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(Eds.)

Emerging Topics in the Practice of Enterprise Modeling

5th IFIP WG 8.1Working Conference, PoEM 2012
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Preface

Enterprise modeling (EM) is a fruitful research area with great practical significance and has been attracting both the academic community and practitioners in industry, service sector and public administration. A variety of EM methods, approaches, modeling languages, and tools have been developed. In practice enterprise modeling is used in diverse organizational contexts, such as, strategy development, organizational change processes, business and IT alignment, process improvement, enterprise architecture management as well as, corporate and IT governance.

PoEM 2012 — the 5th IFIP WG 8.1 Working Conference on the Practice of Enterprise Modelling — took place in November 2012 in Rostock, Germany. The focus of the PoEM conference series is on improving the understanding of the practice of EM by offering a forum for sharing experiences and knowledge between the academic community and practitioners from industry and the public sector.

PoEM 2012 received 45 paper submissions with authors from 17 different countries (Austria, Belgium, Brazil, Chile, Germany, Hungary, India, Latvia, Lithuania, Luxembourg, Netherlands, Norway, Poland, Portugal, Russia, Sweden, and Switzerland). Based on at least three reviews per submission the international Program Committee selected 15 high-quality papers for inclusion in the conference proceedings published by Springer (LNBIP, volume 134). Additionally, 11 short papers addressing emerging topics and innovative proposals were accepted for publication in this volume. The authors of these papers include both researchers and practitioners.

The PoEM 2012 program reflects different facets of the topic of EM, including organizational and social issues, as well as methodical and technical aspects related to the development of information systems. The program was organized in five thematic sessions on Enterprise Modeling, Business Modeling, Process Modeling, Enterprise Architecture, Model-Driven Development as well as short paper sessions and "hands-on" sessions on exploring selected EM tools.

The program also featured two keynotes, one from industry and one from academia. The academic keynote was given by Mathias Weske, of Hasso-Plattner-Institute, Potsdam (Germany) on the future of business process technologies. The second keynote was by Tino Weichert, of alfabet AG, Berlin (Germany), an experienced practitioner discussing the industrial challenges of enterprise architecture management.

We dedicate special thanks to the members of the international Program Committee for promoting the conference, their support in attracting high-quality submissions, and for providing excellent reviews of the submissions. Without their committed work a high-quality working conference like PoEM 2012 would not have been possible. Our thanks also include the external reviewers supporting the paper selection process. The PoEM 2012 organizers would also like to thank Fraunhofer-Institute for Software and Systems Engineering (ISST), Jönköping University, and The University of Rostock for supporting the organization of the conference.

October, 2012

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Comparative Analysis of the Implementation of Business Process Management in Public Administration in Germany and Switzerland

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Abstract. In the private sector business process management is a common and well-established practice. In the public administration in Europe, this does not hold true to the same degree. However, currently we observe some considerable challenges. Important keywords such as eGovernment, networking, interoperability, compliance and governance and their relation to the administration processes are getting increasing focus. As a result, process management is gaining importance in public administration, especially where the execution of business activities or electronic integration of the process handling is concerned. This article focuses on the different strategies used in the analysed countries. Different approaches to business process management are explored. The objective of the article is to present two case studies, Germany and Switzerland, and to examine the different ways in which these countries handle process management.

Key words: Business Process Management, Knowledge Sharing, Public Administration, Success Factors

1 Introduction

1.1 Problem Statement

If administrative action is viewed as a process, the following challenges need to be mastered. Firstly there is the aspect of networking the public administrations and their processes. In the wider context this means that the customers also need to be integrated into these processes to a greater extent in the future. Thus, the goal is to obtain a larger degree of customer orientation and a reduced workload for the administrations [1]. Last but not least the administration is confronted with a progressive technologisation of everyday life and the diffusion of information technology into the processes. This opens up new possibilities, but also poses considerable challenges that are in conflict with the paradigms of the administrative action as conducted so far [2].

From the perspective of the end customer of the public administration and where the cooperation within the administration is concerned, process management presents a special organisational challenge. Administration is first and foremost *networked action* and has been networked for years, yet this involved a great degree of media discontinuity (e.g. side-by-side use of paper files and computer databases). In this context, the following questions present themselves: Why have the initiatives for electronic integrated business process management (BPM) so far not led to a comprehensive and integrated administration process management? Is the focus of the course of action wrong? Does the problem lie in the organisational form of today's administrations? Is there a lack of willingness to modernise? From an administration perspective, there are various restrictive factors that counteract a seamless process integration or an integrated process management:

- The territorial principle, federalism and subsidiarity and lack of mechanisms for handling federal and organisational borders: The use of eGovernment and portals enable a completely new way of handling of federal borders and paradigms [3, 4, 5, 1]
- Functionally structured administrations: Administrations usually do not have a process- or customer-oriented structure [1], here Weber's bureaucratic model is of relevance [6].
- Lack of thinking beyond the horizons of the areas of responsibility/functional organisational silos of the individual employees in the administration [7]
- Seeing the IT as instrument that is to be subjected to legislative action instead of positioning IT as *enabling factor* for shaping public administration
- In large part, no political negotiation process on the topic of integrated modern administration exists; usually this is performed away from the public eye and is initiated by the IT department or the processes are independent of each other.
- *Resistance to change* on the side of the administration (employees/organisation); accompanied by the *not-invented-here* syndrome.

The current process initiatives in public administration either focus on support processes in the administration (IT, personnel, finances, procurement) or selectively on service management. Where the latter is concerned, the customers are citizens and companies that provide or receive services in account with the constitution and the legislation. However, in most cases no analysis of policy-relevant administration processes (policy making) or strategic administration processes is performed. Similarly, no clear delimitation of the management processes has so far been performed. Here a differentiation can be made between the management of the political administration, the service administration as well as the support administration [8].

An analysis of BPM in public administration also has to have an architectural basis. Here different aspects of BPM can be addressed by considering different viewpoints: Information architecture view (use and distribution of data within the process cycle), business architecture view (organisational view of the process cycle), application architecture view (implementation of the business processes within applications and across applications), infrastructure view (technical implementation of workflows as technical representation of processes). With the architecture views and their different characteristics, the topic of interoperability also can and has to be addressed on the levels mentioned. In the end, the architectures mentioned represent different system views with different relations between the elements, be it organisational, application-specific, as well as with regard to the relevant technology components.

1.2 Objective

In essence, the purpose of this article is to make a comparison between different approaches towards implementation of BPM in public administration in Germany and Switzerland. From a methodical point of view, this comparison is of interest as the basic parameters of the endeavour are very similar in both countries (e.g. in some regards there is a high degree of federalism), yet very different approaches have been selected for the implementation.

For discussion purposes and in preparation of the country comparison, a system-theoretic approach is taken at first. It is used to discuss administration (process management) as a system, its elements and their mutual interaction with each other. These mutual interactions occur sooner or later when different approaches are used for introducing BPM. Due to different chronological courses of action, different logical mutual interactions can be observed that lead to a more or less successful BPM.

1.3 Methodical Procedure

For this article, different methodical aspects are of importance: Action research, triangulation, case study research.

The *action research* approach is a socio-scientific research method, where the researcher is directly integrated in the social process [9]. In our case this is the development of a process exchange platform[1] or the development of eGovernment standards for BPM. Using action research as basis. only a limited generalisability of the results can be achieved. However, practice-based hypotheses and implications for problem-solving can be developed. In action research, the relations between the researcher and the research subjects develop into a work relationship aimed at mutual action and reflection. The work relationship follows the cyclic research pattern described by Lewin [9]: Project planning turns into specific action, which is then monitored and evaluated jointly. This in consequence leads to a new planning phase and to the initiation of further actions. The objective of the research process is to reflect reality as accurately as possible, as well as transparency, relevance to the practice and interaction [9].

The *triangulation approach* in qualitative research is used to increase the validity and reliability of the results obtained from action research or by the means

[1] Start date set for summer of 2012.

of case studies. Thereby, various methods are employed. As a result, differentiated views of or different approaches to the research subject become possible. In essence, triangulation is about using the strengths of one approach to eliminate the weaknesses of the other approach. As pointed out by Denzin, triangulation has a certain proximity to mixed-method research [10]. Thereby, Denzin differentiates between four types of triangulation: *Data triangulation*: Data from different sources or different data from the same source; *Investigator triangulation*: analysis of the data by multiple researchers; *theory triangulation*: different theories are applied to the same data/the same research subject; methodological triangulation. According to Denzin [10], the methods can be combined to increase the validity and the reliability of the methods. In the case at hand, investigator triangulation and data analysis by multiple researchers are implemented in the mutual looks across the border, and a mix of written-down own experiences, studied documents, etc. is used.

With a *case study*, the researcher attempts to obtain statements about the research subject through explorative and descriptive means [11, 12]. With the description, a holistic presentation of the research subject is achieved. Case study research thus has close proximity to participatory observation or to action research. Of the different case study types that can be differentiated, we used the investigative case (stated problem method).

The following supplementary information can be provided regarding the methodical procedures used in this paper:

- The characteristics for the comparison were derived based on a system-theoretic approach [13, 14].
- A comparison of two countries with respect to the approach to and implementation of a comprehensive BPM in public administration follows below.
- The comparison will be repeated - then also including other countries - on this basis after one or two years.

2 Derivation of Comparison Criteria

A lot of research has been conducted regarding BPM in public administration. For example, many system models from different viewpoints have been developed on the topic of how process management can be positioned in public administration [15].

Wimmer and Traunmüller have described the relationship between fundamental terms used in administrative activities [16]. Building on this framework the BPM expert group of the eCH association for standardisation in the field of eGovernment in Switzerland has developed a framework that derives the tasks and services (service catalogues and service architectures) of the public administration using the legislation as a starting point and that then in turn derives further processes (process maps) from this data [17]. From a systemic point of view, the process management can be interpreted as a hinge function acting across several dimensions.

In principle, administration (process management) can be represented as a system - with input and output. The input usually comes from the suppliers (private sector or other administrations) or customer requests by means of forms. The output typically takes the form of bilateral service exchanges between the customer and administration. The elements of the BPM system, which is determined by the input and output as well as by the system limits, respectively exist on each organisational level of the administration, such as German Federal Government/federal states/local authorities or Swiss Confederation/cantons/municipalities. The division of tasks between these elements and the relationships are clearly defined in accordance with the constitution, legislation, and directives (subsidiarity). These determine the tasks of the administration, which can in turn be accessed through services.

From a technological point of view, this system includes methods, tools (for the BPM as well as for the technical implementation of business processes) that are in turn used by the administrative units. The system of process management in turn is determined by means of external factors: Politics, market, justice system.

From the presented system we can derive certain comparison criteria for the case studies at hand. Adding a consideration of the remaining challenges, we will focus on the following four criteria:

- Framework conditions (politics, justice system, culture and market)
- Methods and standards
- Tools (modelling, application and implementation tools for process management)
- Challenges

In the following two case studies, significant criteria were examined to describe the respective status of BPM in the countries.

3 Case Studies and their Comparison

3.1 Germany

The different initiatives in Germany that support BPM in the public administration cannot all be examined in their entirety here. Nevertheless, an overview based on the criteria mentioned can be provided.

Framework Conditions. In the political decision-making process, the processes of administrative action and the idea of process management are gaining foothold [18]. Corresponding decision-making processes take place in political committees that get impulses from the administration. Consensus-building or grass-roots democracy elements as part of the decision-making, as implemented in Switzerland, do not play any role within this context.

To safeguard cooperation and thus also the interoperability, agreements are made between the Federal Government and the federal states, as well as between the federal states and the local authorities. The IT-Planungsrat (German IT planning board) is an important element of this agreement process[2]. The relevant interaction with the so-called conference of ministers in the respective fields have however not yet reached the level of maturity required for effective structuring of cross-institutional and cross-level cooperation. On the respective levels, standards[3] exist, however, these do not comprehensively and/or exclusively cover the topic of BPM.

