`. Various authorization constraints (e.g., cf. $RBAC_2$ [11]) might need to be modeled, using `Authorization constraint`. Similarly to `Access rule`, the modeler can also relate an `Authorization constraint` to an `Access policy`. Finally, three patterns occur repeatedly in the design of the proposed unified metamodel. First, a specific form of grouping is used at `Attribute`, `Subject` and `Object` represented by ArchiMate's `Core element`: The grouping entity (titled a *-set* or *-group*), inherits from its immediate base entity, and aggregates a set of its instances. This allows arbitrary tree-like grouping under the name of the base entity (e.g., `Subject`). Second, relations of partial order allow the modeler to create arbitrary lattice-like hierarchies. Third, multiplicities of relations are highly permissive, and in most cases allow *0..** rather than the more constraining *0..1* or *1..**, to provide higher flexibility. The proposed metamodel includes bindings to ArchiMate entities, in figure 2 distinguished from others using dashed lines. Following, four illustrative examples of the metamodel's usage are presented.

Example of DAC: File system (figure 3a). Let us have a school computer file system, one teacher and two students. The students, belonging to a group called "Students", are allowed to read contents of the course study directory, and execute a program for exam submission. The teacher, belonging to a group called "Teachers", is allowed to read and write grade records, and read the contents of an exam directory, which stores exams submitted by students.

Example of MAC: BLP multilevel security (figure 3b). Let us have an environment with multilevel security policy according to the Bell-LaPadula

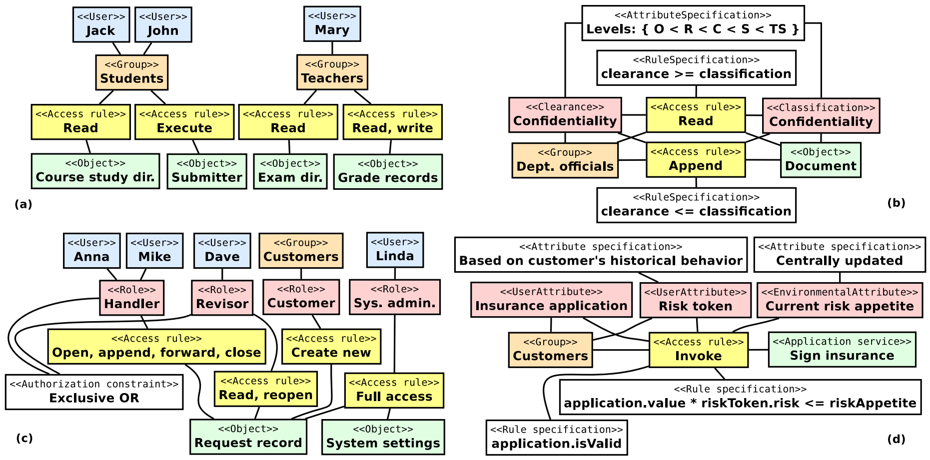

Fig. 3. Illustrative example of a (a) DAC; (b) Bell-LaPadula; (c) RBAC; and (d) ABAC/RAdAC/TBAC model configuration.

model [7]. Let us only consider a single group of users called "Department officials" and their authorizations to read and append to protected documents.

Example of RBAC: Request tracking system (figure 3c). Let us have a request tracking system with two types of objects – system settings and request records, a few users, a group representing customers, and four roles, each having different access: system administrator, customer, request handler and revisor. Further, let it be forbidden to combine the roles of handler and revisor.

Example of ABAC/RAdAC/TBAC: Insurance application system (figure 3d). Let us have an automated processing of insurance applications in an insurance company. Let the company use a risk token, which calculates risk value for each customer based on the customer's history; and let there be a risk appetite setpoint providing a threshold for how risky a deal the company can sign at a given moment. Let the system register the customer's insurance request as an user attribute automatically upon the customer applying through a web-based form. Finally, let us only allow the system to invoke an insurance signage service if the insurance application is valid, and if the risk that the signed deal would pose to the company does not exceed the risk appetite.

4 Discussion and conclusions

The proposed metamodel offers a high degree of modeling flexibility, which emerges mainly from the presence of four features: (1) broad possibility to group items or present them as groups/sets (e.g., attributes, subjects, objects) with the possibility of introducing further detail; (2) the possibility to arbitrarily textually specify attributes, attribute values, access rules, policies and constraints; (3) the conceptual redundancy provided (e.g., the modeler can model a DAC or a

RBAC model both as an ABAC model, or entirely avoiding the use of attributes in the former case while making use of `Role` in the latter case; (4) the possibility to exploit the permissive cardinality constraints to make abstractions similar to grouping, and so to reduce the number of modeled instances and connections.

Although the generalizability of the metamodel to all existing models of access control is difficult to evaluate, the consideration of well-known and highly generic models of access control such as ABAC provides outlook for a high degree of generalizability of the proposal. Similar concern relates to how applicable will the metamodel remain over time, which depends on the amount of innovation taking place within the domain of access control.

Although the proposed metamodel of this study shares many conceptual likenesses with the results of Gaaloul & Proper [22], Gaaloul et al. [23], Basin et al. [20], Slimani et al. [24] and Muñante et al. [25], it surpasses these works in terms of the breadth of coverage of the different existing models of access control. Additionally, this study shares much likeness in terms of its ArchiMate mapping compared to that proposed in Gaaloul & Proper [22]. However, the latter is more direct and constraining (e.g., the entity `User` inherits from ArchiMate's `Business actor` and `Role` inherits from ArchiMate's `Business role`, rather than associating with them), which leads to lesser modeling flexibility in comparison to the mapping proposed in this study.

In terms of conceptual modeling, this study has summarized a number of relevant models of access control including a few recent ones, presented an ArchiMate-mapped unified metamodel capable of expressing configurations of all the individual models of access control treated, and finally provided four illustrative examples of using the metamodel in distinct scenarios.

In the future, enriching the unified metamodel with automated analysis is intended, enabling the metamodel to warn about risky patterns of configuration, or deviations from best practice. Additionally, the metamodel could analyze attributes related to a given access control implementation and configuration, enterprise needs and maintenance processes (e.g., cost, amount of maintenance, modifiability or security through the likelihood of being in a state of misconfiguration), and so help enterprises optimize their architecture.

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A Context Modelling Method to Enhance Business Service Flexibility in Organisations

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Abstract. The change of the global business environment implies unforeseen requirements that the enterprises did not take into account during system design. Based on such rapid changes and uncertainties in the future that are not predictable, organizations need to be flexible, not only in terms of their organizational structures but also regarding the Information Technology (IT). One challenge is the adaptation and evolution of software systems in changing situations, which is reflected by the criticism of poor flexibility. This work proposes a context modelling method based on enterprise capabilities and Information System (IS) Design, which is a model-based solution approach and aims to improve the flexibility of digital services provided in changing environments.

Keywords: Context Modelling, Capability Modelling, Method Engineering

1 Introduction

We are living in an economy which is characterised by the rapid change. The technological advances and the increasing globalization of the economy require in many areas high adaptability of enterprises. Based on such rapid changes and uncertainties in the future that are not predictable, organisations need to be flexible, not only in terms of their organizational structures but also regarding the Information Technology (IT). The change of the global business environment implies unforeseen requirements that the enterprises did not take into account during system design. Necessarily, this poses new problems for Information System (IS) Development, such as the adaptation and evolution of software systems in various situations, which is reflected by the criticism of poor flexibility [1], [2] as well as increased operative costs based on the manual configuration of the systems. Since it is not possible to propose a one-size-fits-all solution, the investigation has been limited to the service organisations due to following reasons:

- Changes in the role of operant resources caused a shift from Goods Dominant Logic to Service Dominant Logic (SDL) [3]. The growth of the service economy caused by this paradigm shift impacts the business processes of the organizations and makes it even more important for enterprises to adopt themselves to changes.

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- Organizations face the need to adapt their business services according to various situations. In this regard EU-FP7 research project Capability as a Service (CaaS) aims to facilitate a shift towards a capability delivery paradigm. In order to ascertain cross-industry applicability of the new paradigm, the CaaS project follows a use case driven approach. The use cases analysed in CaaS are related to the enterprises offering (digital) services that needs to be designed flexible [4].

The need for manual configuration of business services can be reduced by model-based design of the service application context. The observations from the industrial use cases in CaaS showed that organizations possess necessary knowledge on application contexts of the digital services influenced by various drivers, yet a methodological support on how to capture and model such application context is missing. Thus, the main research goal followed in the thesis is to improve the flexibility of business services provided in changing environments by developing a context modelling method based on enterprise capabilities. The method uses enterprise models as a starting point for the development processes. The approach aims designing business services adjusted to their application context and aligned with enterprise goals, which we call capability. First, Section 2 describes the research approach followed in the thesis. Then Section 3 addresses the problem investigation phase, gathers evidence from industry and theoretical work, which are then used to derive requirements to the design artefact. Section 4 introduces the context modelling method and finally Section 5 reports the current state of the work.

2 Research Approach

The design process of the developed artefact must be defined rigorously and show relevancy to the motivated problem. Due to its socio-technical structure, IS Development is a wicked problem. Wicked problems do not have a definitive formulation, they are unique and solutions to them are good or bad and not true or false [5]. Therefore we apply the Design Science Research (DSR) approach to tackle the problems, i.e. we follow the DSR guidelines proposed by Hevner [6]. The whole research process is conducted design-science oriented and is based on three cycles. *Relevance cycle* is assured by the use cases taken from three industrial application scenarios. In *rigour cycle* we use the applicable knowledge in the literature by investigating frameworks, models and methods that might help in solving the problem. Both relevant and rigour cycles are presented in Section 3. Finally, in the *design cycle* we develop the artefact (the method) based on the inputs from both cycles, observe how the developed artefact behaves in these scenarios and refine it after the gathered feedback in the evaluation (see Section 4). In line with the relevance and rigour cycles of DSR, two main research questions arise when tackling the flexibility issues in IS Design.

- RQ 1: How can the enterprises be supported from a method perspective in improving flexibility when offering digital services?
  - RQ 1.1 What are the current problems of the organizations offering services in changing environments? (Section 3.1)

  - RQ 1.2 Which approaches exist to align business services and IT? (Section 3.3)
  - RQ 1.3 What are the current problems in context modelling support for enterprises (Section 3.1)? Which approaches exist to model context (Section 3.3)?
  - RQ 1.4 How should a methodological support for increasing flexibility look like? (Section 3.2)
- RQ2: Does the method use lead to an improvement in enterprises offering digital services based on business processes? (Section 5)

3 Problem Investigation

3.1 Theoretical and Practical Relevance

Enterprises offer business services to satisfy customer needs and to support the exchange of business value across a network of enterprises [7]. Business services are perceived as high-level implementation components that operationalize an organization's strategy [8]. Thus the modelling of business services should depend on enterprise goals, business context and not only comprise of technical aspects. This addresses business/IT alignment, which is a serious challenge in today's enterprises due to changes in regulations, time-to-market pressures and technological advances. One way to tackle these challenges is the management and modelling of (IT) capabilities [9] (see Section 3.3).