The existing management structures and paradigms do not fundamentally prevent a successful implementation of BPM in public administration in Germany. However, those who are immediately affected still largely exhibit lack of understanding that BPM is a management discipline, also within the field of public management. This becomes even more apparent if a management function, e.g. organising in the sense of decision-making, is delegated to a special unit within the administration and those employed there cannot or should not perform this function. Nevertheless external factors act on the system and can cause an acceleration of the implementation of the BPM approach. The German Federal Government and the federal states have set themselves significant consolidation targets by means of the *Schuldenbremse*[4] (debt brake); this means the administrations have to slim down considerably. This can only be achieved by means of automation of the business processes (among other measures). The European financial and debt crisis is likely to accelerate this process even further. Simultaneously, the demographic developments in Germany are creating an enormous pressure to preserve the expertise of employees who leave the organisation. This expertise can be preserved in process modules, with the additional benefit that this creates a basis for redesigning the processes, if this should become necessary.

Methods and Standards. Processes and process management today play an important role in a whole range of beacon projects. As early as the year 2000, a *BPM Virtual Community* was set up and operated at the FHVR (University of Applied Sciences for Administration and Law). This project marked the first cross-institutional possibility for exchanging process expertise in Germany. Subsequently and as supplements, cross-institutional registers (of the federal state authorities and local authorities) were set up in the federal states of Schleswig-Holstein and Saxony within the scope of the implementation of the EC Services Directive (2006/123/EC) in 2009. However, owing to the content of the directive, the primary focus of these registers is (currently still) local processes. In November 2010, the KGSt[5] followed suit with their process library for communal processes,

[2] In essence, this is also a committee that mediate across federal, federal state and municipal levels, see http://www.it-planungsrat.de/ DE/ITPlanungsrat/itPlanungsrat_node.html.

[3] SAGA 5.0 on Federal Government level; standard specifications in system concepts of federal states or by means of explicit standards of the federal states, FAMOS as modelling standard of KGSt on the local/municipal level.

[4] http://www.bundesregierung.de/static/flash/schuldenbremse/index.html

[5] Kommunale Gemeinschaftsstelle für Verwaltungsmanagement (German local government association for municipal administration); www.kgst.de.

however this is restricted to the members of the KGSt. On Federal Government level, only the BMI (German Federal Ministry of the Interior) has within its departments a process platform that has been designed to be cross-institutional and that is also being used as such. Within the individual administrations or authorities on Federal Government, federal state and local level, process analyses have been conducted with relation to specific eGovernment projects. However, currently sustainable process management can only be found in a few individual cases. For example, within the Federal Employment Agency, an end-to-end BPM has been established through implementation of a service-oriented architecture[6].

Tools. The NPB [7] (National Process Library) is the first attempt at implementing a comprehensive cross-institutional and cross-level approach. A conscious decision was made not to enforce (standardised) restrictions with regard to tools or methods, in order to make sure that at least this aspect does not restrict the exchange of process expertise. The initiators of this endeavour are aware of the fact that standardization is unavoidable in the medium or long term. However, the intention is to let this standard take shape in an open process in which suitable methods and tools for the different aspects of the process management can establish themselves.

In this context the xProzess interface of XÖV (project for standardisation of XML in public administration) deserves special mention. This interface makes it possible to integrate existing and future registers (for example, there are plans for connecting the federal state of Saxony and its process library to the NPB). Furthermore, all BPM tool manufacturers in the German-speaking region will implement this standard and integrate it into their tools[8]. Through the bidirectional usage options for tools and manufacturers that this offers, the establishment of the BPM approach in public administration is supported significantly.

Challenges. In the process management system, the employees of the administrative unit, both as affected parties and as participating parties, play a significant role. They provide expertise to and are users of the respective systems. In the field of knowledge management in general and in process management in particular, the externalisation of process expertise can be seen as the biggest challenge. There is still a great need for further research on how the corresponding restraints can be overcome, in particular under the framework conditions present in public administration.

Finally, it can be said that currently BPM is still, to too large an extent, being initiated by the IT departments of the individual administrations and, on the other hand, the support provided by the executive personnel is not adequate. The initiatives mentioned in this article do not change this basic finding in any way.

[6] http://www.arbeitsagentur.de/nn_387830/Dienststellen/besondere-Dst/ITSYS/IT-Themen-und-Projekte/SOA-ROBASO.html

[7] Research and development project at the Humboldt-Universität zu Berlin, commissioned by the Federal Ministry of the Interior: http://www.prozessbibliothek.de.

[8] The manufacturers have furthermore committed themselves to providing the administrations with editors free of charge (in some cases with reduced functionality).

3.2 Switzerland

Using the system model as a starting point, there are several initiatives in Switzerland that support BPM. In the text that follows, selected aspects are examined using the description criteria for process management as a system in public administration.

Framework Conditions. Switzerland is based on consensus-oriented democracy and opinion formation. Agreements for safeguarding the collaboration are made between the Confederation and cantons, as well as between cantons and municipalities. Within the scope of the framework agreement of the Conference of the Cantonal Government (CCG) (2007), eCH standards are declared to be binding for the joint eGovernment project. Thus, in the end, the interoperability is provided for in all dimensions, as eCH standards implicitly form the basis for the interoperability. The mentioned agreements between the Confederation and cantons, as well as between cantons and their municipalities (the latter is not yet the case for all cantons) also ensure that the internal borders are no obstacles any more, at least not where the cross-border cooperation is concerned.

eCH has been set up as eGovernment standardisation body (association). eCH approves standards that have typically been developed in expert groups, although these standards are not legally binding. eCH offers the expert groups the opportunity to involve manufacturers, users etc. in the standardisation, by means of public-private partnerships, and to thus further the diffusion of the standards on a voluntary basis. Furthermore an agreement on eGovernment cooperation between the Confederation and the cantons require that eCH standards are binding within the cross-institutional e-government[19].

In various beacon projects regarding the handling of BPM, for example at the Swiss Federal Department of Foreign Affairs (FDFA), at the Federal Office for Agriculture (FOAG), or at the Federal Office of Police (fedpol), it has been proven that BPM is a suitable instrument for supporting architecture management, the Internal Controlling System (ICS), as well as for personnel management.

Methods and Standards. By means of the eCH standardisations[9], a comprehensive basis for the introduction of end-to-end BPM has been created. The eCH standards for business process management are divided into a framework, descriptive standards, reference directories and help documents. It has to be emphasized that eCH has specified BPMN 2.0 as descriptive language. The tools for BPMN use have not been standardised. Starting with the eGovernment strategy of Switzerland as a basis, the focus has been placed on customer-oriented governance. This means that the private business sector can conduct all communication with the authorities electronically; the authorities communicate with each other electronically; the general public can conduct important formalities with the authorities electronically [20].

[9] For information on BPM-relevant standards, see www.ech.ch for the following documents: eCH-0126, eCH-0138, eCH-0139, eCH-0073, eCH-0140, eCH-0141, eCH-0088, eCH-0049, eCH-0070, eCH-0074, eCH-0096

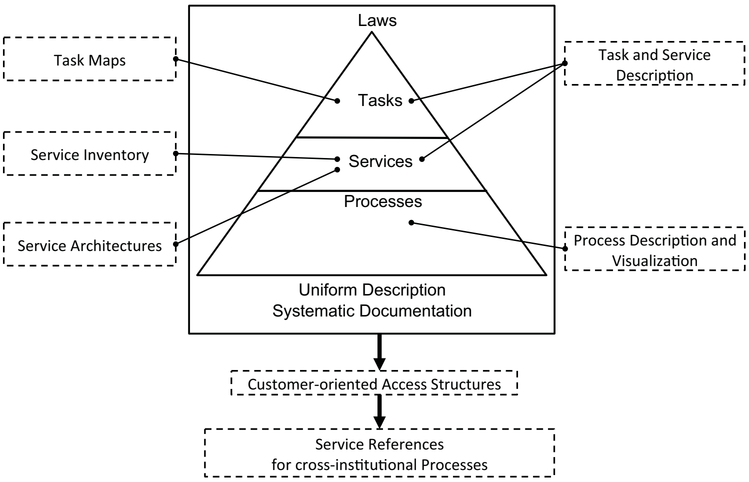

Fig. 1. BPM Ecosystem, in account with eCH-0138 [17]

It is also crucial to eCH that selected federal offices and canton representatives participate in the eCH expert group for business processes. These include the Federal IT Steering Unit (FITSU: chief of the expert group, division for corporate and eGovernment architecture), the Federal Chancellery, the SECO (State Secretariat for Economic Affairs) the cantons of Basel (city) and Aargau, as well as Zurich, tool providers, consulting services and software companies involved in BPM, as well as members of academic institutions (universities and applied science universities).

The eCH export group has structured the actual standards (see footnote earlier) in account with Figure 1. Based on the legislation, the tasks, services, processes, and appropriate access structures are structured using inventories and architectures. The strategic thrust of all these initiatives has been defined in the document *Vernetzte Verwaltung* [1] within the context of the modernisation of public administration.

In the so-called prioritised eGovernment projects, the BPM standards are also used almost exclusively[21]. With this approach, Switzerland has succeeded in setting up a *BPM ecosystem*. However, this cannot be considered to be equal to a successful implementation of the BPM approach. Instead, it provides the prerequisites for achieving organisational changes towards process orientation within the administrative units themselves. From the current point of view, this seems to be a very slow process.

Tools. In addition to these standard specifications, Switzerland is now - after an earlier attempt - setting up a process exchange platform . The platform http://www.ech-bpm.ch/de (in addition to www.ech.ch) already makes some content available (project guidelines for BPM implementation, BPM starter kit, etc.). The focus lies on the distribution of the eGov BPM starter kit.

Challenges. A continuous harmonisation with the corporate architecture management, which falls in the area of responsibility of the Federal IT Steering Unit (FITSU), is of central importance for the Swiss endeavour. The corresponding eCH expert group SEAC closely cooperates with the BPM expert group of eCH on the topic of harmonisation. The SEAC expert group also develops and publishes a range of standards on architecture management for eGovernment (among others).

It should be mentioned that the coordinated initiatives in the fields of BPM and architecture are currently mostly technology-driven and are only inadequately being supported by the management of the administrations. This is one of the possible reasons for the slow progress of BPM in public administration, as many executives do not give full commitment to such initiatives and BPM thus does not become a strategic initiative of the respective administrations. Furthermore, the BPM and architecture initiatives are being pushed by the Federal IT Steering Unit (FITSU), which is associated more with informatics than with management in the public administration.

4 Comparison of the Case Studies

BPM has reached the practice in public administration. The diffusion is not very high yet, but various initiatives are in progress on all federal levels in Germany and Switzerland.

Framework Conditions. In general, we did not observe a significant impact of the framework conditions. In Germany, the structure of the public administration is frequently used as justification for the current state of affairs and thus is one of the most significant de facto obstacles for a faster implementation of the BPM approach. However, when it comes to the business model, Germany closely cooperates with the providers - a sensible approach - and pro-actively negotiates with various participants, for example regarding integration of platforms of the federal states (for example, connection of the Free State of Saxony is in planning) or other BPM platforms.

Although Switzerland is based on consensus-oriented democracy, the structure of the public administration is similar to Germany. However, the size of the overall population cannot be denied as an influencing factor. Similarly to Germany, also Switzerland follows a partner-oriented approach by introducing the eCH standards.

Methods and standards. The most significant differences can be found in the form and procedures of the standardisation. In both countries, the approaches in part also have political backing. This has to be strengthened in future, as the political support and the support of the management of the administrative units are central success factors for the introduction of BPM. Past initiatives lacked this political support and thus finally withered away.

Switzerland chose to build on standardisation and on designing the process management in the form of a BPM ecosystem. Where the standards are concerned, the uniform specification of BPMN as modelling standard is an important aspect.