Due to the achievements in IT, business services are electronic-oriented and can also be offered digitally, which require the infrastructure of an IT-based Internet for service creation, request or delivery [10]. Especially in the domain of e-services, actors exchange information based on IT Systems. We define such business services as "digital services". Although digital services are developed for a specific customer group, they need to be configured in line with the actual application context. The need stems both from external constraints, such as changes in customer requirements, regulations or service deployment environment and internal constraints, such as priorities changes, delay constraints and staff schedule [11]. In summary, digital enterprises need to offer IT-based flexible services to improve their chances of survival [9]. In order to support theoretical observations from the literature, we also analyzed the problem from the practical point of view and investigated two organizations offering digital services within two distinct domains.

• **SIV.AG** is an independent software vendor for the utilities industry with particular focus on Germany. The company owns a BSP that provides services for the customers running kVASy®, SIV's industry specific Enterprise Resource Planning (ERP) platform. The BSP deals with inter-company business processes between partners in the utility market that requires exchange of bulky messages about energy consumption data. Currently, if an exception occurs in validating or processing the message, the BSP acts as a clearing center involving the manual interaction of a human agent, which causes extra costs on the side of the utility as well as operational efforts.

• **everis** is a multinational consulting firm providing business and strategy solutions, application development, and outsourcing services. The everis use case is based on the public sector and the main emphasis is put on electronic services provided to municipalities, which are then used by citizens and companies. The company provides in a SOA platform a service catalogue with up to 200 services in 250 municipalities. Different factors and actors involved has to be taken into account when offering the services, such as public administration's laws, regulations, multinational corporations, administrative consortia and calendars, as well as various technological tools.

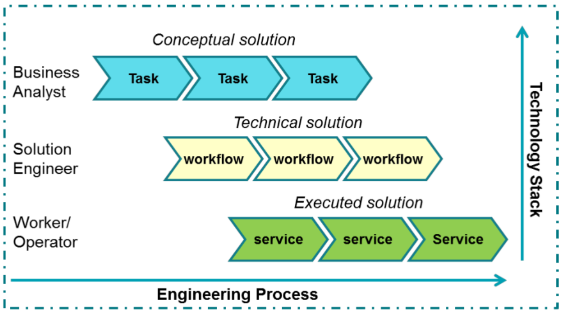

Fig. 1: Roles, Processes and the Technology Stack [12]

The aforementioned enterprises have established development and operating processes, technology stacks, and roles which is shown in **Fig. 1**. The horizontal line represents the *engineering process* encompassing the steps for designing, developing and operating digital services whereas the vertical line, technology stack, addresses all IT-tools, notations, languages, workflow engines, software development environments required in the engineering process. The engineering process consists of three phases. In the *conceptual solution* phase digital services are developed, in the *technical solution* phase the conceptual solution is prepared for execution and finally in the *executed solution* phase the solution is deployed. Different roles participate to the engineering process, i.e. *business analyst* develops solutions expressed in appropriate models, *solution engineer* configures them for deployment in line with the application context and *worker/ operator* monitors the deployment.

Both enterprises offer services that have to be adapted to business requirements of the customer. The requirements are strongly related to the service application context. Currently these organizations envision reducing operative costs required to adjust the business services by increasing the flexibility. One prerequisite is aligning the needs of business and IT as well as reaching a common understanding with participating roles on different levels. This could be achieved by model-based design of the services and their application context, which represents the configurable parts. Although there is enough knowledge about the service application contexts in the enterprises, such knowledge is either hard-coded in the systems or preserved in separate documents. As a result, their configuration is a cost-intensive task, which can be reduced by a methodological support addressing how to capture and model this knowledge.

3.2 Artefact Requirements

The requirements towards the method to be developed were derived from the industrial use cases presented above by conducting workshops and expert interviews with the industrial partners as well as analysing secondary data. The use case requirements were cross-examined based on industry-wide surveys that illustrated its relevance towards a wider user base rather than just the project's industrial partners (see [4], [13]). First of all, to support different ways of working, the method has to provide an adaptable development methodology and should not be a monolithic block (REQ1). Business services should be designed in an understandable way for the stakeholders, who do not necessarily have a deep IT knowledge. From the flexibility point of view, this requires adopting model-based design of IS. In particular, based on the developed models, the method should enhance the communication between different stakeholders such as business analysts, solution engineers and knowledge workers (see **Fig. 1**) (REQ2). Due to changes in requirements, the standard processes are altered when offering services to the customers and variants of these standard processes are modelled/ implemented. Thus, the method should offer guidelines on how to manage process variability efficiently (REQ3). Last but not least, the method should document the steps to model the application context in detail with certain inputs, objectives and outputs. Moreover, the important concepts that the method user needs to be acquainted with must be described to have an ontological commitment to the terms and related notation to model such concepts should be provided (REQ4).

3.3 Related Work

Relevant areas for this paper are capability management and modelling as well as the approaches in context modelling, which are briefly discussed in this following.

Capability Management. Capability is a widely used term for the alignment of business and IT. In line with CaaS project, the capability is defined as "the ability and capacity to reach a goal in a given context". Capabilities help to design business services and are related to organizational strategies. They are used as fundamental abstraction instruments in business service design. Moreover, they support flexible service design by taking the business context into consideration [4, 13, 14]. Due to their roots in strategic management, capabilities are less technical-oriented concepts and take a business point of view whereas services rather take a technical point of view and are concerned about the implementation aspects. For business stakeholders, capabilities provide an abstraction from technical concepts [9]. Based on such characteristics, the capability concept is central to context modelling method.

Context Modelling. The state of the art analysis conducted in [15] showed that context modelling and context-based systems are a popular topic in contemporary research and exposed different context definitions and application examples. Most of the works focus on the conceptualization of context, i.e. what elements context typically consists of and how to represent context models. An off-the-shelf context modelling method fulfilling the requirements and showing what steps to take as well as how to identify relevant context elements has not been proposed yet. However, the proposed approaches can be used as inspiration based on the six parameters provided by [16], namely *constraint, influence, behaviour, nature, structure,* and *system*.

4 Solution Artefact

Organizations have different ways of working, in a context where the organizations are in a constant seek of balance work methods should be organized flexible and support various application scenarios [11]. To fulfil REQ1, a modular approach to method engineering was applied by dividing the methodology into several method components. In doing so, the method user could focus on those parts of the method that are needed and select the components relevant for a specific tasks. For this purposes, the method conceptualization framework of Goldkuhl is applied, which allows defining the important concepts and supports their representation with a notation (REQ4). Moreover, the framework is extended, i.e. i) the procedures are refined with additional elements such as *steps* with certain *inputs*, *outputs* and *tool support* and ii) the terms *perspective* and *framework* are replaced by *purpose* and *overview to method components* respectively [14]. The method addresses different aspects of IS Design, i.e. the method components (MC) 1, 2 and 3 are concerned with early design phase, where business analysts and knowledge workers are required, whereas the MC 4 and 5 is concerned with the binding and run-time phases, where the solution engineers play a vital role (REQ2). The context modelling method assumes that the causes of the variability in enterprise models can create the basis for the method user to identify the context elements. Thus, the method offers guidelines on how to identify variations and to elicit context elements from them (REQ3). The concepts shared by the MC are based on the slightly updated version of the Capability Meta Model proposed in [17]. To represent such concepts, the method adopts the Business Process Model and Notation (BPMN) as well as the CDT Notation, which has been developed during the CaaS project. The context modelling method is illustrated in **Fig. 2** and the MC are described very briefly in the following. Detailed discussions on the concepts, notation and prerequisites to use the method can be found in [14].

MC1: Preparing to Context Modelling. As mentioned earlier, variations and their causes are used to elicit the context elements influencing the service provision. Therefore the context modelling method proposes to analyse enterprise models from the variation point of view. For the time being, the thesis is limited to the analysis of business process models, i.e. the variations in the goal models, or concept models are not investigated extensively. If no enterprise models are available or they are not up to date, then the method user applies MC1. To exemplify, we encountered one use case where the organisation captured the enterprise knowledge based on the textual descriptions related to specific services. In such cases the method user can perform MC1. However, if the enterprise models are up to date and used extensively in the service provision, then the MC1 can be skipped.

MC2: Find Variations. In this MC, the modeller analyses the structures that will form the context element in the following method components. The MC2 focuses on identifying possible variations in the business process models. The main motivation of this MC is that such variations in the business models arise due to the factors, from which context elements can be extracted.

MC3: Capture Context Element. Focuses on investigating the entities and aspects of the context by eliciting the factors, which cause variations in the processes and which were identified in MC2. By defining the attributes and measurable properties, the method user defines a context element.

MC4: Design Context. Defines value ranges of the context elements for a certain capability and collects them in a context set. The capability defined in the earlier activities can also be refined in this method component, since the method user now has a better view of the context, goals and business processes.

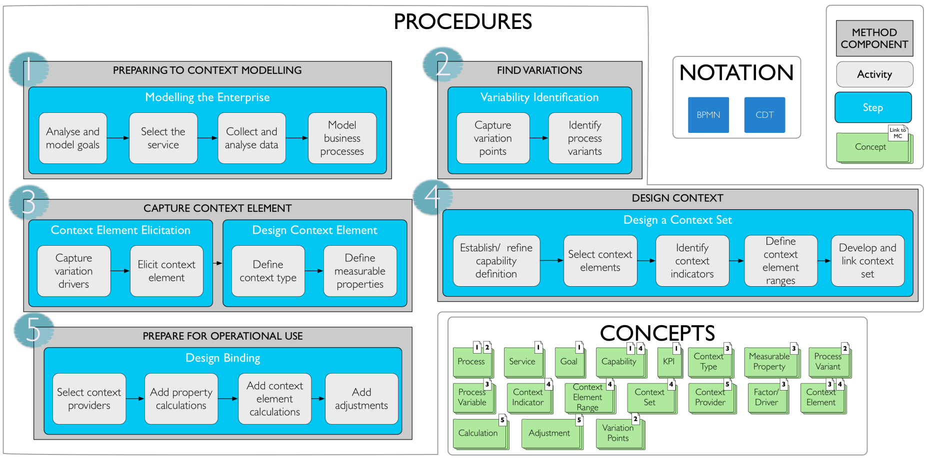

Fig. 2. Context Modelling Method

MC5: Prepare for Operational Use. Describes the way of adding part of the specifications to the context model in order to generate code from the model and make it implementable.

5 Summary and Outlook

The main research goal of the thesis is to improve the flexibility of business services provided in changing environments by explicitly modelling the service application context with a method based on enterprise capabilities. Due to its different entry points, the method can be applied in and adapted to different kinds of situations. The method, which is in the late phases of its development, aims to support various stakeholders in an enterprise on different levels such as business analysts, solution engineers and (knowledge) workers /operators. To date, the method evolved based on the feedback from enterprise modelling experts and application in industrial use cases. Although a systematic evaluation of the method is missing, there are initial thoughts on the type of evaluation approach as well as the available resources. The future work will i) specify the approach to evaluate the method and ii) implement the approach to engineer the final version of the method.

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Towards an Ontology of Economic Value: a Preliminary Analysis

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Abstract. The notion of value and of value creation has raised interest over the last 30 years for both researchers and practitioners. Although several studies have been conducted in marketing, value remains and elusive and often ill-defined concept. A clear understanding of value and value determinants can increase the awareness in strategic decisions and pricing choices. Objective of this paper is to preliminary discuss the main kinds of entity that an ontology of economic value should deal with.

Key words: value, ontology, enterprise modeling

1 Introduction

The concept of value and value creation process have raised the interest of economists for more than 30 years, spanning from disciplines such as strategic planning to accounting and marketing. Nonetheless, value remains "perhaps the most ill-defined and elusive concept in service marketing and management" [8, p. 2], becoming "one of the most overused and misused concepts in the social sciences in general" [19, p. 428]. As a result, a broader understanding of its meaning, both from the organization and customer perspective is needed.

In the economic literature, the process of value creation has been mostly understood from the point of view of the *value producer* (typically an organization) focusing on notions such as *profit* or *revenue*, either current or potential, or again as *utility* or *quality*. On the other hand, marketing studies have privileged the *consumer value* point of view, focusing on perceived value and customer experience. We believe that a proper analysis of value needs to take both perspectives into account, aiming at a broader understanding based on primitive, general notions that can ground the meaning of the various value-related terms used in the business practice. This analysis, beside the theoretical relevance, is also particularly relevant in practice. Indeed, as stated by Anderson [2, p. 17], "a theory of value should help us rationally guide our actions". In other words, a value theory should help us in the definition of which actions is more appropriate to perform, i.e. it is the premise for a *theory of rational choice*. In order to actually provide insights for the decision making process, it is useful to account not only for revenues but, more in general, for value. Value-related information is used by organizations to (a) increase the awareness in strategic decisions or (b) for pricing purposes. For a proper understanding of value-related notions

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enterprise modeling is crucial, which can be regarded as the construction and use of conceptual models to describe, analyse, and (re-)design organizational action systems (e.g., business processes, organisational structure, resources) and information systems (IS) [5]. However, the literature on value modelling is still in its infancy, and we can't say nowadays that value modeling is well integrated with more traditional enterprise modeling activities such as process modeling and organisational modeling. The relevance of the concept of value requires a broader understanding. As previously stated, the notion of value is often "ill-defined" and "misused". Thus, in order to exploit the benefits of value analysis and avoid communication problems, a precise and rigorous conceptualization is needed. This is achievable by means of a foundational approach apt at the development of a core ontology. The aim of this research project is to provide a well-founded ontology (the artefact) to integrate value modeling into enterprise modeling, with special reference to service systems. In order to do so, we follow the design science approach [14, 1]. This methodology implies the identification and motivation of the problem, the definition of the possible solution (*Relevance cycle*), the adoption of grounding theories and methods at the state of the art (*Rigor Cycle*) and the design of the artefact and its evaluation (*Design cycle*). In particular, this work is concerned with the relevance cycle and the rigor cycle of the process. The evaluation will be performed against the competency questions that will be defined starting from the literature analysis.

The research project is currently in the rigor cycle. After having outlined the motivations of this work and clarified the role ontologies could play, we shall focus here on some first ontological choices (Section 3). These choices are the result of an analysis of the literature in economics (Section 2) and are set up on foundational ontologies such as the Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) [16] and the Unified Foundational Ontology (UFO) [10]. The need for an ontology of value is better clarified in Section 4, where we compare the existing approaches on value modeling against the identified primitives. Finally, in Section 5 we draw our conclusions.

2 The notion of value in economic literature

Among the years, several authors discussed *value* and *value creation*. Nonetheless, most of these works result ambiguous in the definition of *what is value* and *which are its determinants*.

In microeconomics a dichotomy has been outlined between value as the sum of the resources used for the production and value as the utility of products. The latter is strictly connected to the approach followed in marketing, whose emphasis is on value perceived by customers. For this study, we will focus on perceived value, that, as stated by Sanchez et al., "implies an interaction between a subject (the customer) and an object (the product); it is comparative, personal, and situational (specific to the context); and it embodies a preference judgement" [19, p. 439]. The motivation of this choice lays on its relevance for strategic decision purposes and on the recursive nature of the microeconomic notion of value, which also does not contain enough information. With recursive we mean that, if we follow this approach, we have to keep calculating the value of every single resource that compose the product, then the resources of the resources and so on. With respect to the latter point, an example can be given by products where the brand acquire a huge relevance, whereas brand is not quantifiable as the mere sum of the resources used. In marketing, several works have been devoted to the analysis of customer perceived value, though without reaching an agreement. Consumer value has been seen in some works as uni-dimensional, i.e., value has some antecedents (or determinants) such as quality, price, brands, etc., and in others as multi-dimensional,. i.e. value is a complex concept that embeds several factors [19]. The first branch includes the price-based approach, first developed in 1979 by Monroe, who states that value originates from a trade-off between perceived utility or quality and sacrifice. Later on, Dodds et al. stated that the "cognitive trade-off between perceptions of quality and sacrifice results in perceptions of value" [4, p. 308]. Also other factors have been encompassed as antecedents of value, such as social value, time and effort spent, sacrifice, benefit and personal preference. Among the multi-dimensional approaches, there is the *utilitarian and hedonic value theory*, in which not only the instrumental and functional aspects are accounted for, but also the hedonic ones, i.e., the emotional or non-instrumental responses to the consumption of a product. Another approach has been defined by Woodall [25] with a taxonomy of customer value ($\mathrm{V_C}$), highlighting the concept of *derived* V_C, concerning the experience of use and strictly connected to the notion of use value. In marketing research and, in particular, in service science, special emphasis has been also put to the concept of *value co-creation* [8]. However, for the purposes of this paper, we will focus only on the general notion of economic value, without considering the implications of the co-creation process. In this case, the problem – partially addressed by [8] – of understanding what "value creation" means arises.

3 Some first ontological choices

As a first step towards an ontology of economic value, we present here a preliminary analysis of the main kinds of entity such a theory should deal with. This is just a rough inventory of the inhabitants of the"value world", with the purpose of listing and understanding the main ontological choices we have to make. On a first attempt, we could say that value is a relational notion: something *has* a value for somebody in a context, that is agents ascribe value to entities, such as objects and events. It seems plausible, therefore, to think of value as a *relational quality* of an entity, i.e., a quality that is not intrinsic to the entity, but is existentially dependent on an agent's mental attitude. Consistent with this approach is the definition proposed by Zuniga, who suggests that value is "a significance attached to a good resulting from a conceptualization of the good in terms of a desired end. Such a conceptualization can be characterized as an interested evaluation, since the agent perceives a causal connection between the possession of the good and the fulfilment of an end" [26, p. 306]. A refinement along this suggestion can be done by distinguishing between the value of objects and the value of events (including processes). Regarding this distinction, particularly relevant is the preference theory developed by Sen [22], in which he distinguishes between *culmination outcomes*, where only the final outcome of a certain process determines the value judgement, and *comprehensive outcomes*, where the process that brings to the outcome is considered as well. This distinction clearly emerges from the fruit choosing example discussed in [21]. The example shows how an individual that, in general, prefers mangos to apples, in specific social conditions can choose apples instead of mangos because there is only one mango left: it is not the outcome per se that drives the choice of the individual, but rather a series of conditions affecting the decision process (e.g., num. fruits available, social circumstances). Nonetheless, the same individual would still appreciate if somebody would give him the mango, without asking him: so the value of an object (the mango) is clearly different from the value of a event (a decision process) involving such object. Related to this aspect, it is worth noticing the difference between the value of a product or a service and the value of the action performed to obtain it. In the previous example, the mango has the same value regardless of the external circumstances (who is choosing, how many mangos there are, etc.), what changes is the value of the action needed to acquire its possession and disposition. The beneficiary action is more strongly related to the context, and, as such, also to ethical concerns. The previous example brings to light the need to discern who is performing the action, i.e., whether it is the beneficiary, the provider or a third person. For our purposes, we shall adopt the comprehensive outcome perspective while dealing with the value of events, since it seems plausible to assume that, in general, the process involved in the delivery of products and services affects also customer choices. In addition to the previous considerations, we have to treat in a different way the context, according to when value is perceived. For instance, value assigned before the purchase can be partially or totally independent from the user preferences. So there is a non-context dependent value and a context dependent value, which is the one that affects the costumer choice to buy a product. The latter is perceived and factored in when the product is bought or when the purchase is feasible. In the opposite case, the customer will assign a potential value, connected to the practical purposes of the product and how much these purposes are valued in the society. Thus, both customer preferences and products functionalities need to be modeled. To clarify this aspect, let us think about a house on sale. One agent (a) is not looking to buy, while the others – (b) and (c) – are. Walking in front of the house, they will all assign some kind of value to the house. Since (a) is not interested in acquiring a house, is perception won't be affected by his budget or by specific personal requirements, but it will be more general because he has no interest in going more in detail, the evaluation happens outside of the intentional to possess or dispose of the house. Instead, (b) and (c) will take into account more factors, and specifically the ones related to their requirements. The comparison of these expectations and the experience of consumption or use generates the a posteriori value, which is the focus of customer experience analysis and on which complaints are based.

We can assert that each object has one or more functionalities, meaning with functionality an "epistemically objective" [20, p. 14] function, i.e., a function that is not just a matter of the user's opinion, but it is somewhat accepted by the society, i.e., it is not an absolute objectivity. The notion of function is useful to define the derived value or use value as defined in [25], functional value, as defined in the consumption value theory, and utilitarian value. In this case, the functions of the product and its ability to fulfill them should be compared to the desired goals of the customer. Thus, also the notion of *achievement* as defined in [16] should be included. Let us think at guns; they have a socially accepted value (they are sold, they are given to policemen for public defence, etc.), but this value is different from the value assigned by each individual, who – for instance – could associate a negative value to guns, due to ethical concerns. Following from this, we can state that this kind of value is similar to the notion of market value and sometimes they may coincide, but it is not always the case. This difference is related to the resource shortage and to its importance. This can be clarified if we think of water; society assign a high value to water, but the market value is low because it is available and it is a basic need. These considerations are in line with Nunes et al. [18], who states that customer preferences can be seen as the result of goals and constraints. Yet, preferences are determinants not only of functional, use and utilitarian value, but also of hedonic value. Indeed, hedonic and emotional value imply the analysis of preferences not only with respects to products' functions and features, but also to aspects connected to the emotional and social sphere. In general, goods and services have a set of qualities (e.g., temporal and spatial qualities) through which the context can be defined. Indeed, some products get different values depending on the place or the time at which they are used. This is the case, for instance, of water in the desert. From the provider point of view, a broader analysis of the organization is needed, as well as of the different kinds of costs that the customer will bear. In other words, the provider has to evaluate the action that constitute the service offered (e.g., the actions of the customer service unit or for the warranty) and the actions that the customer has to perform in order to use the product or service. Thus, it is necessary to take into account the departments involved or eventually available in order to exploit the commitments related to the product. The analysis of the organizational structure and behaviour allows to understand whether it exists a help desk, the possibility to customize products/services, etc. These aspects constitute additional services, with respect to the product, offered by the organization. From the customer perspective, they are perceived as a bundle offer (product plus services), therefore the organizational structure per se is not relevant for the customer. Instead, from the provider point of view, its analysis and comparison to the bundle product is useful in order to evaluate the offer feasibility and to better understand which costs impact on the price. With costs we do not mean only monetary costs (including, but not limited to, the price), but also non-monetary costs (such as psychological costs, time, effort) and opportunity costs. The primitives are listed in Table 1.