As in Germany, no restriction to a certain tool has been specified. Now, after the first wave of standardisation, Switzerland is following a logically consistent path by setting up and providing a process exchange platform to allow exchange of process expertise across all institutions and levels.

Whereas Switzerland is first implementing a comprehensive standardisation initiative (BPM ecosystem) and then building a process exchange platform on this foundation, Germany is pursuing the path of first setting up a process exchange platform and hoping that standardisation (with regard to notation) will slowly but surely occur in consequence. This strategy could be successful, solely on account of the power of accomplished facts. Facts are for example created by the *Nationale Prozessbibliothek* (National Process Library), which is in an advanced state of completion.

Tools. In both countries, initiatives for developing process exchange platforms have been started recently. Germany is taking a more pragmatic approach and is first setting up a process exchange platform. This process is accompanied by standardisation efforts (in particular of interfaces), however, this does not constitute an integrated complete model or strategic action. In Germany, skilled negotiation with all relevant providers of BPM tools resulted in viewers and simple modellers being available free of charge from the NPB. These issues have not been solved in Switzerland yet. Germany is furthermore counting on the xProzess standard interface definition, based on the xÖV family, for process exchange.

Challenges. One aspect that is more or less dominant in both cases is the mostly technical approach to the BPM topic. Those responsible for management have to take charge and create a culture of process orientation and overcoming silos (*mental change*). Currently the BPM implementation of both countries can be said as being too heavily *bottom-to-top*, furthermore it has a too strong technical focus.

5 Conclusion

In this paper we investigated the BPM implementation in the public administration of Germany and Switzerland. Therefore, we conducted and compared two case studies with a set of systematically derived comparison criteria. We found that Switzerland is ahead of Germany where standardisation is concerned, Germany on the other hand has a wide range of free tools available for the process management. Currently it is not possible to predict which approach will be potentially more successful in the long run. Germany definitely has to invest more effort where standardisation is concerned, Switzerland has to strive to enter into similarly self-confident negotiations with the suppliers of BPM(N) tools as those conducted by Germany.

Based on the research subject and the small number of case studies, it is not possible to make generalisable statements. It is planned to include Austria and other countries in future analyses. This might yield information on which factors contribute to a successful end-to-end BPM in public administration. Furthermore, working from hypotheses that can be derived from this article, further research can be initiated, and a further systematisation of the comparison can be attempted.

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Determining the Role of Abstraction and Executive Control in Process Modeling

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Abstract. In this paper, we describe our study on the relation between formation of abstractions and aspects of executive control in the context of process modeling. We have observed and recorded three business process modeling projects in different companies. We report on the findings resulting from the analysis of the first project. We find evidence that certain traits related to high-quality abstraction formation contribute to more structured modeling performance. Through our analysis we gain more insight in the cognitive mechanisms involved in modeling, which provides us with another step towards design of effective modeling support.

Key words: abstraction, executive control, process modeling support

1 The Need to Understand Modeling

Designing effective process modeling support depends on a thorough understanding of the basic properties of modeling. Many authors have written about the crucial importance of modeling in system design [1], [2], [3], [4], [5]. Yet, despite its ubiquity in the design world, it is a poorly understood and error-prone activity [6]. In this article, we present a way of observing modeling sessions and inferring principles of modeling based on psychological mechanisms involved in facilitating modeling.

We distinguish between two core phenomena: abstraction and executive control. Executive control processes involve metacognitive activities such as planning, organizing, monitoring, inhibition of distractions and initiation of corrective actions. Based on observations in practical modeling situations involving modelers and domain stakeholders, we explore how abstraction and aspects of executive control work together to guide modeling behaviors in group situations. In particular, which aspects of executive control feature most prominently in the formation of abstract representations? What differences are there in executive control between the formation of medium-level and high-level abstractions?

With the increasing role of business analysis and engineering in IS industry, the importance of skills related to learning, planning, organization and monitoring for IS professionals is apparent [7], [8], [9], [10]. As McCubbrey & Scudder [11] put it: "This will require that analysts learn to function at a more abstract level; and then translate those abstracts into concrete systems". Such activities typically happen during interactive, collaborative sessions involving both modeling analysts, and domain stakeholders. Involving stakeholders is very important in a modeling process [12], yet problems appear at the point where stakeholders and modelers have to communicate, due to lack of common understanding [13], [3].

Viewing modeling as a conversation in which individuals' mental models are being made explicit and merged into a shared mental model [14], guided by goals and interests and directed by executive skills allows us to decompose modeling into elementary processes pertaining to conversation structure, abstraction formation and executive processes. From this, we may gain an understanding of where some of the key difficulties may lie, and consequently training programs can be adapted to suit such needs.

We begin with a discussion of the core concepts involved in our research and how we used them to create an analytical framework for the study of modeling sessions. Then, we discuss the behavioral patterns emerging from analysis, and finally we speculate on how these might be used as guidelines to design modeling training programs.

1.1 Abstraction: Continuous Refinement of Representations

Modeling involves a continuous refinement of the participants' mental representations. They gradually take shape as they are continuously being explained to others. Such representations are abstractions of the daily practice, involving the domain structure, constraints on information flows and all kinds of domain properties. The process of forming such abstractions is very much an iterative, cyclic process. Abstraction occurs as early as during the perception phase. There is no clear distinction between concrete, sensory experiences and abstract representations, free from such experiences. A concept in the mind may be just as concrete as the real thing in practice, depending on how the representation has been formed in the mind [15]. Good abstractions should be structured and organized, and describe a whole range of behaviors of the issue under discussion in order to create a better model for the intended goal: more complete, or maybe simpler and more elegant. Only in an organized whole can some features hold key positions whereas others become secondary [15]. In support of this, Vennix [16] notes that people indeed tend to think in parts rather than viewing the whole context when improperly trained.

There are many ways to define abstraction, depending on which perspective is taken. In an early theory of abstraction, George Berkeley (1685 - 1753) argued that abstraction occurred through a "shift in attention"; it is possible to focus on a particular feature of a single object, and let that feature represent a whole group of objects [17]. In philosophy, mathematics and logic, it is common to characterize abstraction in this way as *information neglect*: "eliminating specificity by ignoring certain features" [18]. However, whereas the rigid nature of abstractions in mathematics allows ignoring of information, the highly dynamic and interactive nature of computer science is fundamentally different and therefore requires a different interpretation. Arnheim [15] provides a nuance to this view, adding that an abstraction is not a single distinctive attribute or property, or not even a random collection of properties, for that matter. A mere enumeration of traits does not constitute a coherent integrated concept. Rather, it should represent the innermost essence of a concept. This may be explained by saying that a concept should be generative; a more complete description of the object in question must be constructible from the concept in question. Nevertheless, feature distinction is very much guided by interests or goals, and a similar element will not be considered in the same way in every single percept.

Colburn and Shute [18] further specify this notion by introducing the concept of *information hiding* as opposed to information neglect. The main idea is that irrelevant information is deliberately omitted so that the focus is only on relevant aspects within the current scope. However, this omitted information is not forgotten; it is assumed to be in place and correctly functioning at all times. Therefore, the choice for any abstraction level depends on the purpose, goals and intentions of the modeller wishing to view certain system functionality [19]. This notion is fundamental to Rasmussen's *abstraction hierarchy*: "a systematic way to view different system functions according to the purpose, goals and intentions of the person working with a certain part of the system" [19]. Each level in the hierarchy provides certain details and features of the system based on what the person working with the system needs for his task. A change in abstraction level involves a shift in concepts and representation structure as well as a change in information suitable to characterize the state of the function or operation at the various levels of abstraction. For a process at any level of the hierarchy, information on proper function is obtained from the level above, and information about available resources and their limitations is obtained from the level below [19].

Models must provide proper abstractions of the problem domain, but they often end up containing too many details, not using an adequate modeling granularity, or providing inappropriate abstraction layers [6]. Reasoning with abstractions has been found to be considerably more difficult than reasoning with concrete premises, requiring much more information to be held active in mind [20], [21]. Indeed, the ability to form abstraction representations, the quality of the resulting representations and the ability to make them explicit to others differ per individual, which greatly tends to influence the way a modeling session proceeds [22]. Also, it has been found that humans are not very good at following complex chains of reasoning, such as are typically involved in modeling [16]. However, humans learn progressively to handle more formal things [23], as their mental models develop, and content and way of working gradually become more automated. To understand this, we need to explore the principles of executive control and how they play a role in modeling.

1.2 Executive Control: A Facilitatory Mechanism?

Mental representations are made explicit to others by means of conversation [24], [14]. However, while there is usually some basic structure for a modeling session in advance, the actual properties of the model discussed depend very much on the associations made by the participants at the moment of discussion. This may lead to rather fragmented knowledge elicitation, the results of which afterwards have to be coherently integrated by modelers. Regardless of communication abilities, which we do not explicitly consider here, this presents a high cognitive load to modelers, as correctness of model content, coherence of model structure and group discussion progress with regard to project goals have to be monitored simultaneously. Organization of goal-directed behavior requires strong executive control [25], a lack of which can leave modelers overwhelmed with information and at a loss for structure.

Executive functions are a set of cognitive processes mediating one's actions and thoughts, which are separate from cognitive slave constructs such as long term memory. There are metacognitive and self-regulatory executive functions [25, 26]. Metacognitive functions are higher-level functions like planning, organizing, monitoring and initiation, whereas self-regulatory functions are more basic processes like inhibition, attention shifting and updating working memory content. Staying focused on a task [27], as well as fully-fledged multitasking problems [28], have been related to strong executive control. More specifically, attentional control over intruding thoughts is implicated as contributing to better reading comprehension [29]. The most generic mechanism executive tasks tap is hypothesized to be "the maintenance of goal and context information in working memory" [30]. Also, Engle et al. [31] propose that "any situations that involve controlled processes (such as goal maintenance, conflict resolution, resistance to or suppression of distracting information, error monitoring, and effortful memory search) would require this "controlled attention" capacity, regardless of the specifics of the tasks to be performed."

There is a lot of research emphasizing the need to implement executive processes in order to facilitate effective team functioning [14]. For instance, teams should learn to plan effectively, to communicate effectively, to define each others' roles, to learn about each others' background, to develop techniques for monitoring and feedback, to develop communication rules etc. There is no denying that these skills are indeed vitally important for successful team functioning. A deeper understanding of these skills in relation to modeling, however, would be welcome.

1.3 Learning and Reflection During Modeling

Argyris [32] describes a general learning problem in organizations: people in knowledge-intensive, interdisciplinary functions show precious little ability to engage in metacognitive activities. Mere problem solving is not enough, managers and employees need to reflect critically on their own performance and adjust accordingly if improvement is to persist. However, humans have difficulties reasoning with complex structures and they tend to ignore feedback on their performance [16], [32]. Research from the domain of learning theory finds that students do not spontaneously engage in activities in which they reflect on their own work, asking themselves why they have done something in a particular way or looking for possible alternatives. Rather, they have to be actively prompted to go beyond the level of fact-based learning and memorization [33]. In this same fashion, Jeffery et al. [14] recommend the implementation of communication and monitoring strategies for collaborative modeling teams in order to aid their performance.

Vygotskian learning theory states that social situations with lots of interaction facilitate learning that involves both fact based learning and critical reflection on what has been learned [34], with the latter in particular facilitating improvement [35]. Understanding based on passive recall differs from understanding based on active reasoning and knowledge construction [36, 35]. This is where executive processes come into play. We know that students do not spontaneously engage in this type of interaction, and we see in our observations that modelers who do so spontaneously are the minority. Yet these reflections are necessary for structuring the model, monitoring it for correctness and completeness, and structuring and monitoring the discussion leading to this model.

Therefore, we should structure modeling discourse such that it induces the type of conversation that involves active manipulation of present knowledge. This is achieved by involving activities such as explaining, thinking aloud, prompting, resolving discrepancies and trying to integrate different ideas and perspectives [35].