4 Related works and comparison

Two main approaches have been developed in value modeling literature, namely the Resource, Event, Agent (REA) Ontology, developed in 1982 by McCarthy [17], and e3value, developed by Gordjin and Akkermans [6], who proposed a multi-viewpoint approach for the business model development, accounting also for a value viewpoint for value creation and exchange process.

The REA ontology describes economic transactions and internal processes by means of some basic constructs related to organizations, such as resource, event and agent, with the aim of developing Accounting Information Systems (AIS). Although REA is concerned with business transactions, the value of the resources and exchanges is not accounted for. The main notions described in REA are resource, event and agent. The original model has been extended [15] in order to include also concepts such as commitment and claim. However, several issues have been identified in this approach [13], such as the lack of a temporal dimensions of events and of the definition of the notion of role

e3-value is an ontology-based methodology for defining business models for business networks [6], commonly used for the modeling value exchanges. It adopts the economic value perspective by representing what is exchanged and by whom [7]. The e3-value ontology is based on the principle of reciprocity emphasizing the dual character of business transactions. This "give and take" approach denotes that every actor offers something of value, such as money, goods, services, etc., and gets a value in return. However, e3-value focuses on the exchanged value among actors, leaving out the analysis of why value is exchanged, thus stakeholders' goals [24] or other aspects such as commitment, organizational structure, and so on. It defines in an abstract way value objects, without further analysis concerning their nature or the one of the actors that exchange them.s

5 Discussion and conclusions

This work investigates the notion of value, largely discussed in literature, under several points of view, but yet not adequately defined and often misused. In socio-technical systems value analysis, and in particular the analysis of perceived value, can be highly beneficial, since it can help in decision-making processes such as which products to offer, at which price and so on. In this sense, a value theory can be seen as the basis of rational choices. However, the shaping of value aspects requires a broader analysis, that can be provided by enterprise models, which offer an abstraction over organizational elements. The misuse and the lack of a general definition of the concept of value, calls for a precise and rigorous conceptualization. This can be achieved by means of a foundational approach apt at the development of a core ontology. With this general aim, we

Table 1. Value related primitives

Primitive	*Type*	*Definition*
Value (and subforms)	Relational quality	Quality of a product or resource as perceived by an agentive physical object
Good	Endurant	object that can be traded and transfered
Service	Perdurant	complex temporal entity, not transferable, consisting of a service commitment and the corresponding process [9]
Product	Role	"role of the good or service [. . .] that is offered for sale by a vendor or agreed to be exchanged by the vendor with the actual customer in a sale" [23, p. 32]
Resource	Role	role of an endurant that participates in an action [23, 11]
Customer	Role	agent who buys a product or request a service and pays for it
Consumer	Role	agent who is beneficiary of the product
Preference	Mental individual [11]	Mental state of a customer that is more inclined to specific characteristics
Goal	Proposition [11]	"propositional content of an intention" [3, p. 182]
Constraint	Role	restrictions on the use of a functionality
Function	Role	observer-relative feature assigned to a product by the society
Price	Abstract quality	monetary amount assigned to a product by the provider
Cost (and subforms)	Abstract quality	A sacrifice – monetary or not – endured by an agent in order to obtain a product
Commitment	Social moment [11]	promise of an agentive physical object towards other agents
Person	Agentive physical object	
Market segment	Non-agentive social object [16]	segment of customers to which the product is directed
Atomic event	Event	"event that happens instantaneously". [12, p. 358]
Complex event	Event	event resulting from the composition of other events [12]
Process	Complex event	complex event made by events in sequence [12, 16]
Achievement	Atomic event	atomic eventive occurrence [16]

perform an interdisciplinary analysis of literature based on value theory and on marketing. Based on the existing literature, we perform a preliminary analysis of the main kinds of entity that an ontology of economic value should deal with. Part of these kinds of entity (e.g., event, complex event, atomic event, process, achievement, goal) are already defined in foundational ontologies such as the Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) [16] and the Unified Foundational Ontology [10]. The other kinds of entity were connected to notions already defined in these ontologies. Finally, we compare these enitities to the ones available in e3value and REA. It emerged that, only some of the concepts are defined and the ones available need further investigation investigation. Indeed, the literature on value modelling is still in its infancy, and value modeling is not well integrated with more traditional enterprise modeling activities such as process modeling and organisational modeling. Future works will move towards the general objective, i.e., to provide a well-founded framework to integrate value modeling for services into enterprise modeling.

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Enterprise Architecture Modeling for Business and IT Alignment

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Abstract. Efficient support of business needs, processes and strategies by information technology is a key for successful enterprise functioning. The challenge of Business and IT Alignment (BITA) has been acknowledged and actively discussed by academics and practitioners during more than two decades. On one hand, in order to achieve BITA it is required to analyse various focal areas of an enterprise, which motivates the benefits of Enterprise Architecture (EA) in this respect. On the other hand, it is also required to deal with multiple interests of involved stakeholders and create a shared understanding between them, which motivates the benefit of using Enterprise Modeling (EM). Therefore, this paper describes the idea of investigating the role of an integrated practice Enterprise Architecture Modeling in the context of BITA.

Key words: Business and IT Alignment, Enterprise Modeling, Enterprise Architecture, Focal Area

1 Introduction

IT is a key facilitator for a successful functioning of the today's enterprises. Through IT companies are able to change the way they organize business processes, communicate with their customers and deliver their services (Silvius, 2009). The quest of finding efficient IT support that satisfies business needs has been addressed in the literature as Business and IT Alignment (BITA) (Luftman, 2003; Chan and Reich, 2007). Currently research recognizes many dimensions of alignment between business and IT. In general it is possible to differentiate between four dimensions of BITA: strategic, structural, social, and cultural (Chan and Reich, 2007). Of these, the strategic dimension currently receives significantly more attention (ibid). However, consideration of all these four dimensions is required in order to increase IS effectiveness and efficiency, the enhancement of business and IT flexibility, the improvement of business performance and other positive effects (Vargas, 2011; Schlosser et al., 2012).

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If BITA is to be achieved, there needs to be a clear and up-to-date representation of the AS-IS and TO-BE states that accurately reflects – for the different stakeholders within the enterprise – the various *focal areas* that these states imply (Engelsman et al., 2011; Jonkers et al., 2004). The various focal areas of an enterprise can include organizational structure, business processes, information systems, and infrastructure, which together form an Enterprise Architecture (EA). There are many different EA frameworks available today, each defining a set of focal areas for viewing an enterprise in a comprehensive way.

Jonkers et al. (2004) define Enterprise Architecture (EA) as a coherent set of principles, methods and models that are used in the design and realisation of the various focal areas of an enterprise. Coherent description of various focal areas of EA is able to provide insights, enable communication among stakeholders and guide complicated transformation processes (Jonkers et al. 2004). There are different terms currently used when talking about how to organize and manage different focal areas of EA in a holistic and integrated way and address dynamic nature of EA evolution in whole. Buckl et al. (2009) refer to EA management as a way to deal with EA and argue that EA management is designed to integrate with the existing enterprise-level management functions to conjointly manage and develop the EA towards aligned business and IT.

The unambiguous description of EA components and their relationships requires a coherent modelling language (ibid.). In this relation, Enterprise Modeling (EM) is often addressed as an adjacent concept of EA that is able to describe various focal areas of an enterprise and EA to allow specifying and implementing the systems (Chen et al., 2008). However, a coherent modeling language cannot guarantee to solve the BITA problem (Jonkers et al., 2004). The problem of BITA is complicated by a numerous stakeholders having multitude of interests and agendas, which cannot always be captured by means of a modelling approach (ibid.). Existence of different, often contradicting, interests of the stakeholders, strengthen the need for active communication between them when it comes to enterprise transformation initiatives aiming to close the gap between business and IT. Here the benefits of participative Enterprise Modeling (EM) become noticeable. According to Barjis (2011), collaboration, participation, and interaction among a large group of stakeholders is highly beneficial in the practice of modeling, as it enables more effective and efficient model derivation and it increases the validity of models.

Despite the contribution that EM can offer to support BITA, social issues (as for example, the ability of EM to create shared understanding between business and IT stakeholders) receives scant attention in studies considering the role of EM in the context of BITA (McGinnis, 2007). However, EM practices that do not allow the integration of human issues in the modeling do not meet the needs of enterprise transformation initiatives (McGinnis, 2007). Thus, the main aim of my research is to investigate the contribution of Enterprise Architecture Modeling in solving the problems of BITA within its various dimensions, taking into account the participative approach in modeling. The main research question of this work is the following:

How can participative Enterprise Architecture Modeling contribute to BITA?

In order to answer this research question I have broken it down into several sub-questions, which are presented in Table 1 below. A set of knowledge contributions will answer these questions and will be presented in a number of publications. All the knowledge contributions will be integrated in the Framework for EAM in the context of BITA, which will be the final deliverable of my doctoral thesis project. The first research question is related to participative EM. This group of question has to do with *how* aspect, i.e. how to use EM so that it contributes to BITA. The first research question was considered in a licentiate thesis (Kaidalova, 2015, supervisors: Ulf Seigerroth, Jönköping University; Anne Persson, Skövde University). The second research question is related to the ability of models to capture and represent various focal areas of EA. This question has to do with *what* aspect, i.e. what are the focal areas that need to be considered in order to deal with BITA.

Table 1 Relationships between research questions, knowledge contributions and relevant publications

Research questions	Knowledge contributions	Related publications
1. How can EM contribute to BITA?	*The procedural EM framework for BITA*	Synthesized and presented in licentiate thesis
2. How can EA contribute in solving different dimensions of BITA problem?	The contribution of EA in BITA, considering different BITA dimensions	Paper X
2.1 What are the relevant and the sufficient sets of EA focal areas when dealing with BITA?	*Knowledge contribution 2.1: Sets of relevant and sufficient EA focal areas for dealing with BITA*	Kaidalova et al. (2015) – BIS 2015 Paper Y
2.2 How these EA focal areas are related to different dimensions of BITA?	*Knowledge contribution 2.2: The link between EA focal areas and BITA dimensions*	Paper Z

This doctoral consortium paper will focus on the second research question. The remainder of the paper is structured in the following way: Section 2 describes the planned research approach. In section 3 the relevant theories are described. It mostly covers the BITA, EA and EM areas. The results derived so far are presented and discussed in Section 4.