2 Methods and Observations

Our study was conducted at a Dutch organization. We observed two different projects, which were part of an effort to chart the organization's business processes and to design new ones in order to develop a new automated information system. They made use of collaborative modeling workshops to elicit domain knowledge from stakeholders, and separate collaborative modeling sessions involving the analysts only to integrate the elicited knowledge into coherent models. These were again presented to the stakeholders in the consecutive workshop for review. The following stakeholder roles were involved: project manager, business analyst, business architect, change manager, 2 heads of departments, 2 supervising seniors, internal auditor. The minimum group size in our study was two. The types of models used were process models.

2.1 Data Collection

One researcher has spent three months at the company, being present at relevant sessions, and recording them in audio format initially, but as the stakeholders became more accustomed to the researchers presence, a video camera was installed in the workshop room and video recordings were made in addition to audio. The stakeholders indicated not to be bothered by its presence. Additional time was spent getting to know the stakeholders, but care was taken not to talk about the research objectives to avoid introducing research bias.

The modeling sessions and stakeholder workshops all took place in the same project room, which was equipped with a beamer and two flip chart boards. The models under discussion had been printed and were attached to the walls. During the stakeholder workshops, the modelers presented the models to the stakeholders and these were required to respond to certain issues or things that appeared odd to them. In some cases, bits of model were explicitly shown, in other cases, issues were formulated in natural language. During the analyst-only modeling sessions, heavy use was made of the flip charts, and interaction was not explicitly structured. Models were adapted and contradictory issues discussed.

2.2 Coding and Analysis

We recorded a total of 30 sessions. So far, we have transcribed 4 sessions, and selected 12 interval-based fragments. They were coded for conversation structure, cognitive processes, abstraction and executive control by two coders.

The components of conversation structure were taken and adapted from [37]. We have included here only those conversational constructs which have so far appeared in our modeling sessions. Also, the adjacency pairs, as specified in [37], do not necessarily always occur in direct pairs. Sometimes the expected reply is missing, the pairs are nested or multiple pairs get mixed up. But in general, they give a good overview of the kind of conversational constructs that are used in different phases of the modeling discussion.

Cognitive processes are those operations that people perform either on directly available knowledge, such as inferences or justifications, or more complex situations in which they reason with pro, such as reasoning by analogy or comparing different outcomes. The goal of analyzing cognitive processes is to find out whether people use different types of reasoning as the discussion progresses, or whether there are individual differences in reasoning styles which may correlate with abstraction and executive control skills.

Abstraction is viewed from two perspectives: the different levels of abstraction, ranging from concrete to highly abstract [38], [21], and the process of refinement people go through during a discussion [15], characterized by shifts in abstraction levels, either instantiating to a lower level, or generalizing to a higher level.

The structure of the executive control section is based on [25], and has been adapted to include specific behaviors occurring during modeling sessions.

In order to code, we used a table in which we assigned codes for each coding component to each sentence uttered by a participant. We defined a sentence as a set of words, separated by pauses in speech. This does not mean that a sentence has to be complete, it can be broken off halfway through. Also, there can be multiple sentences within a single speaking turn.

So far, our analysis has not proceeded far enough to do actual counting of code occurrences, so we infer patterns of behavior based on what we have seen in the sessions analyzed. After coding, we discussed our findings. As the codebook is also still developing, no inter-coder reliability could yet be computed.

3 Results: Patterns of Modeling Interaction

The general pattern of interaction observed in both modeling workshops and analyst-only session is that a discussion cycle covering one topic generally starts with extensive refinement of representations. A combination of speculating about possible situations, and paraphrasing them to make sure everyone understands the issue at hand correctly, is used. This is followed by a cycle of inferences, elaborations, instantiations, justifications on the cognitive side, structured in the conversation in terms of questions, contradictions, encouraging and doubt-signaling probes and extensive answer accounts using illustrations and examples. In abstraction terms, this second cycle is characterized by a continuous set of shifts to a lower level: from a medium abstract to a concrete level of representation. Shifts to higher levels are rare during this cycle, and they often tend to fail because of insufficient comprehension. Only after this cycle has been repeated for several minutes do shifts from medium abstract to highly abstract levels start to appear more frequently, and importantly, more successfully.

One of the main differences observed in the formulation of abstract representations is that some participants tend to pick out single properties and use them as a metonymy for an entire issue. Others give generic descriptions of how issues behave in more generic context using multiple properties. They complete their abstraction refinements more often, reasoning them through to the end rather than breaking off halfway through.

Monitoring of the modeling goals, the entire group progress, and group discussion topics, appear much more frequently in participants who make more complete abstractions. They were also more flexible in topic and strategy switching, and they also more easily self-correct and explicitly admit faults. They stay more focused and recover faster from distractions, such as jokes or irrelevant issues. In the other participants, monitoring is more limited to self-monitoring on a smaller scale. On top of that, the behavioral pattern includes much more frequent deviations from focus, difficulty understanding and keeping to the scope of concepts and echoing peers.

Important to notice that these monitoring skills are not limited to modelers, stakeholders engage in monitoring behavior and good abstraction formulation just as much if they are capable.

3.1 Examples

Below is an example of an initiation of a discussion cycle, with a stakeholder trying to formulate an issue, and other participants (stakeholders (S) and modelers (M)) trying to refine what he means by means of examples. This represents a cycle of shifts to a lower level of abstraction.

```
S1: look, the employer also delivers to eh... the tax office,
and if you ... have to deliver your data from the same salary system ...
yes... well then eh... you should eh...
in my opinion... use it, finished...

M1: [...] what we should figure out for this is... what is the
percentage that someone does not deliver... and actually is out of
service... so that you get a kind of code 23 and that appears to be
correct because he has forgotten to send in his AAD... and what is
the percentage that something else is going ... going on... [..]

S2: so you would... you would say that hey, 95 percent is eh...

S3 and S2: out of service!

S2: but has not sent in an AAD... and 5 percent is indeed
something else... that we can conclude eh...
```

An example of an abstraction shift to a higher level being corrected because it had been attempted too early on in the process:

```
M2: okay so currently... it is too much to say okay,
if an employer delivers, we can assume that it is complete...

S1: no, you have to see if the employer will eh...
 deliver, you will get a signal immediately
[...]
so then with eh... what you miss... you already report that,
we don't do that now
[...]
now he gets 5 days [..] hey we have not received an AAD
from you... if that .. report comes back immediately...
then you can initiate action... in whatever form...
```

An example of a case of explicit monitoring between two modelers:

```
M2: why don't I go and put it into the tool, like this?
M1: what if..... eh.... Goal of the process is to register the
details about the wages....
[...]
M1: what if we eh.... Monitoring..... huh.... We send a reminder,
hey good friend, eh.... Eh.... You haven't sent us anything yet....
M2: yes...
M1: we get no reply....
M2: yes..
```

```
M1: what happens then?
M2: there is no reply, then we receive nothing...
M1: right, then we receive nothing
M2: and then we don’t achieve our goal...
```

4 Discussion and Future Research

There appears to be a clustering of behavioral traits that lead to desirable modeling performance: the ability to formulate generic abstractions capturing the essence of a concept, switch flexibly between abstraction levels to good effect, be able to structure a discussion, stay focused on the topic and scope, monitor both one’s own thoughts and contributions and the group’s progress towards modeling goals as a whole. On the other hand, participants who make more superficial abstractions, focusing rather on single properties of concepts and using them to represent the entire thing, also show less awareness of what is being discussed, deviate from focus more often, become more easily distracted and tend break off their reasoning processes and sentences halfway through. If we keep in mind Arnheim’s [15] definitions for what does and what does not constitute an abstraction, we can say that the first group makes abstractions of a higher quality than does the second group. Given that this appears to depend on the individual rather than the individual’s background and training, it seems that individual differences may override background and experience, in any case when explicit training has not been given.

The higher or lower quality which these traits display seems to be a collection of symptoms resulting from a psychological mechanism, which may function more or less efficiently in different individuals. We suspect that working memory (WM) capacity may play an important facilitating role in the formation of abstractions. WM has been implicated in executive control, and since our analysis suggests a strong associative relationship between executive control and abstraction, it will be interesting to test whether WM capacity plays a direct role in abstract reasoning processes during modeling. If this should be so, executive control for our purposes will be no more than a descriptive construct, and it may be necessary to find ways to directly support memory and attentional resources during modeling rather than the higher-level communication and feedback processes described by many authors.

However, a lot more study is required before we gain a sufficient understanding of the role of memory in modeling. On the short term, promising results are being obtained with explicit training of executive and metacognitive skills using strategy training, eg. [39], [40]. This is a form of training used in education to make students aware of their ways of learning and reasoning. People are taught metacognitive strategies to monitor their comprehension and progress.

Teaching modelers strategies which lead to successful modeling results may provide them with footholds based on which they can structure a modeling session. For instance, making goals explicit before starting a session, ensuring that the initial phases of a session contain lots of discussion in which different mental representations are made explicit using examples and illustrations on a concrete level before moving on to higher abstractions, using predefined moments to monitor progress and evaluate where the modeling process is in relation to the previously specified goals, or explicitly testing whether abstractions made really do capture the essence of a concept rather than a single random property.

In summary, it boils down to making people consciously aware of a certain structure to aid their way of working, and implementing explicit markers to remind them to perform the necessary actions. In a way, this is already a form of directly supporting working memory, since its contents are being offloaded to a static form in which they can be viewed and re-evaluated at all times.

5 Conclusion

We find that some of the most prominent aspects of executive control in facilitating the formation of abstract representations are the ability to stay focused, to finish complex chains of reasoning, to monitor individual and group progress at all times, and to view concepts holistically rather than according to single properties. All these executive aspects demand focused attention and reflective awareness of one's actions.

The essential difference in abstraction formation quality does not appear to be so much whether or not a certain level of abstraction can be achieved, but rather *how* the abstractions are formed: people who form abstractions based on single properties can make high-level abstractions and still be corrected by their peers because some aspect of the object's behavior has been overlooked in this way. Those who make generative, holistic abstractions can make high-level abstractions which are good reflections of the essence of a certain concept in a given context. This difference appears to correlate with overall strength of executive functioning in individuals.

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For an overview of the codebook, please contact the first author.

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Towards a coherent enterprise modelling landscape

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Abstract. When modelling enterprises, for instance as part of an enterprise (re)engineering effort, one typically uses a range of models. These models differ in their intended purpose in terms of the domain which the model should pertain to and the intended usage of the model by its audience. The models are therefore generally created in purpose-specific modelling languages; i.e. not just *domain-specific* languages.
While using purpose-specific modelling languages has clear benefits in terms of the suitability of the language to a purpose at hand, there is also a downside to it. As each of the resulting enterprise models refers to (different aspects of) the same (version of the) enterprise, it is desirable to maintain coherence across the different models. The use of a wide range of purpose-specific models (and modelling languages) can easily lead to a fragmentation of the modelling landscape; i.e. a break up of coherence. This leads to a natural polarity between coherence and purpose-specificity. We argue that this polarity requires careful management, but first and foremost a better understanding.
To cope with, or avoid, the consequences of fragmentation, different strategies to achieve the integration of models and languages used in enterprise modelling have been suggested in the literature. These approaches, however, focus mainly on syntactic aspects of the models, while sometimes indeed including their (formal) semantics, and only to some extent their pragmatics.
The aim of the research, reported on in this paper, is to achieve a deeper understanding of the needs and challenges of the use of different models in enterprise modelling.

Key words: enterprise modelling, model integration, modelling languages

1 Introduction

When deliberately changing (parts of an) enterprise, one generally uses models to understand the current situation of the enterprise, analyse the problems/challenges with regard to the current situation, sketch potential future scenario's, and design selected future desired states of the enterprise, etc. We use the term *enterprise modelling landscape*, or simply *modelling landscape*, to refer to the variety of models (and corresponding purpose-specific modelling languages) used in such efforts. The developing

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field of enterprise engineering [1, 2] also strongly promotes the use of a model-enabled approach to the transformation of enterprises.