2 Research Approach

In order to answer the first research question a research process has been constructed and carried out as a part of my licentiate thesis project (for details see Kaidalova, 2015). This research process included three parallel parts: theoretical work, empirical work and conceptualization work. The division of the research process into these three parts is related to the grounding of knowledge described by Goldkuhl (1999), who suggests differentiating between empirical, external theoretical, and internal knowledge grounding. This research process resulted in generating the procedural EM Framework for BITA, which is marked with (*) in Figure 1 below. Elements with white filling represent steps of the research, whereas elements with grey filling represent results (knowledge contributions from Table 1).In order to answer the second research question the research process will be organized in a similar manner. Theoretical work, empirical work and conceptualization work will be carried out in parallel, each employing a different research method in a sequence of interlocking steps to produce a set of knowledge contributions. Literature review will be applied in the theoretical work, interviews - in the empirical work, whereas the conceptualization work will include an iterative refinement of the results by restructuring them, by adding new constructs, and by packaging the results for their subsequent use.

The first step in the planned research process is a systematic literature review on Enterprise Architecture Modeling (step 1). The aim of this step is to understand the state of the art with regards to usage of the term "Enterprise Architecture Modeling" and the main interest areas in this area, including the attention which is currently given to participative approach. After that, the following knowledge contributions will be generated with the help of literature review and then validated via number of semi-structured interviews (steps 2a and 2b; steps 3a and 3b): a set of relevant and a set of sufficient EA focal areas relevant when dealing with BITA, the link between EA focal areas and BITA dimensions. Potential candidates for interviews are EA practitioners with experience of using existing EA framework and tools within enterprise transformation projects.

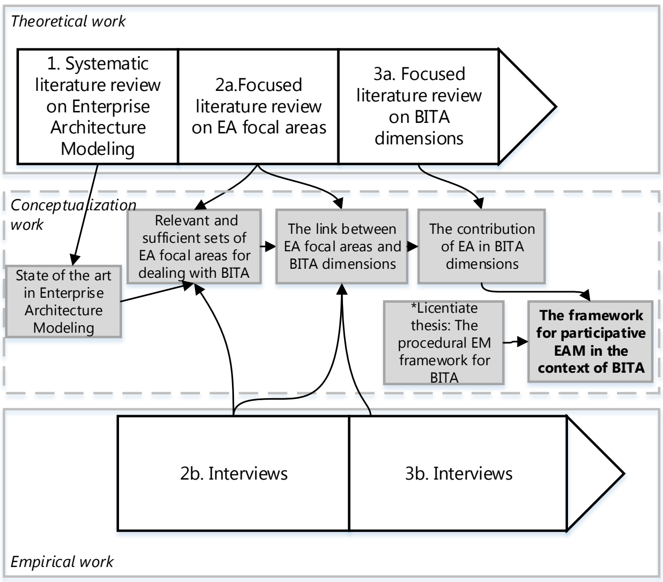

Fig. 1. Research process aimed to answer the main research question – theoretical, empirical and conceptualization work

Conceptual refinement of the derived knowledge contributions will allow to generate the contribution of EA in BITA dimensions, which is the knowledge contribution answering the second research question. Finally, after integrating the answers for the first and the second research questions it will be possible to generate the Framework for EAM in the context of BITA, which will answer the main research question of my doctoral thesis.

3 Relevant Theories from the Problem Domains

In this section some relevant theories from the problem domains are presented. First, general description of the BITA problem and its various dimensions are introduced in sub-section 3.1. After this, the relevant theories regarding EA are presented in sub-section 3.2, and the participative EM – in sub-section 3.3.

3.1 Business and IT alignment - Dimensions and Domains

According to Chan and Reich (2007) there are several *dimensions* of alignment: strategic, structural, social, and cultural. The strategic refers to the degree to which the business strategy and plans, and the IT strategy and plans, complement each other. The structural dimension refers to the degree of structural fit between IT and the business that is influenced by the location of IT decision-making rights, reporting relationships, decentralization of IT, and the deployment of IT personnel. The social dimension refers to the state in which business and IT executives within an organizational unit understand and are committed to the business and IT mission, objectives, and plans. The cultural dimension refers to the need of IT planning to be aligned with cultural elements such as the business planning style and top management communication style. Achievement of BITA requires analysis and improvement of all BITA dimensions. On one hand, there is a need for an accurate and up-to-date representation of an enterprise and its focal area, as it enables alignment of the considered focal areas and in this manner deals with the strategic and structural dimensions of BITA. On the other hand, BITA achievement requires to deal with numerous interests of involved stakeholders and create a shared understanding between them, which could allow managing the social and cultural dimensions of BITA.

In addition to BITA *dimension*, a term *domain* is used in relation to BITA. In my thesis I address BITA domain in a similar manner to Chan and Reich (2007) who differentiate between a BITA dimension and a BITA domain. A BITA domain is a bounded area that an enterprise structure contains and that together with other domains show the constitution of business and IT architecture. Generic framework for information management designed by Maes et al. (2000) contains three domains: business, information and communication and technology. Basically, in this framework technological aspects are divided into two parts: (1) Information and communication, i.e., software components for interpreting information, communication and supporting knowledge processes, and (2) Technology, i.e., infrastructure: hardware and middleware. Another approach is adopted by Pearlson and Saunders (2010) in the framework Information Systems Strategy Triangle. The framework focuses on relationship between three domains: information, business and organisational strategy, and also how Information System (IS) strategy can influence other strategies in a company.

3.2 Enterprise Architecture

EA community mostly doubts the existence of a general EA management process fitting to any size of enterprises (Buckl et al., 2009). Timm et al. (2015) point out the need for investigation of EAM practice in Small and Medium-sized enterprises (SME). Winter et al. (2010) emphasize the lack of research regarding EA management and argue that there is neither a common understanding of the scope and content of the main activities in EA management, nor has a commonly accepted reference method been developed. It motivates the need for new reference models and methods related to EAM.

At the same time, emerging new products and services require a tight integration of what often is separated in many enterprises into enterprise-IT (i.e. the IT supporting business and administrative parts) and product-IT (i.e., what is built into the products or supporting industrial automation). One potential benefit of such integration can be an ability to conveniently access to the data that a vast number of product-IT instances collect during their operation. Potentially, Enterprise Architecture Management (EAM) can serve as a mean to support both, continuous alignment of business and IT, and the integration of product-IT and enterprise-IT.

3.3 Participative Enterprise Modeling

EM is a practice for developing, obtaining, and communicating enterprise knowledge, like strategies, goals and requirements to different stakeholders (Stirna & Kirikova, 2008; Sandkuhl at al., 2014).

Collaboration, participation, and interaction among a large group of stakeholders is highly beneficial in the practice of modeling, as it enables more effective and efficient model derivation and it also increases the validity of models (Sandkuhl et al., 2014; Barjis, 2011). The participative approach also implies involvement of stakeholders in modeling for better understanding of enterprise processes (Sandkuhl et al., 2014). The role of the EM practitioner who leads this kind of EM effort becomes vital for the efficient creation and use of enterprise models (Sandkuhl et al., 2014; Rosemann et al., 2011).

4 Preliminary Results

So far, the author has investigated the first research question in the licentiate thesis and also has done some investigation related to the second research question. The answer for the first research question is the procedural EM framework for BITA, but it will not be presented in this paper due to the space limitation. The results existing so far for the second research question are presented in section 4.1. In particular, those are related to the sets of relevant and sufficient EA focal areas for dealing with BITA (knowledge contribution 2.1) (Kaidalova et al., 2015).

4.1 EA Focal Areas in the Context of BITA - Relevant and Sufficient

This section presents how EA focal areas (Zachman, 1987) can be positioned within the domains of the chosen BITA frameworks. As BITA frameworks the Generic framework for information management (Maes et al., 2000) and IS Strategy triangle (Pearlson and Saunders, 2003) are considered. Zachman framework has been chosen as an example EA framework for illustration, since it is one of the fundamental EA frameworks that contains a comprehensive set of well-defined EA focal areas. Focal areas are defined according to six basic questions: (1) data (what?) – data needed for the enterprise to operate, (2) function (how?) – concerned with the operation of the enterprise, (3) network (where?) - concerned with the geographical distribution of the enterprise's activities, (4) people (who?) - the people who do the work, allocation of work and the people-to-people relationships, (5) time (when?) – to design the event-to-event relationships that establish the performance criteria, (6) motivation (why?) – the description that depict the motivation of the enterprise, which typically focuses on the objectives and goals.

The positioning of Zachman's six focal areas within the domains of the Generic Framework for Information Management is presented below in Figure 2, the left-hand side.

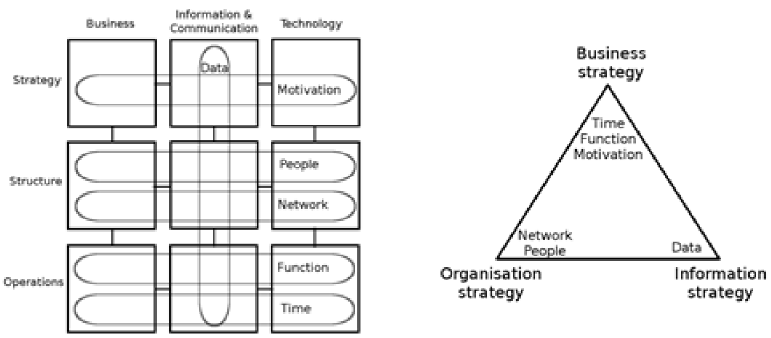

Fig. 2 The positioning of EA focal areas (Zachman, 1987) within the BITA domains of Generic Framework for Information Management (Maes et al., 2000) (left-hand side) and the positioning of EA focal areas (Zachman, 1987) within the BITA domains of IS Strategy triangle (Pearlson and Saunders, 2003) (right-hand side)

Data focal area provides a support for dealing with Information & Communication domain of BITA, since it provides various kinds of information that are fundamental for enterprise functioning. It does not have direct connection to Technology domain, which has to do with infrastructure of the enterprise in terms of hardware and middleware. Focal areas function and time are able to facilitate dealing with the operations domain, as together these two focal areas are able to describe business processes of the enterprise and the way it operates. Focal areas of people and network provides a strong support for the structure BITA domain, as it allows describing the hierarchy and disposition of business units and employees within it. Motivation-related issues contributes to the clear picture regarding an enterprise strategy, as it gives an understanding regarding visions and goals of an enterprise.

The positioning of Zachman's six focal areas within the domains of the IS strategy triangle is presented in Figure 2, the right-hand side. An important point here is that the domain of the IS strategy triangle are considered to imply not only strategies, but also operational issues to a certain extent. The focal area of data can facilitate dealing with the domain of Information Strategy, as it enables analysis of various information needed to make an enterprise operational. Relations within networks and between people is able to contribute to analysis of organisation strategy, as it gives a clear picture of how responsibilities are distributed in an enterprise between employees and units, the hierarchy of units that form an organisational structure and the disposition of this structure. Focal areas of time and function provides a clear picture of business processes within an enterprise, and thus plays an important role in dealing with the domain of business strategy. Focal area of motivation is able to contribute to the domain of business strategy, as it represents vision and goals of an enterprise that have a decisive role in business strategy.

A set of sufficient EA focal areas would allow to minimize the usage of resources within EA modeling, by enabling to model an enterprise in a "good enough" way. In that case it might be suitable to decrease the number of modelled focal areas. Possible way to do it would be to unite people and network focal areas into an organisational structure, and unite function and time into business processes. By doing so the total number of focal areas to be modelled would decrease from six to four: motivation, data, organisational structure and business processes. This would be still a sufficient set of focal areas to deal with various BITA domains. The presented positioning considers only enterprise-IT, whereas the product-IT remains disregarded. It definitely calls for further investigation, since integrated view on enterprise-IT and product-IT within EAM would be a benefit and enable competitive advantages as discussed in 3.2.

Also, as it has been mentioned earlier in section 3.1, apart from BITA domains, it is possible to differentiate between four dimensions of BITA: strategic, structural, social and cultural. Each BITA framework has its own focus and puts an emphasis on certain BITA dimensions. It is equally important to deal with all four dimensions, but currently strategic and structural dimensions of BITA receive more attention than social and cultural (Chan and Reich, 2007). The chosen BITA frameworks provide rather minor support for dealing with social and cultural dimensions, particularly Generic Framework for Information Management includes Information & Communication domain that is to a certain extent related to these alignment dimensions. It is therefore interesting to investigate which of the existing BITA frameworks allow to deal with cultural and social alignment dimensions, which calls for a comprehensive state-of-the-art study in the BITA domain.

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Modelling and Facilitating User-Generated Feedback for Enterprise Information Systems Evaluation

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Abstract. Most enterprises operate within a complex and ever-changing context. Users understand the software as a means to meet their requirements and needs, thus, giving them a voice in the continuous runtime evaluation of software would naturally fit this level of abstraction to ensure that requirements keep pace with changing context. However, this evaluation knowledge is often provided in an ad-hoc manner, which endures a great deal of impression and ambiguity leading to another problem, which is how engineers can extract meaningful and useful information from such feedback to inform their maintenance and evolution decisions. This doctoral work is novel in providing classifications of users' feedback constituents and how they could be structured, which can be employed for a formal feedback acquisition method. Also, capturing structured feedback using systematic means can aid engineers in obtaining useful knowledge for evaluating enterprise information systems in order to maintain and evolve their requirements.

Keywords: Users' Feedback; Feedback Analysis; User Involvement; Requirements Models; Enterprise Information Systems Evaluation;

1 Research Problem and Motivation

Requirements management is still one of the most challenging fields in software development [1] [2], has the most impact on project success, and is a major issue for decision makers in enterprises. Requirements are gathered from a diverse group of users; and they are basically volatile in nature. These issues are worsened by the problem that users still typically provide their feedback on the fulfilment of their requirements in a natural language and in an ad-hoc manner, which introduces a great deal of imprecision and ambiguity.

To cope with such a lack of precision, a range of semi-automated techniques have been suggested to handle such user data (this includes techniques such as text mining and/or human facilitator). These techniques may be used to gather, interpret, aggregate, and revise what users say, partly to mitigate for such issues as bias and subjectivity in their textual responses. However, more effective results can be reached if the feedback is written in a structured manner. Structured feedback text would, arguably, allow approaches, such as text processing, to provide more accurate results within less time and with fewer human interventions. Also, if text is structured the

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requirements extraction process can be more systematic, eliminating complexity and ambiguity found in natural language, and requiring less effort.

Presently, the design and conduct of feedback acquisition are heavily dependent on engineer's creativity. To maximize the expressiveness of users' feedback and still be able to efficiently analyze it, feedback acquisition should be designed with that goal in mind. Hence, the need to provide foundations to develop systematic approaches is needed for the structuring and use of users' feedback [3, 4], and supporting engineers with appropriate tools for evaluating requirements and thus making appropriate maintenance and evolution decisions.

2 Research Aim

The aim of this research is twofold that is 1) to explore common feedback structures and their pillars so that acquisition methods can be provided, which maximize quality without hindering users experience, and 2) to explore how to support requirements engineers in analyzing and transcribing end users feedbacks into well-defined requirements. This will lead to a more effective management and richness of the users' role as evaluators. Also, it provides a systematic means for requirements engineers to capture and analyze and prioritize feedbacks and thus requirements too.

3 Research Questions

RQ1) What are the concepts that constitute the feedback structure? How can they be modelled? And utilized in a feedback acquisition method?

RQ2) How can requirements knowledge be extracted from the collected end-user feedback to help engineers in evaluating requirements?

4 Research Objectives

Objective 1 - Background Search and Literature Review: the first objective is to review the relevant work done in the literature in order to analyze what peers have reached regarding the definition of users feedback, how it is analyzed, and utilized. Thus, the gaps can be identified and new methods proposed that can move the research field forward. This objective will be accomplished in parallel with other objectives in the PhD, because it is an ongoing task of analysis and criticism to the relevant topics, which should be continuously maintained throughout the research.

Objective 2 - Developing a new classification of feedback components and types: the aim is to come up with a new classification and definition of feedback types, the elements that constitute each feedback type, and the details that users employ to describe their feedbacks.

Objective 3 - Developing a Structured Feedback Acquisition Method: our goal is to provide a systematic means that is able to automatically classify users' feedback, be able to validate this feedback and store it in a structured and interrelated manner.

Objective 4 - Developing new evaluation templates for the engineers that can be used to support software maintenance and evolution: the analysis of classified structured feedback will provide the engineers with a unique set of cases that carry important knowledge that can inform the evaluation process. Our goal is to design a combination of cases that will deliver a novel set of evaluation templates that contain concrete and formal instances of inter-related feedback that can help engineers in different decision-making situations they encounter in runtime evaluation.

Objective 5 - Verification and validation of the effectiveness of the approach: At the end, the proposed approach will be verified and validated through a case study to: investigate whether it is successful in providing engineers with useful/ meaningful instances of the feedbacks, and in helping them in taking evolution and maintenance decisions.

5 Literature Review

Mainly this research literature is divided into three main streams. The first stream is user-centered approaches in which general topics were reviewed regarding how users are involved in traditional approaches and how enterprises benefit from user involvement to communicate problems and enhance their overall process. There are several paradigms where the role of users is central such as User centered design [5], User Experience [6], Agile methodology [7], Usability Testing [8]. These techniques can aid the design of enterprise information systems, but they are expensive and time consuming when used for highly variable software designed to be used by a large number of users in contexts that are hardly predictable at design time. Furthermore, this research is similar to End-user Computing [9] in the motivation of involving users and enabling them to change in the system itself to meet their requirements and needs. However, this research relies on users to provide feedback in order to decide on maintenance and evolution decisions rather than taking actions. .

Recent research has been directed towards involving users in evaluating and modelling evolving requirements for large enterprise software. Authors in [10], main contribution is a theoretical understanding of user involvement as a key success factor in implementing and maintaining business intelligence solutions. Moreover, in [11], authors suggest users involvement in developing Business Process Management projects. Their modelling approach involves using User Requirements notation that integrates goals and usage scenarios, from which requirements can evolve. Additionally, in [12] the authors present how strategy maps can be augmented by consumer values to include goals reflecting consumer values, which can be used as requirements for new solutions. All the above work supports the importance of users in driving the enterprise business process as a lifelong activity. However, their work operates on the management of requirements at a rather strategic level to ensure goal satisfaction, and business strategy implementation. In contrast, this research aims to provide engineering approach with concrete constructs to model and acquire feedback and enable their role to take place.

Also, in the last decade there has been a lot of interest in the area of engineering runtime self-adaptive systems [13] [14]. In spite of its importance, the role of users in supporting and tailoring the adaptation process and decisions is still unclearly presented. The involvement of users as partners with the adaptation process amplifies its potential and range of applications.

Second, more focused topics were reviewed to study the work that peers have reached regarding the definition of users' feedback, how it is communicated, analyzed, and utilized. Authors in [15], extract the main topics mentioned in the feedback, along with some sentences demonstrative to those topics using sentiment analysis. Also in [16], have defined a simple domain ontology consisting of generic broad types of feedback and associations. They cluster feedback messages according to the entities they refer to, use natural language parsing and heuristic filtering that can match the detected keywords to domain ontology. Moreover, in [17], the research aims on providing an elicitation approach that can offer new opportunities for users to support them in documenting their needs using a mobile tool. In contrast, and instead of analyzing given feedback, e.g. through forums and social networks, this research contributes to forward engineer the acquisition process itself making the analysis more efficient.

Finally, facilitating paradigms and platforms have been studied such as requirements models [18] [19] [20], ontologies [21] [22], controlled natural languages [23] and recommender systems [24] with the intension to employ them in the proposed solutions.

6 Research Methods

To achieve objective 2: a two-phase empirical study was designed. In the first phase study a two sessions focus group study was conducted, which is a popular technique of qualitative research in software engineering [25]. The Grounded Theory [26] was one of the most appropriate approaches to take. The Grounded Theory allows researchers to discover as much as possible variations in people's behaviors, issues and/or concerns about the problem rather than depending on prior hypotheses.

The focus groups' sessions lasted 2 hours and 52 minutes. Both sessions were audio recorded and transcribed with consent from participants. The goal was to collect insights and experience from users who have actually given feedback before. Also, both junior and senior software engineers were invited to understand how more high-tech users give feedback and how they think a good feedback should be structured in order to be easily understandable and analyzed. The main areas to explore were:

RQ1) How users would like feedback to look like, and the criteria that judge whether the feedback is meaningful and useful?

RQ2) How users would like to be involved in the process of providing feedback, and what encourages them to act as evaluators?

The research aim necessitates building a more concrete description for feedback structures. So in order to get the elaborated view, the second phase in-depth study was conducted, which involved the analysis of three actual enterprise systems' -online forums where people give feedback on business software. Two hundred feedback from twenty different sources found on enterprise software forums, which are Microsoft's TechNet, WordPress, and SAP were analyzed. The main areas to explore in the second phase study (i.e. the three forums analysis) were:

RQ1) What are the main concepts that constitute the feedback structure?

RQ2) What are the designs of the identified feedback concepts?

Enterprise business software was targeted, as normally users tend to give a more serious and focused feedback, because of the social norms in such kind of forums. These three forums were chosen in order to target different types of business users with diverse technical capabilities.

Actual users' feedback was studied through observation and analysis of their posts and responses on forums. Forums provide a considerable amount of feedback that was analyzed using thematic analysis [27] with the intention to come up with the main concepts that constitute a feedback, and the outlines of the identified concepts.