When modelling enterprises in an enterprise engineering context, one must do so from the perspective of different domains, such as business processes, value exchanges, products and services, information systems, etc. The fact that enterprise modelling needs to deal with different domains, within the context of a specific enterprise is certainly not new. In the field of information systems engineering, the use of a multi-perspective approach has long since been advocated, e.g. [3, 4]. In the case of enterprise modelling, however, the number of domains to be included increases. For example, enterprise architecture frameworks suggest a much wider range of views that look beyond the traditional business-to-IT stack [5, 6, 7].

We argue that the plethora of models used in enterprise engineering efforts is brought about by the fact that models are needed for different *purposes*. In our current understanding, and based on our earlier work in e.g. [8, 9], we see the purpose of a model as a combination of:

1. the domain which the model should pertain to (e.g. different aspects and/or versions of the enterprise, the scope, granularity, etc.) and
2. the planned usage of the model (e.g. analysis, sketching, contracting, execution, etc.) by its intended audience.

In other words, the *purpose* of a specific model is to capture some *domain* to enable some *usage* by its audience.

Ideally, such models are created in a *purpose-specific* modelling language that tunes the modelling constructs of the language to the domain to be modelled, as well as adjust the precision/form of the medium, syntax and semantics of the language to the intended usage of the models. In practical modelling situations we have observed how, depending on the modelling purpose at hand, generic modelling language, such as UML [10] or ArchiMate [11], are used in different ways with regard to the 'discipline' with which the syntax and semantics of the generic language is obeyed to. In our view, this essentially leads to purpose-specific 'variations' of the same original generic modelling language (differing in their syntactic and semantic restrictions).

The notion of purpose-specific modelling language is certainly related to the notion of domain-specific languages [5, 12]. We argue, however, that the intended usage of the model also has a key role to play in tuning modelling languages to the needs at hand. We also acknowledge the fact that the notion of *model purpose* is related to the notion of *model quality* [13, 9]. We will revisit this relationship in the remainder of the paper. It is also important to realize that *model purpose* is different from *modelling purpose* [13, 9]. The purpose of a model is indeed dependent on the modelling purpose, but we see them as being different phenomena. In this paper, we limit our discussions to *model* purpose.

Since all of the models of an enterprise modelling landscape provide different views on the *same* enterprise, it is quite natural (and in line with an engineering perspective) to expect that the sets of models form a coherent whole; i.e. linked where relevant and consistent as a whole. Having such coherence among models also enables cross-cutting and impact of change analysis, traceability analysis, etc. So, while using purpose-specific modelling languages has clear benefits in terms of suitability of the language (and models) to a purpose at hand, there is also a potential downside to it. A plethora of purpose-specific models can easily lead to a fragmentation of the modelling landscape; i.e. a break up of coherence, also addressed as a "*Tower of Babel situation*" [14]. This leads to a natural polarity between coherence and purpose-specificity. A number of strategies has been suggested to achieve integrated use of models and languages used in enterprise modelling, e.g. [5, 15]. We argue that this polarity deserves careful management, but first and foremost requires more research to better understand the forces at work.

In this paper, which is the result of an ongoing research, we present our current understanding of fundamental challenges related to coherent enterprise modelling landscapes. We will start in Section 2 by exploring the polarity between coherence and purpose-specificity in more detail, with the aim of gaining a better appreciation of the forces that are involved. We will then continue in Section 3 by exploring some of the existing strategies to manage this polarity. This discussion is then used as a base to develop the first-most elements of a theory on managing the coherence of modelling landscapes in Section 4.

2 Fragmentation of enterprise modelling landscapes

As already discussed, enterprise modelling is likely to involve a plethora of purpose-specific models covering different aspects of the enterprise. At the same time, the diversity of models/languages increases the risk of fragmenting the modelling landscape. This section explores the forces having a potential fragmenting effect on the modelling landscape, by taking two main ingredients of a model's purpose as a starting point. We discuss our current understanding of the "fragmenting forces", as exerted by each of these ingredients respectively.

2.1 Domain-specificity based fragmentation

The perspective from which the enterprise is to be modelled is a major force of potential fragmentation. When modelling enterprises, several dimensions exist in which to identify distinct domains (aspects, viewpoints, perspectives) to model. This potentially leads to even so many domain-specific models and languages. To illustrate the diversity, without having the ambition yet to provide an orthogonal set of dimensions, consider the following possible dimensions:

Intervention design – This concerns the motivation/rationalisation of a desired intervention[3] (e.g. transformation or development effort) in an enterprise. Examples of different models along this dimension include:

– Models capturing the goals/motivations for changing the existing enterprise.
– Models capturing the requirements on the desired (direction of) change of the enterprise.

[3] Note that since an enterprise is a socio-technical system that, by its nature, has a tendency to change due to the initiatives of the humans that ultimately make up the enterprise, we prefer to use the term *intervention* rather than *system development* or even *implementation*. The term intervention more clearly signifies the fact that an enterprise is not just a technological artefact.

– Models (plans) of an intervention in the current enterprise to change it in the desired direction.

Within the plans for the intervention, one may also distinguish between different time horizons. In other words, what one might want to achieve in the next year, in five years from now, and beyond.

Enterprise design – This dimension deals with the motivation/rationalisation of the (existing/planned) design of an enterprise. In this dimension, one could for example distinguish between:

– Models capturing the goals/motivation for owning/using the (parts of the) enterprise.
– Models capturing the requirements on the enterprise that follow from this.
– Models capturing the design of the enterprise (meeting the requirements).

Design domains – This dimension concerns the domains that are considered relevant to the design of an enterprise, e.g. Zachman framework cells [4], the distinction between different levels of implementation specificity in Capgemini's Integrated Architecture Framework [16], the distinction between business, application and technology layer in ArchiMate [17] and TOGAF [18], etc. This dimension also includes 'cross cutting' domains such as security and governance as in e.g.[16], and different 'projections' on design aspects relevant to specific concerns/stakeholders using viewpoints [11].

Granularity – This concerns different granularities at which one might want to model parts of the enterprise. Depending on the specific aspect of the enterprise, different ways to identify levels or granularity might be relevant. For example, in the case of process modelling, one could distinguish:

– Level of key processes, without any triggering relationships between them.
– Level of major sub-processes, with some overall triggering relationships.
– Level of specific work tasks, with complete triggering relationships, including splits and joins.

Governance domains – This concerns the domains from which an enterprise wants to govern itself. As argued in the GEA [7] , these are not the same as the design domains. The design domains are typically formulated from an "engineering" perspective (blueprint thinking), while the governance domains are formulated more from an organizational and political perspective, e.g. human resourcing, compliance, acquisition, marketing, etc. These dimensions are also highly organization specific.

2.2 Usage-specificity based fragmentation

Models are created with an intended usage in mind, e.g. analysis, sketching, contracting, forecasting, simulation, execution, etc. The intended usage of the model by some audience will have a direct impact on the requirements on the modelling language used to capture the model [19, 8]. This invites more variety in models/languages used, adding to the potential fragmentation of modelling landscape. We suggest to identify:

Restriction of notation – refers to the level of restriction that is put on the notation that can be used to represent the model on a medium. The medium itself can for example be restricted to a specific form, such as graphical, textual, or video, but the notation in general can also be restricted in terms of fonts, icons and layout rules. See [20] for the role of notation in modelling.

Restriction of syntax – concerns the level of syntactic restrictions that may be put forward by the modelling language used. For example, one might consider “free format” drawings or text on one hand, and UML diagrams or text-based specification languages on the other extreme.

Restriction of semantics – refers to the extent to which a language is to be used with (an enforced!) formalized semantics. Formality in this context refers to the fact that the modelling language (graphical or textual) has an underlying semantics in some mathematical domain. See e.g. [21] for an elaborate discussion of formalizing the semantics of modelling language, and its relationship to the purpose of the models.

3 Managing coherence in enterprise modelling

Different strategies can be used to manage this potential fragmentation of the modelling landscape. In this section we discuss some of the strategies suggested in the literature, as well as their involved trade-offs.

3.1 Unified language

A classical approach to enable integrated modelling of the enterprise would involve relying on an all-encompassing and *unified* modelling language, to integrate all the relevant perspectives on the enterprise. This approach essentially boils down to preventing the fragmentation from occurring in the first place: it involves a single and stable language with an a priori defined set of concepts and their links, to be used uniformly. This would also lead to the standardisation of the language, i.e. vocabulary used for modelling, which in turn should facilitate knowledge transfer and communication about the system being engineered.

Such a line of reasoning can for instance be observed in the definitions of UML [10] for software design modelling, or ArchiMate [17] for enterprise architecture modelling. However, in the context of enterprise modelling, the feasibility of a unified language approach is questionable. First of all, it is nearly impossible to a priori identify which domains (and modelling concepts) should be part of an integrated language for enterprise modelling. Furthermore, the relevance of different domains is also highly situation-dependent. For example, different perspectives may be relevant for different enterprises, or even in different transformation projects of the same enterprise, or new perspectives may become relevant as the result of the evolution of the enterprise. A language such as ArchiMate was designed [11] to deal with this by enabling users to define their own viewpoints; i.e. essentially purpose-specific modelling languages where the model (the “view”) is derived from the unified/integrated model. At the same time, however, one can see how there is a drive for the ArchiMate language as a whole to be extended with additional domains, the move from the ArchiMate 1.0 standard to the ArchiMate 2.0 standard [17] included two additional domains (motivation and migration). Further integration between TOGAF and ArchiMate is likely to lead to even more extensions, while extensions dealing with e.g. value modelling, are also considered. *Where will it stop?*

Secondly, in dealing with an enterprise, one has to acknowledge the heterogeneity of communities and their (sub)languages [22, 23]. In such a context, imposing the single unified language for modelling the enterprise is likely to cause the conceptual misunderstandings around the resulting models, and a lot of time and effort would have to be put in resolving them.

3.2 Federated languages

A more flexible strategy results when allowing the co-existence of different modelling languages to model different perspectives on an enterprise. Essentially, this approach acknowledges the benefits of focused modelling languages for particular purposes. The integration strategy here consists in seeking to establish the links between these different languages and models used, in general having the ambition of interoperability of modelling languages at syntactic and semantic levels. For example, the MEMO [5] framework provides a common meta-language (i.e. the MEMO meta-metamodel) for all the special purpose modelling languages. Any special purpose language can be included in the framework, once it is expressed in the common meta-language. The integration of languages is achieved by their sharing of common conceptual foundation.

The Unified Enterprise Modelling Language (UEML) [15] has the ambition of making languages definitions semantically interoperable, and in that way facilitate the integrated use of models in enterprise modelling. While it also allows the inclusion of new modelling languages in the framework, this approach requires full formal precision of all the enterprise modelling languages, regardless of the purpose they are intended for. The core of the UEML approach lies in a common and evolving ontology [24], in which the modelling constructs of the modelling languages are to be precisely described This approach focuses on precisely describing (only) the *type semantics* [25] of the language constructs based on their specifications. However, as already discussed, one can observe the existence of different purpose-specific syntactic and semantic variations of the same original generic modelling language. It is our belief that the pragmatics of languages, and not only their specifications, should be considered within the efforts to integrate languages and models. We discuss these concerns in more detail in Section 4, motivating the need for its further research.

Even when using a common language to express the syntax and semantics of each language, bridges between the different languages and models still need to be built. To enable the creation of such bridges between modelling languages, it has been suggested in [26] to use ontologies. The approach outlined in [25] suggests using ontologies to make the *inherent semantics* [25] behind the language and model constructs explicit, and that way considerably reduce mapping complexity and ambiguity.

3.3 Family of languages

One can take this idea of using a common ontology a step further, by (re)designing the different purpose-specific modelling languages as specializations of a common generic meta-model. This leads to an approach in between the *unified languages* and *federated languages* approaches, which might be called a *family of languages*. Note that such a generic meta-model is *not* a meta-meta-model. It is a generalized meta-model, where the meta-models of more specific languages can be seen as specialization/refinements of the generic meta-model (i.e. not as instantiations of a meta-meta-model). The idea of using a generic meta-model is akin to older work on the so-called meta-model hierarchy [27], which has also inspired the hierarchy in the meta-model of the ArchiMate language [28].

4 Towards a theory for coherent modelling landscapes

In this section, we develop the first elements of an explanatory theory that aims to gain better insight into the needs and challenges underlying the use of different models/languages in enterprise modelling. We first explore the dimension of domain-specificity in 4.1, by analysing the interplay between domain concepts and normative restrictions on the modelling languages. In 4.2, we discuss the relation between purpose-based model/language tuning, model quality dimensions and identified dimensions of fragmentation.

4.1 Modelling domain and modelling language

To support this analysis, we introduce the matrix as shown in Figure 1. The horizontal dimension of the matrix corresponds to the *openness to different interpretations* of the domain concepts, i.e. (natural language) concepts used to communicate about the domain. Its extremes are defined as:

Open – where multiple interpretations of the domain concepts are possible. This is typically the case in domains with heterogeneous communities, whose practise and use of language differs significantly, resulting in different environments of discourse within the domain [29].

Normative – where there is a single (allowed) interpretation of domain concepts. Typically, domain concepts are defined within the normative documents. For example, in the insurance sector, standardized definitions of the insurance concepts exist within the i.e. Business Glossary[4], and are intended to be used as the basis for communication between industry partners, in the development of services, architectures and applications etc.

The vertical dimension of the matrix represents *the scale of normative restriction of modelling language*. We define the extremes on this scale as follows:

Open – with modelling language not being restricted a priori, but being constructed along the process of domain modelling.

Normative – refers to the modelling languages whose both syntax and semantics are formally defined in a mathematical language, resulting in one possible interpretation of the modelling language constructs.

[4] `http://acord.org/resources/framework/Pages/default.aspx`

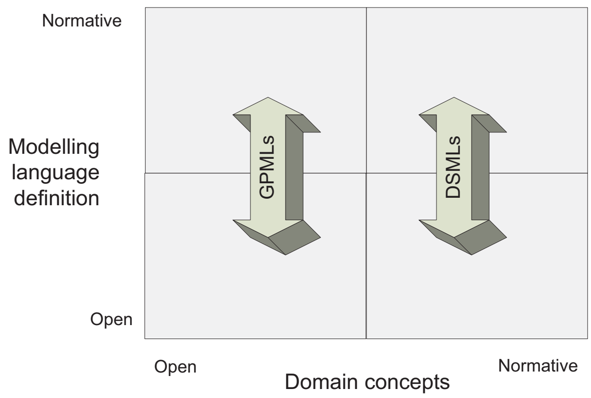

Fig. 1. Language construction view

As already discussed, there is a natural drive towards using domain-specific modelling languages (DSML) in enterprise modelling [12]. Essentially, by incorporating specific concepts tuned to modelling particular problem domains, the ambition of DSMLs is to foster modelling productivity, facilitate the understanding of the models by the stakeholders and increase the overall (in particular semantic and pragmatic) quality of the resulting models. By incorporating domain concepts into modelling language definition, more semantic precision is intended to be given to the language constructs. However, as discussed in [12], the conception of a DSML is bound to complex challenges and contingent decisions, and the level of specificity of the language is a matter of trade-off with the reusability of DSML in different contexts. The more specific DSML is, the more semantic precision it will have, the fewer the number of areas it can be applied to [12]. At the same time, this will increase its conceptual clarity within the intended domain of use, i.e. it will increase the quality model's of socio-cognitive interpretation [9].

DSMLs can be defined and used at various levels of formality, e.g. as semi-formal and visual [5], or executable [30]. The formality of the DSML is a means to improve the quality of technical interpretation [31] of the resulting models. This immediately suggests that the (required) formality of the DSML depends on the intended usage of the resulting models, as will be discussed later.

However, besides DSMLs, rather general-purpose modelling languages (GPML) such as i* [32], e3Value [33] or UML [10] are also used in enterprise modelling practises. They are usually more expressive, but at the same time less suitable than DSMLs in dealing with specific problem domains. The concepts of a GPML are rather generic and their meaning may vary across different contexts of the language use. For example, a modelling language such as i* [32] can be used for modelling strategic goals of actors in relation to the system, but also to express information systems requirements. In each of these contexts, the inherent semantics of e.g. the modelling construct *actor* will vary: when modelling strategic goals of enterprise, actor can only be a human actor, while in the context of modelling software requirements, a machine may be an actor as well.

This context-dependent semantic variation of GPML concepts is to be determined by taking into account the context of its use, i.e. purpose.

Following these discussions, we position DSMLs across the cells on the right side of the matrix, and GPMLs across the cells on the left side of the matrix. The boundary between a GPML and a DSML is not as straightforward, but what clearly distinguishes these two families is the ambition of DSMLs to exclude as much as possible the potential different interpretations of the domain concepts incorporated in the language. While DSMLs offer advantages of zooming in a particular domain with its specific concepts, they also come with the cost, since they emphasize particular terminologies, do not facilitate cross-domain communication, and exert the fragmenting effect on the enterprise modelling landscape. On the other hand, GPMLs are easier to reuse for modelling different domains, however the interpretation challenge of the models expressed in GPMLs is more pronounced.

4.2 Model purpose and model quality

The purpose for which the model is to be used influences the requirements on the information conveyed by the model, but also the way the it should be represented for its intended audience). Therefore, there is a clear connection between the notions of *model purpose* and *model quality* [13, 9]: for a given purpose, different dimensions of model quality are emphasized. This in turn implies different requirements on the modelling language(s) to be used, which ideally is tuned to the purpose at hand.

More specifically, in terms of the SEQUAL framework [13], we see the following relationships between the model quality dimensions and the identified purpose dimensions, which we discussed in Section 2:

Physical quality – links directly to the *restriction of notation* dimension, more specifically referring to the actual medium that is to be used.

Empirical quality – also links to the *restriction of notation* dimension, though referring more to the way the notation is used, e.g. in terms of comprehensibility and readability.

Syntactic quality – links directly to the *restriction of syntax* dimension.

Semantic quality – links directly to the *restriction of semantics* dimension.

Perceived semantic quality – covers the correspondence between actors' interpretation of the model and their current knowledge of the domain. The actor's interpretation of the model will be influenced by a priori choice of the domain and *restrictions on notation, syntax, or semantics*, in particular if they support the actor's prior knowledge and abilities to understand model's representation.

Pragmatic quality – as the correspondence between the model and its interpretation by the audience links to the spectrum of *usage-specific fragmentations*. Combined they enable or restrict the freedom of modellers to *influence* the pragmatic quality of models. In this regard, as argued in [9], we find it useful to distinguish between the quality of socio-cognitive interpretation and the quality of technical interpretation, as language restrictions are differently combined to meet these qualities.

Social quality – is not linked directly to *model purpose* dimension, in our view, but embedded more in the *process* of modelling, and therefore linked to the model*ling* purpose.

Organisational quality – is in our view linked mainly to the *domain-specificity* dimensions, determining the primary goal of modelling in capturing some domain in terms of a model.

We illustrate these considerations with several more or less typical model purposes within enterprise modelling:

Collaborative domain modelling in a heterogeneous community – This variation of domain modelling is typical for the domains with heterogeneous communities, whose practice and use of language differs significantly, resulting in different environments of discourse within the domain [34, 22]. The focus of the modelling process in this context is on reaching conceptual clarity and consensus between participants and the gradual construction of a shared conceptual model. However, given the terminological heterogeneity within the domain, the consensus on the entire vocabulary would not be realistic, so concepts' definitions are not likely to have a normative character. Given the focus on reaching common understanding and agreement, the aspects of the model such as syntactical correctness will be less relevant, therefore, informal and semi-formal modelling notations would be sufficient for this purpose.

Stakeholder communication – In this context, the models are intended to provide various stakeholders with needed insight in issues/problems at hand, and aid in human decision-making. As typically these stakeholders do not have an engineering background, there is a clear preference towards graphical and rather informal or 'box-and-line style' representations [35]. On the other side, the focus on semantic precision of domain concepts used in models is strong, and to avoid misunderstandings, ideally the concepts (and notation) stemming from the stakeholders' professional background would be used. This clearly indicates the tendency towards domain-specificity, i.e. the focus on semantic and pragmatic quality of models.

Model execution – When the model is intended to be directly executable by tools (e.g. specification of the software system), what matters the most is its formality, therefore the focus is on syntactic and semantic quality of the model. The corresponding modelling language therefore should be a formal one, covering at least execution semantics for the model, e.g. [30, 36]. Given that these models are to be used both by human users and machines, the corresponding languages may also combine both textual and visual notations e.g. [30]. However, they need not necessarily be domain-specific.

5 Conclusion

In this paper we explored the issues involved in assuring the coherence of enterprise modelling landscapes. We argued that while there is a clear need to have coherence among the set of models used to represent different aspects of the same (version of) an enterprise, the purpose-specificity which enables the tuning of models (and languages) to the purpose at hand, has a fragmenting effect on the modelling landscape. We concluded that the polarity between coherence and purpose-specificity should therefore be managed carefully. In this context, we discussed some of the existing strategies to reach integrated use of models and languages in enterprise modelling, including their trade-offs. Finally, we sketched some elements of an explanatory theory to better understand the use of enterprise models/languages at various level of domain- and usage-specificity. As a next step, we aim to further develop the latter theory, where we will initially focus on *model purpose*, but in later versions also involve *modelling purpose* in the equation. With such an explanatory theory in place, we can then endeavour to develop heuristics to balance the needs for purpose-specificity of models and the need for coherence.

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Enterprise Architecture Management - State of Research Analysis & a Comparison of Selected Approaches

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Abstract. IT alone is no longer sufficient for business success. Companies need to control enterprise-wide processes and adopt matching actions. This paper presents an overview of existing approaches of Enterprise Architecture Management (EAM). By reasoning, the importance of integrated EAM for small and medium-sized enterprises (SME) is underlines. The study is structured as a systematic literature review of papers published by selected journals and book series from 2006 till 2012.

Keywords: Enterprise Architecture Management, systematic literature analysis, small and medium-sized enterprises, IT Management, Business Architecture, Business Engineering, Business IT Alignment

1 Introduction

It is essential to make the organization more sensitive towards the interaction of business strategies, customers, application systems and organizational units. At the same time there is no coherent architecture covering the majority of problems. [1, 28, 45]

Enterprise Architecture (EA) is the formal declaration of the basic structures of an organization, its components and relations, as well as the processes used for development. [2, 3, 4, 10, 12, 45] The specific implementation of EA is derived from a rich set of framework models and the economic and organizational situation of the specific enterprise. Caused by industrial changes like automatization, standardization and innovation, enterprises began to focus on software products and IT. In the past, IT focused architectures failed to integrate other layers and functions of the enterprise. The complexity of integrating different layers like business processes, applications and technologies should be controlled to get long-lasting opportunities of action. [6] "It is such a complex topic that easy and general solutions are unlikely to appear." [18, p. 268] Therefore, EAM is getting more and more important, but is still mostly unexplored and rarely used, especially in context of SME. However, the terms EA and EAM are used inconsistently. This is in part a result of different authors focusing on specific parts of companies. [6, cp. p. 234]

The objective of this paper is to identify the current research state of EAM, its terminology and its applicability for SMEs. The research approach is described in section 2, followed by the design of the systematic review. Some approaches from the selected papers are compared based on the aptitude for use in SME, after the research questions have been answered in section 4. The paper ends with a summary.