To achieve objective 3: the main method that will be used to ensure formalism is to build ontology [21] of feedback concepts in order to reach a common definition of the structure of feedback and the rules and relationships that govern its use. Ontologies include machine-interpretable definitions of basic concepts in the domain and relationships among them. Also, it can be easily maintained and extended. Furthermore, the ontology will be validated by an ontology reasoner to ensure its efficiency and consistency.

To achieve objective 4: the interviewing technique [28] will be used to gather information from engineers. This involves providing them with examples of new validated feedback linked to mainstream RE models such as goal models to represent the stakeholders' goals. This can also be related to the feature model to represent both the functional and non-functional requirements of the system. By relating the structured feedbacks to the feature model, engineers can propagate through the interconnections between them to determine different levels of evaluation information. Moreover, this technique will help to gain information about the RE methods and models they use, its drawbacks and the possible advantages they can reach when using the suggested methods, and models. This will assist in gaining a deep understanding of how the instances of formalized feedbacks entered by users can be utilized to create new cases that constitute evaluation templates that map to the actual needs of engineers in real situations of enterprise software evaluation.

To achieve objective 5: a case study [28] will be performed to describe that particular case of users providing feedback, its acquisition, validation, and utilization in enterprise software evaluation in detail. Also, it will be investigated whether it is successful in providing engineers with useful/ meaningful instances of the feedbacks, and in helping them in taking evolution and maintenance decisions, and take learning from that to develop theory.

7 Results Achieved

The focus groups were analyzed using the thematic mapping approach [27]. The results of the focus groups analysis were initially introduced in [29] and further elaborated in [30]. This study provided a good level of understanding of users' feedback aspects. The resulted thematic areas can be viewed from two different perspectives. In the first perspective, participants gave several insights regarding the structure of the feedback and what are the characteristics they think make their feedback meaningful and useful. These ideas are covered in the environment and structure thematic areas. In the second perspective, participants gave their perceptions regarding what they expect from a feedback acquisition method. How it can support, motivate and value their feedback. These ideas are covered in the engagement and involvement thematic areas [30]. **This contributes to the literature by providing an initial set of thematic areas, where each can be studied and elaborated more to move the research field forward.** Our research motivation and aim directed us to further study and observe components and types of user feedback in business context in more details. The two studies are linked through taking partial initial results from the focus groups' themes, enhancing and expanding them through in-depth **enterprise systems' forums analysis and observation, which resulted in a novel classification and definition of feedback types and level of details used to describe them** as elaborated in [30]. Also a set of conclusions regarding each feedback type's elements was derived from the analysis of the forums' feedback threads that will serve as a basis for providing formal definitions of the resulted classification (i.e. to achieve objective 3).

8 Next Steps

To realize Objective 3: 1) to formalize the definition of user feedback elements the ontology [21] will be developed that classifies these elements using a set of rules; 2) to improve clarity and enable consistent automated semantic analysis of the feedback, a feedback controlled natural language [23] can be employed as an acquisition method for users to provide their feedback. It will restrict the user by general rules such as keeping sentences short and only use reserved keywords to define textual blocks; 3) a workflow integration layer will be designed to orchestrate the workflow between controlled natural language engine, the ontology reasoner to validate users' feedbacks, and relate feedbacks to a feature model that will provide further systematic assistance for the engineers in extracting problems related to certain features, or determining which features are more problematic.

To realize objective 4: new templates can be derived that combine multiple feedbacks and feedback types to form new cases that can inform the engineers by giving them a detailed view of the software's evaluation status from the users' point of view. This can be accomplished by: 1) defining the template building blocks through combining the feedback types that match together to form a concrete, useful and meaningful set of information (i.e. case). This will be designed by ontology rules that will contain the rules that govern the case identification; 2) describing a set of rules for extracting information, and building templates that can support engineers in taking maintenance and evolution decisions from the numerous users' feedbacks that are continuously filled in the ontology knowledge base; 3) designing a workflow integration layer that will manage the interaction between the ontology reasoner for case definitions component, the template extraction rules component, relating them to the system's goal model, and the component for handling the utilization of recommender systems [24] that will be applied on the users' feedbacks to help eliminate extra time and effort and produce more accurate templates.

9 Conclusions

This paper has presented the current results and ongoing research on modelling and facilitating user feedback for enterprise information systems' evaluation. Moreover, an explanation was provided of how the findings can be employed to develop a collaborative acquisition method that utilizes the ontology's formalism and the controlled natural language to validate and store structured feedbacks for representing problems in a systemized way where the risks resulting from human interventions are minimized. Finally, high level view architecture was suggested that will inform the construction of evaluation templates, which will help the engineers in taking the maintenance and evolution decisions. Therefore, the current research results serve as a foundation step for a holistic approach for the structuring and use of users' feedback for enterprise software requirements evaluation.

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Modeling Software Process Configurations for Enterprise Adaptability

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Abstract. Modern enterprises are expected to continuously evolve and adapt to uncertain environmental conditions and evolving customer trends. Adaptability in software processes enable enterprises to respond to changing situations by selecting software process configurations that help best meet enterprise-level business goals. Conventional methods of modeling and designing software processes are limited in their ability to visualize these software process configurations, reason about them and select an appropriate configuration which meet functional and non-functional requirements while considering enterprise-level perspectives. As part of our PhD project, we propose a requirements-based software process adaptability framework that considers software process adaptability, first at a process-centric and then at an agent-centric level. Key constructs for this framework are discussed and illustrated by using the DevOps approach as an example.

Keywords: Enterprise Modeling, Software Processes, Software Process Variability, Agent and Goal Modeling, Adaptive Enterprises.

1 Introduction

1.1 Background

Modern enterprises are expected to continuously evolve and adapt to uncertain environmental conditions and increased competition from new market players, including those from non-traditional sectors [1]. Customers are increasingly expecting personalized services while emerging technologies are causing the digital transformation of enterprises. To this end, more and more enterprises are relying on software to aid in the delivery of customer-centric products and services in progressively more turbulent and dynamic environments [2]. As a result, software processes (SPs) are becoming an integral part of enterprises' strategic and operational processes. Recent years have seen the emergence of various software development approaches and practices. The current rapid adoption of DevOps [3] creates an opportunity to re-examine the ability of enterprises to quickly deploy new software product features, through to the end-user, by having frequent product release cycles. DevOps enables the achievement of enterprise business objectives through (a) the automation of process tasks in the soft-

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ware development lifecycle, (b) solicitation of customer feedback and usage of software metrics to continuously refine and improve the software development process, and (c) reducing department silos by promoting a culture of collaboration and sharing of information across teams [2][4]. The above are attained through diverse considerations, ranging from systems design and software tool support, business and process configuration, to social and organizational behavior matters.

1.2 Problem Statement

Each enterprise has unique characteristics and business goals; software development processes can vary significantly between enterprises as these processes are configured considering the unique variations and nature of software products and projects, and the behavioral peculiarities of each organization [5]. An appropriate configuration of SP needs to be selected based on defined enterprise-level functional requirements (FRs) and non-functional requirements (NFRs). The SP needs to be adaptable so as to be able to handle evolving enterprise situational needs, particularly those that result from emerging digital technologies (such as social media, mobile technologies, big data analytics, and cloud computing) within an enterprise setting. NFRs for SPs include adaptability of the development process, speed of adaptation, shortening the deployment cycle etc.

Adaptability requires the consideration of social- and enterprise-level perspectives, while addressing practices such as continuous software engineering, using concepts of multi-level adaptive systems, and linking software process design considerations with organizational stakeholder interests and enterprise-level business goals. While there is significant literature which studies the variations and commonalities between SP families, these studies do not sufficiently cover the high-level abstractions for representing adaptation constructs of SPs and mostly deliberate at a software process adoption and implementation level. Furthermore, conventional methods of modeling SP reconfigurations are limited in their ability to consider the multiple enterprise-level viewpoints for each alternative SP configuration and have also not been applied to the range of considerations that are present in DevOps.

1.3 Research Objectives

The objective of this research can be succinctly described as "to define and develop a requirements-based SP adaptability framework which enables enterprises to ensure ongoing and sustained delivery of products and services under varying circumstances while adhering to enterprise-level FRs and NFRs." An enterprise has fundamental SP adaptation tendencies, particularly those pertaining to emerging digital technologies; the nature and nuances of these need to be understood, determined and categorized, as well as the link established between SP reconfigurations and enterprise business goals. Based on this understanding, SP adaptability realization techniques need to be developed and abstracted for representing SP adaptability with respect to relevant constructs, concepts, relationships, information flows, dimensions etc.

The determined abstraction will be visually depicted through modeling notations. Additionally, these aspects need to be represented as a meta-model formalization. Existing modeling languages from the areas of system dynamics, systems and component modeling, business and software process modeling, agent and goal modeling etc. will be considered and extended as required. SP adaptability requirements need to be established and verified for requirements satisfaction. The SP adaptability framework aims to provide a way of characterizing the as-is and to-be states as alternate SP configurations. An existing as-is state may be deemed to not be satisfying adaptability requirements and thus necessitate the selection of an alternate to-be state. This research will develop software tool support for different parts of the framework such as the visualization and drawing of adaptability requirements, analysis of adaptability models and simulation of model evaluation.

2 Related Work

Tactics exist for the tailoring [6] and improvement [7] of standard SPs to meet the specific needs of an enterprise; this is accomplished through some form of adaptation of certain activities or SP parameters based on an assessment of environmental factors, product and project goals, and other organizational aspects. The Capability Maturity Model Integration (CMMI) models provide guidance for process development and maturity for different organizational areas, including software processes [8]. Software Product Lines (SPL) can reduce development cost for product families through the determination and reliance on variation points [9]; delaying the placement of these variation points along the software development cycle can provide certain technical and business benefits (e.g., increased code reuse) across multiple products at the expense of other goals (e.g. simpler architecture). A family of software processes can have task commonalities and variabilities; these could be integrated to produce Software *Process* Lines (SPrL) [10] which would help reduce the effort of managing many individual SPs that exist in any enterprise.

Situational Method Engineering (SME) can be used to create development methods for specific purposes by selecting and combining method fragments previously stored in method repositories [11]. Social actor modeling frameworks (such as *i** [12]) focus on the social dimension of any domain by allowing the incorporation of actor intentionality, motives and goals during domain analysis. This allows for the evaluation of alternatives based on the satisfaction of actor goals which can assist in the selection of software process configurations based on enterprise NFRs. At an enterprise level, Business Product Architectures (BPAs) have been previously discussed in [13], including the nature of relationships and the dependency types that exist between business processes, and the “binding” of variation points on alternative selection.

The above is not an exhaustive listing of related work but serves to demonstrate the range of study that can be considered related to the general “software process adaptability” area. This research aims to deal with software process adaptability at an enterprise level by considering system-, process-, and social-level factors while advancing current methods for software process modeling and design.