2 Research Approach

The research approach used by this paper is a methodological review of research results. The approach aims to be transparent, conclusive, and repeatable for the audience. The purpose of this paper is to summarize knowledge on EAM, to distinguish it from other terms of management disciplines, and finally to identify its applicability for SMEs.

We have conducted a systematic literature review based on the guidelines of Kitchenham et al. [25] A preliminary overview has shown a limited amount of existing conference submissions with relevance to this topic. Therefore we decided to shift our focus and cover journals and book series and modified the search process for literature due to limited availability and access.

The research proceeded in the following steps are recommended by B.Kitchenham:

1. Formulation of the research questions to define the important topics and relevant research fields.
2. Identification of literature sources covering EAM
3. Selection of papers for inclusion in the analysis
4. Data extraction from selected papers
5. Presentation of results
6. Interpretation of results

The remaining part of paper is organized by following these analysis steps.

3 Systematic Review Design

To develop the role of EAM in research and practice, as well as in the context of SMEs, a literature selection was conducted and the result analyzed. This section describes the different steps of the systematic literature analysis.

3.1 Research Questions

The research questions (RQ) and expectations for answers addressed by this paper are:

1. How can Enterprise Architecture Management be classified? This question aims to clarify the tasks of EAM. It tries to illustrate the importance of several parts of an organization in accordance to the management methodology.
2. Are SMEs a target group of the EAM research? Are there any articles addressing EAM directly in the context of SME?

3. What are the different research approaches? Are they using literature analysis, surveys, case studies or other kinds of research methods?
4. What are the limitations of this research with regard to the covered literature?

3.2 Identification of Literature Sources

The initial search for appropriated literature sources itself was performed using the internet services Citeseer and Google Scholar and sorted by common ranking evaluation. Search terms like "enterprise architecture" and "enterprise architecture management", as well as the corresponding German terms were used for the initial literature identification process. Based on the abstracts and reference lists of the initial matches the list of search terms was refined (e.g. "enterprise models) and additional journals as candidates for inclusion identified.

Overall we found ten journals covering the topic more than once; individual articles were not considered in the latter analysis. Furthermore, we selected journals based on the rank and the number of potentially relevant articles supplemented by two book series. The first one is *Xpert.press*, a book series following the popular journal with the same title. The second one, called *Business Engineering*, offers a whole book on the topic. Both of them are published in German.

The ranking was approached from the perspective of Information Systems Research and not of Business Economics. The *HMD* journal for example only got a "D" in the business oriented JOURQUAL [39], but a "B" in the "WI-Journalliste 2008" [43]. German and English sources were included without specific preference.

The journals *Wirtschaftsinformatik* and *HMD* were chosen because of their classification as popular journals of the Oldenbourg-Verlag by the Encyclopaedia of Information Systems Research. [21] *Knowledge and Information Systems* was chosen because of the SCImago Country and Journal Rank. [35] Due to availability and the iteration of search terms, both book series and *Information Systems Frontiers* were chosen. The journal *Wirtschaftsinformatik,* published in both German and English, is released six times a year. The magazine publishes innovative and quality assured research results as well as trend-setting and other kinds of interesting practical ideas in the field of Information Systems. [42] *HMD - Praxis der Wirtschaftsinformatik* is issued six times a year. The German magazine points out solutions for problems of IT experts and managers, presents implementation possibilities and informs about news on Information Systems Research. [20] The English journal *Knowledge and Information Systems* "provides an international forum for researchers and professionals to share their knowledge and report new advances on all topics related to knowledge systems and advanced information systems." [43] *Information System Frontiers,* also an English journal, is about Business Information Systems, its management and systems theory and control. It is issued four to five times a year. [38]

Business Engineering is in contrast to other selected journals and book series not restricted to business, but also includes articles of the cultural and political implications. [36] The book series *Xpert.press* offers actual and qualified knowledge to professionals of software development, internet technology and IT Management. It is mainly focused on technologies and applications of modern Information Technologies. [37]

All editorial and scientific articles of the chosen sources are subject to a profound quality assurance including peer review. Except for the *HMD*, all sources are published via SpringerLink.

3.3 Paper Selection

As period of time we used the last six years, ranging from 2006 till 2012. The majority of potentially relevant articles is from 2004 till 2012 and increases over the years. We curtailed the timeframe to analyze enough articles, while remaining up to date. Furthermore, we used a two-pronged approach to look for relevant papers.

Selection path A means selecting paper by matching with the primary keywords like “enterprise architecture”, “enterprise architecture management” and the corresponding German terms within the abstracts and bodies. These papers were directly selected. Selection path B includes all papers with several models of architecture and management disciplines. This is deeply rooted in the fact that EAM includes management disciplines like IT and Business Management. In the second phase papers were chosen, if they contained at least two different secondary keywords like “architecture” and “SME” and were not already selected as part of Selection A. The selection was reduced based on a cursory reading of the abstracts.

We found the majority of papers (> 300) in the *Information System Frontiers*. Nevertheless we just left five articles within our literature selection, which cover enterprise management disciplines and particularly SME. The search within the *Wirtschaftsinformatik* journal led to the smallest number of hits (17).

As a conclusion we started with 418 papers in the first iteration of literature sources. This was extended by 176 papers in the second iteration (section 3.2). Ultimately 35 papers were selected for this evaluation. Overall this constitutes 5,9% of our starting pool of 594 papers after the second iteration.

4 Data Analysis

RQ1: How can Enterprise Architecture Management be classified?

Different classifications of EAM are possible. [22, cp. p. 65] introduces EA as a management instrument, because the EA has to be part of the classic management processes in every organization. By comparison, [27] defines EAM as a discipline of the IT Management. The majority considers EAM a combination of different management disciplines working together for an integrated enterprise view.

The design and reorganization of architectures is consolidated as Architecture Management. Furthermore it defines roles and responsibilities as well as the guidance of participating employees. [10]

[3, cp. p. 189] divides Enterprise Architecture into two parts: the Organization Architecture and the IT Architecture. The first one contains organizational structure and business processes. The IT Architecture is influenced by the Information System Architecture. Often the IT governance follows the business governance. [32]

EAM is divided into different layers by [12, p. 169]. He describes four layers with its functions: the strategy layer, the organization layer, the IT and Business Alignment layer and finally the IT layer. In contrast to this, the paper by [19, cp. p. 104] lists business architecture, process architecture, application architecture and IT architecture as the aspects to manage.

It is essential to manage and arrange the different aspects. Otherwise the enterprise will not reach the reuse of models and a homogeneous archetype of matching components. To build an EAM it is necessary to know the layers, where an architecture takes effects. [6] Without managing the overall context it is difficult for enterprises to satisfy their customers, to extend their market shares and to react to society changes." Nowadays the IT management is the backbone of many enterprises." [31, p. 52]

[14, p. 67 ff.] concentrates his research on the Architecture Management of information systems. The management of information systems is divided into three layers: the strategic one, the administrative one and the operative one. Information Management concentrates as part of the Business Management with the identification and best conversion of the IT potentials in solutions. [14, 15] The orientation of EAM is mentioned to consider the same three levels of management: strategic, tactical and operational. The strategic level is focused on the enterprise future and consequently covers a long time horizon. The tactical level implements the future by the creation of concrete plans and has a medium time horizon. The last one, the operational management, includes the detailed planning and realization. [13, cp. p. 71]

RQ2: Are SMEs as a target group of the Enterprise Architecture Management considered?

At first it is remarkable, that there is no paper addressing EAM directly to SME. Most of the examples in the articles are mentioned for large enterprises like the Credit Suisse [18], T-Com [16] and Volkswagen [11]. EAM is a necessary factor of target-oriented controlling and governance of medium and large enterprises. Implementing EAM and documenting it is a complex and expensive undertaking. The implementation is specific to each company and has to be supported by a matching communication policy. The expense of such a project is justified even for SME, because defining all elements of an EA is less work and provides other synergy effects. [27, 30]

According to [31, cp. p. 55] the European Commission defines enterprises up to 250 employees with a yearly business volume of up to 50 million Euro or a balance sheet total of up to 43 million Euro as SME. All others are considered large enterprises. The management of SME is characterized as less comprehensive. As a result corporative and operative planning are less formal and often do not exist in written form. Furthermore SME are predestined for flexibility due to their flat hierarchies, less bureaucratic structures as well as the direct inclusion of decision-makers. To make an enterprise-wide management possible the enterprise units have to be involved in strategic decisions and several management disciplines have to be differed. SME often operate in specialized markets where each product is highly customized for this specific customer. SME are more sensitive to investment decisions and often require more directly visible Return of Investment. As a consequence many SME has heterogeneous, historically grown IT structures. [30].

These facts lead into different conclusions, why an EAM might be challenging in SME, apart from not having a multitude of elements and a number of dependencies, which is ment as a main reason for implementing EAM. [6] Nevertheless even SME have to respond to changes forced by rough environments and IT developments. [31]

Firstly, SME are not interested in EAM because of the complexity and price for thedesign and management of EA. [41] Even the expenses to introduce methods, tools, customizations and trainings might not be justifiable in SME. [12, 18] Furthermore they are aware of temporary and commercial restrictions influencing their business operations. Typically, SME need more time to compensate changes and losses than large enterprises because of their limited possibilities of evasion. [6]

Secondly, models (e.g. maturity degree model) and tools have to be reduced to core concepts to be usable by SME. [24] Thirdly, small enterprises have few employees with necessary technological skills. The loss of expert knowledge is a high risk for smaller enterprises. [8] Fourthly, the success of EAM is rarely detectable by data because causes and effects cannot be linked as well as most effects cannot be measured (e.g. by quantities) so easily. [6]

Despite all these challenges, there are reasons for using EAM in SME. Firstly, the distinction of management disciplines and its need is a subjective decision. Secondly, security, availability and performance are aimed by every enterprise independently of its size or industrial sector. The usage of EAM can take these goals forward. [10] Thirdly, the main reason, different applications and requirements have to be integrated in a homogenous system in general. Otherwise the maintainability and transparency of an enterprise gets lost. This can even result in a loss of customers. [3, 19, 26]

To summarize, the size of an enterprise does not determine whether it has a complex structure or not. In general “all industry enterprises, whose markets are affected by a high complexity of value creation, are concerned.” [45, p. 187]

RQ3: What research approaches are being used?

After describing the topics investigated by the papers in the field of EAM in research question two, we sorted all papers of our research into the following categories.

1. Case study: Analysis of a specific use case with regard to this topic. 2. Survey: It is a research source, answering a research field, by questioning some stakeholders.

3. Theoretical work: Analysis of a research topic in a methodological way, possibly proving a solution problem, without direct application or experiments.

The emergence of research approaches is offers a lack of surveys (1). The majority of sources are of theoretical nature (24). Additionally some of these theoretical works were titled as analysis, but did not include literature reviews by definition. The second highest amount are case studies (10). They are mostly related to large enterprises.

RQ4: What are the limitations of this research?

The search was done using Google Scholar and Citeseer. Based on earlier studies it was assumed that the full-text search provided by SpringerLink and the homepage of HMD automatically searches for both British and American spelling. Derived from the guidelines of Kitchenham et al. [25] the search was organized as a manual search.

In difference to the guideline, the analysis is based on journals and book series instead of conference proceedings. Thus, we are aware that there is a possibility missing some relevant sources. Articles published in languages others than English and German were not considered for lack of understanding. It is our believe, that the language selection provides a comprehensive overview. Papers not directly using the terms Enterprise Architecture or Enterprise Architecture Management might have been disregarded. The list of search terms was refined by the initial research (section 3.2), but this may not be exhaustive. Additional iterations of wordings for the search term list might be useful.

Thus, our results apply only to national German journals, highly ranked English journals and two additional book series to get more information. We focused on Information System and Business Engineering focused magazines. Individual articles were not considered in the analysis. As a result the decision may be biased. The classification of articles into main topics and management disciplines is not unique as formulations in the papers are often not clear enough. The timeframe was chosen to balance the number of potential papers and the currentness. Choosing a different timeframe affects both factors.