3 Initial Results and Expected Outcomes

Key constructs from the general area of SPs need to be abstracted to express the adaptability nature of SPs. The constructs for SP adaptability will be depicted through a modeling notation with multiple enterprise modeling and architecture perspectives being leveraged for considering these constructs. DevOps is used as an illustration for SP adaptability as the multiple enterprise-level perspectives (such as systems, process, social, and organizational) in the DevOps approach provide an interesting challenge for enterprise modeling. Further, the DevOps approach permits the study of SP adaptability at a process-centric and at an agent-centric level. Supplementing process-centric models with agent-centric models allows for the inclusion of stakeholder interests during reasoning and analysis resulting in more suitable adaptability designs.

3.1 Process-Centric Framework

The process-centric framework builds on the work previously introduced in [14] where the dimensions of Business Process Architecture (BPA) were discussed. *Process elements* (PEs) can be thought of as being a unit of any SP with a PE producing a measurable output based on a set of control and data inputs. Placing of PEs can be done along multiple BPA *dimensions*; the dimensions being temporal, recurrence, plan-execute and design-use. SP configurations (e.g., different variations of DevOps) can be represented through the placement of PEs along an SP. Similar placements across two configurations are referred to as commonalities while differences between configurations are considered as variabilities with "*choice-points*" indicating alternative options of PE placements. The placement of a PE along any one of these dimensions, including their movement along these dimensions, is done after considering suitable enterprise-level NFR trade-offs. *Boundary* conditions exist in any DevOps configuration, with PEs being placed within a boundary based on their relative characteristics. These concepts also allow us to handle different software engineering concepts, such as technical debt [15]. Movement of PEs within a boundary may not result in increased technical debt however moving a PE beyond the boundary may either increase or decrease technical debt significantly. Thus, alternative DevOps reconfigurations are obtained by considering technical debt (or other appropriate) trade-offs of PE placements across boundaries.

As with any modeling technique, adaptability constructs are connected to each other through *relationships* for representing sequencing, dependencies, information transfer, compositionality, triggers etc. Existing notions of relationships and interactions from multiple enterprise modeling techniques will be considered with the objective of extending them by considering the influence of emerging digital technologies and enterprise adaptability demands. For example, DevOps could undergo ongoing adaptation and refinement through the monitoring of software metrics collected through big data analytics which are propagated through feedback and feedforward loops. Adaptation from one DevOps configuration to another can be initiated through *triggers*. Triggers can be "fired" through data-driven sensing mechanisms and re-directed through to PEs as inputs. These triggers would then allow the PE to interpret this new sensory input and act with respect to the selection of suitable alternatives that satisfy the enterprise NFRs based on the changed situation. Fig. 1 shows a BPA DevOps implementation model with some of the aforementioned constructs.

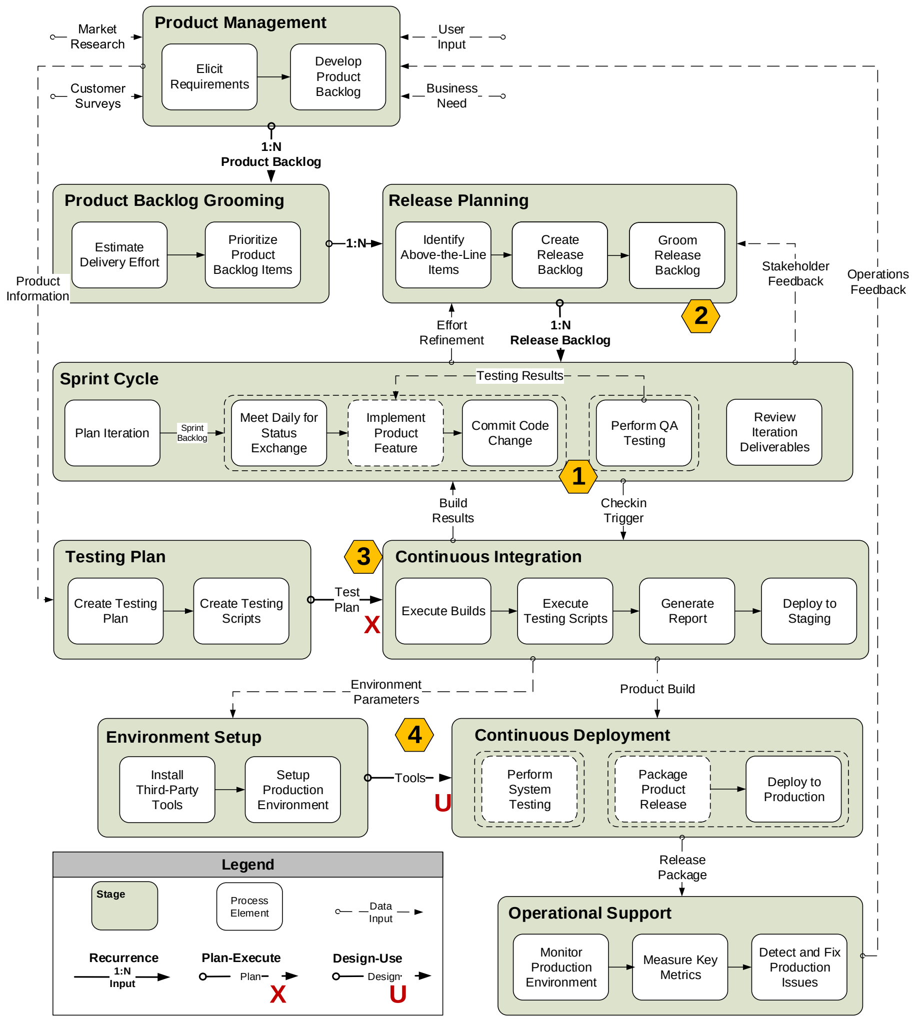

Fig. 1. Business Process Architecture (BPA) for a DevOps approach (Source: [16])

Execution of some PEs result in the production of *artifacts*. Artifacts can adopt different forms; they may be physical objects, a digitized entity or even be informational in nature. A PE along the plan-execute dimension can produce a planning artifact or an executable artifact. Similarly, a PE along the design-use dimension can produce a design artifact or an artifact that is used for some purpose. Examples of artifacts in the DevOps approach include testing plans, testing scripts, testing tools, environment setup configurations, product planning backlogs, software product features etc. Some of these artifacts (such as testing plans or testing tools) are internal to the SP process and are intended to be used for the production of the final delivered artifact (such as product features or product releases). In other cases, the progression along the SP may result in artifacts to manifest into another form. For example, a testing case design artifact can manifest itself as a testing case implementation (testing script) artifact. Fig 2. shows a goal-oriented approach for evaluation between two different process re-configurations through the use of enterprise NFRs (represented by softgoals) [17].

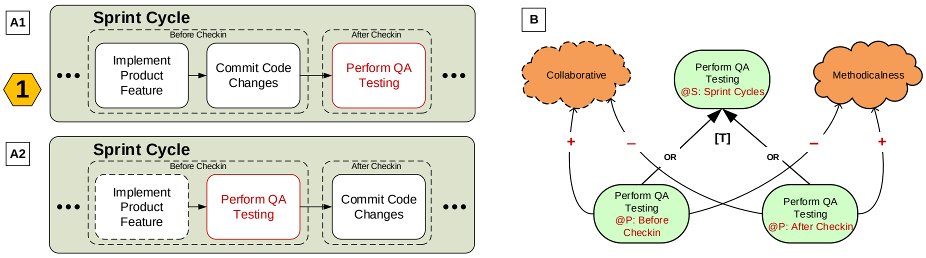

Fig. 2. QA testing alternatives (A1) As a separate phase from product feature implementation, (A2) As part of the product feature implementation phase. (B) Analyzing the temporal placement of QA testing process element based on NFRs. (Source: [16])

3.2 Agent-Centric Framework

The agent-centric framework extends the process-centric framework by allowing the inclusion of social and agent relationships. SPs exist in a complex and collaborative environment which is influenced by a multitude of human and non-human (system) actors. These actors are intentional in nature and can be considered to be executors and influencers of the PEs. Considering actors as having intentionality permits the use of agent-oriented modeling notions (such as [12]), and allows the assignment of goals and soft-goals to these actors. Actor-assigned goals provide motivation for choosing one particular DevOps configuration over another; with the alternative configuration selection being done through the use of goal satisfaction evaluation methods. For example, a particular set of PE placements (and, by extension, a DevOps configuration) would be preferred in a situation where rapid deployment is an actor objective as opposed to a situation where a more structured release based deployment is required.

The agent-centric framework will have similar constructs to that of the process-centric framework. For example, agents too have boundaries of influence however these may or may not align with process-centric boundaries. Agent could have their tasks or goals move within or beyond their boundaries of influence; methods needs to be devised that allow the determination of these boundaries and the common attributes of elements that reside within an actor boundary. Similar to the boundary construct, the relationships and artifacts constructs exist in the agent-centric framework as well, albeit with some conceptual differences from those in the process-centric framework. At present we are studying how both these modeling frameworks can be aligned with each other.

4 Methodology

Design science research has been gaining wide acceptance in Information Systems. The guidelines-based approach introduced in [18] will be used in this PhD project for the development and validation of design artifacts.

- **Design as an artifact:** A *modeling language* (with the model being a set of *constructs*) is being developed for representing SP adaptability along with *methods* that allow for alternative selection based on enterprise goals. These design artifacts will be developed through a study of published case studies sourced from various academic papers. Software tools will provide the design *instantiation*.
- **Problem relevance:** Enterprises (large and small) are forced to continuously adapt and reconfigure their software processes in order to deliver products and services through short-cycle software releases so as to keep pace with evolving customer expectations. A conceptual framework is required that supports such enterprise requirements while considering system-, process, and social-level factors.
- **Design evaluation:** Analytical evaluation techniques will be used for ongoing refinement of the artifact(s) during its development process. Industry partners will be approached to understand their situational needs and constraints and the proposed design artifact will be tested and refined against these real-world situations.
- **Research contributions:** Current techniques for software modeling and design would be advanced by addressing practices such as continuous software engineering and linking software process design and adaptation considerations with organizational stakeholder interests and enterprise-level business goals.
- **Research rigor:** The need and acceptance of variability at a software product, software process and enterprise level is well understood and accepted. The proposed design artifacts extend these foundational areas and will be validated through theoretical and empirical evaluation methods.
- **Design as a search process:** The design search process will start from process-based considerations and be gradually expanded to include enterprise-level concerns. The effects of and on SP configurations by social agents and software product design would be considered as the design artifacts are developed.
- **Research communication:** The research is primarily targeted towards an enterprise modeling and information systems engineering audience and venues of communication will be chosen accordingly. The results will be published in scholarly literature on an on-going basis at the completion of each research stage.

5 Conclusions and Thesis Progress

In this paper we introduced the problem of software process adaptability and proposed a requirements-based approach for evaluating and analyzing this area. The constructs for SP adaptability are presently being understood to define their behavior and characteristics. We aim to form an initial description and definition of these constructs in the third year of our PhD studies, along with their representation as a metamodel and modeling notation. In our fourth year of studies, we aim to seek out industry partners for ongoing refinement and validation of the proposed solution.

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