5 Comparison of selected approaches

In this section four selected approaches (section 5.1) are compared in different aspects to highlight the similarities and differences. We want to identify a consistent understanding of EAM and its applicability for SME.

5.1 Selection Process

We selected four approaches from the 35 literature sources of this paper. They are chosen because they used the terms "enterprise", "architecture" and "management" in the paper title. Two of these four papers, published by the Information System Frontiers, belong together. [22] introduces and refers the paper of [13]. The special case of architectures for extended enterprises of these papers is left out.

5.2 Comparison

Table 1 compares the different approaches in selected categories. Cells labelled with numbers from "1" to "3" indicate the allocation of papers to specific categories. "1" means, the category is named directly. "2" implies, that the category is indirectly named, for example by circumscription. A cell marked by "3" signals, that the content is not mentioned.

The categories are derived from questions like: Which approaches are compared? What are they about? What is the intention of writing? What is their understanding of EAM?

Table 1. Comparison of Selected Approaches

Approach	**[6]**	**[13, 22]**	**[27]**
Journal	Business Engineering	Information System Frontiers	HMD - Praxis der Wirtschaftsinformatik
Initial research interest	• Internal development of architectures as fundament of EA	• Integrated view of business and IT is missing	• Complex relations of IT landscapes • Collection & analysis of information about supporting IT by processes
Focus of approach	Realization of architecture mgmt.	Framework for EAM	Development of procedures for EAM
Reasons for EAM	• Merging of business & IT units to change from business process oriented to enterprise-wide management	• Changes of strategy and business goals of companies have enterprise-wide consequences • Agile, integrated and aligned enterprises	• Introduction of EAM caused by the integrated approach is difficult
Relation of EA and EAM	• Coordination of EA with other business processes to address organizational changes	• EA is a tool of organizational management and blueprint •Architecturing got more attention than managing EA	• EAM has to provide integrated and transparent documentation for the EA to manage the included elements and processes
Differentiation of model states	Actual and target state architecture	Starting and end state	-
Usage of EAM	IT strategy & derived initiatives have to be aligned with business strategy	Integration of IT and business	Integrated usage of EA
Understanding of EAM	• Managing of EA models, regarding processes and gets value by different views and focuses	• EA is a management instrument • EAM includes different models and methods	• Discipline of IT Management
Stakeholder of EAM	• From management to operators and users • Specific information & services	• From management to software engineers • Outside and within the company • Specific information	• Initially IT internal stakeholders, later business extended
Layers of EAM	• Might be derived from the integrated architectures	• Various (e.g. business process layer, data management layer, software systems layer)	• Strategy layer
Orientation of EAM	Directly/Indirectly	Directly	Indirectly
strategic	1	1	2

tactical	2	1	3
operational	2	1	3
Tool support of EAM	• EA models • Portfolio mgmt.	• EA frameworks • management tools	• specific management tools (e.g. for outsourcing)
Implementation by ...	• Chief architect • Architecture office	• All parts of the enterprise (first business, second IT)	• Continuous positions • Organizational units
Recommended for ...	• Historical grown application landscape	• Large organizations • Large systems • Complex systems	• Medium and large IT organizations

The three compared approaches are published in different journals. Their intention of research in the field of EAM is caused by several reasons. [6] and [27] underline their approaches and topics of interest by examples. The paper by [6] points out that EAM is necessary, if the enterprise is characterized by a complex system or a historical grown application landscape with applications used in different environments. The article of [27] is focused on the development of procedures for implementing EAM. EAM is described as a discipline of IT Management; EA as a management tool. [13, 22] concentrate on a framework for EAM, including models, principles and methods. [6] names the alignment of strategies and derives initiatives with the business strategy as a main goal, which is connected to several sub goals, mainly caused by the complexity of enterprises, the costs to control it and the risk to lose it. Even [13, 22] state "changes in a company´s strategy and business goals" [22, p. 63] as necessary preconditions of an enterprise-wide alignment of measures and actions. [6] and [13, 22] are using models to formulate the EAM. [6] directly names actual and target states of architecture, whereas the paper of the *Information System Frontiers* indirectly mentions them in the context of the development of enterprises. The third approach does not mention states for its procedures.

The approaches agree that the stakeholder of EAM are various in number and profession and can be inside or outside of the company. The importance of the results for target groups is different. [13, 22] write about three different orientations of EAM: strategic, tactical and operational. These levels do not have to be implemented directly by the enterprise, but rather has to be the core of working and acting. The strategic level has a long time horizon (five years), is vague by nature and defines the mission, vision and principles. Its implementation includes the creation of more concrete plans in the medium-termed (1-2 years) tactical level. The different projects are structured, fitting the EA. At the operational, short-termed level the detailed planning is made to turn the projects into reality.

All of the approaches include different architectures in their approach. The architectures defined by [6] were adopted as subcategories. All approaches agree that the EAM has to be controlled and implemented by assigned persons or even instances. The EAM can be supported by several tools.

In summary, it is obvious that the focus of research in the field of EAM various widely. All approaches mainly focus on large enterprises as they are used in examples, as well as indirect proofs like naming complex systems. Nevertheless we believe that all of them can be applied to medium-sized enterprises and all except for [27] are possible to implement for small ones. [27] is too much focused on procedures for very complex or even extended enterprises. If small enterprises are structured as organizational units, EAM could be implemented as described in [13, 22]. It is understood to imply that an integrated management is only helpful if complex structures, dependencies and processes exist. EAM has to integrate all units of an enterprise to control and govern it as a whole. It covers several management disciplines and can be supported by a number of tools. The specific tasks, a commonly accepted definition of the term and the applicability to SME have to be scientifically developed.

6 Summary

The majority of research on EAM is done in theoretical work and case studies. All in all the discussion and usage of EAM is focused on IT in practice, although there is knowledge about the importance of processes, strategies and organizational aspects as well. Reasons are the continuous attention, cost, less experiences and expenses to integrate such an EAM model. There is not much work on implementing EAM in smaller enterprises, although some approaches would fit SMEs also. The connection between just business-focused and IT-focused managing has to be established in consideration to the dynamic environment, forcing for adaption and changing of enterprises. The different management disciplines are neither defined, nor used in a consistent manner. It is not clear, what the tasks and members of the management of an enterprise are. Management methods are not supposed to apply to specific company sizes, sectors or organizational units; they are supposed to be adaptable to different circumstances. For that reason companies have to be organized to provide a coherent, satisfying experience. To achieve this, processes and organizational structures have to be aligned, covering all elements, relationships and dependencies in every part of a company.

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A Trust Ontology for Business Collaborations

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Abstract. There are currently some ontologies of business collaboration that facilitate automated collaboration, such as e^3*value*, REA, and BMO. However, these ontologies model the situation that all business actors can be trusted. This is not true in practice. To realize automated business collaboration, trust needs to be added to the business ontology. In this paper, we extend the e^3*value* ontology with the concept of trust and show how this can be used to reason about trust on actors in a business network. We take a minimal approach, i.e. rather than adding all the nuances of the concept of trust, we provide the minimal extension that allows an actor to reason about trusting other actors in a useful way. We end the paper with a discussion of how this approach can be generalized to other approaches.

1 Introduction

Nowadays, the networks that enterprises operate in, become increasingly complex. There are many reasons for this. Among others we can refer to more advanced user needs, upward tendency toward specialization, changing customer demands, higher customer satisfaction criteria, advancement in information and communication technology (ICT), globalization of markets and manufacturing, increasing competitiveness, exposure to a bigger audience, etc. In fact, collaboration of different enterprises to co-produce a product or service is nothing new, however, here in this paper, we focus only on those business collaborations which are facilitated by ICT. In other words, we are concerned with the design and use of IT in IT-enabled business collaborations.

A collaborative network is a network consisting of a set of autonomous actors (e.g. enterprises, organizations and people) that collaborate to achieve common or compatible goals [1, 2]. Collaborative networks come with different names in the literature, such as business webs [3], Virtual enterprises (VE) [4, 5], extended enterprises [6, 7], strategic alliances [8, 9], value constellations [10–12], to name a few. The common theme among all these names is the alliance of some business actors - which often involves technology transfer (access to knowledge and expertise), economic specialization, shared expenses and shared risk [9] to co-produce value with each other.

In a collaborative network each enterprise contributes with its own specific products or services to satisfy the consumer need. The model which shows the creation, distribution, and consumption of goods or services of economic value in such a network is called value model. The main goal of the value modeling is to reach agreement amongst profit-and-loss responsible actors regarding the question "Who is offering what of value to whom and expects what of value in return?" It also enables the actors to assess their potential profitability in the collaborative network and develop an insight into the economical viability and sustainability of the whole collaborative network. The value model assumes that all partners in the business web behave in accordance with the rules and promises expressed in it (they do not act opportunistically). However, the risk in any business network is that a partner will not behave according to the rules and promises and act in favor of its own goals, to the detriment of other partners' goals. This forces a business to take appropriate and sufficient measures against those who it does not trust, i.e. who may not live up to its commitments.

In fact, for doing any business in the real world, trust is crucial for the success of the business, because, after all, we need to trust at least some actors, such as a bank or other trusted third parties. This basically means trust is an inevitable concept in business collaborations. Here in this paper we propose an ontology for business collaborations by enriching the e^3value ontology with trust and risk related concepts.

The rest of the paper is organized as follows. First, in section 2, we discuss the related work and then in section 3 we briefly introduce the e^3value business ontology/methodology. After that, in section 4, we introduce a trust ontology for business collaboration settings based on the e^3value business ontology. We conclude the paper in section 5.

2 Related Work

An ontology is defined as "a specification of a conceptualization." [13]. It specifies the concepts and the relation between the concepts of a specific domain and they play an important role in knowledge sharing in the specific domain.

In [14], Akkermans and Gordijn introduce the e^3value ontology and discuss about the necessity of ontologies for scientific research. Baida et al. [15] developed a multi-actor business model for e-service bundles by ontology-based analysis of e-service bundles in networked enterprises. However, their model represent an ideal situation that lacks the trust related issues.

Andersson et al. [16] represented a reference ontology for business models based on three business ontologies - the REA, e^3value, and BMO. The core concepts in the REA [17, 18] ontology are Resource, Event, and Actor and it claims that every business transaction can be described as an event in which two actors exchange resources. The Business Model Ontology (BMO) [19] aims at providing an ontology that enables us to describe the business model of an enterprise accurately and in detail by considering a single enterprise and its environment which faces a particular customer's demand. Surprisingly non of these ontologies consider trust related concepts.

Chang et al. [20] presented the ontological representation of agent trust, service trust, and product trust in e-service environments. The work presented here is similar to the general service/product ontology of Chang. The main difference is that Chang et al do not look at service and product provision necessarily from a business point of view and consequently they do not include financial risks in their ontologies. They also do not discuss about the source of trust and the way in which trust develops. Schmidt et al. [21] also proposed a number of ontologies to formalize and facilitate autonomous interactions between intelligent agents in centralized and decentralized e-business environments however they also do not consider the financial perspective and consequences of trust in the business collaborations.

Haung and Fox [22] try to formalize the semantics of trust and study the transitivity of trust. From the formal semantic, they identify two types of trust - *trust in belief* and *trust in performance* and formally prove the transitivity of trust in the former and introduce some conditions under which trust relations of the second type can be propagated. Viljanen [23] surveys and classifies thirteen computational trust models by nine trust decision input factors and creates a comprehensive ontology for trust to facilitate interaction between business systems. Later in the paper we analyze our proposed business trust ontology against those nine factors.

3 E^3*value* Business Methodology

The e^3*value* methodology [12] is a tractable and lightweight methodology to explore the innovative e-business ideas - starting from understanding which enterprises and actors are actually involved, to an assessment of profitability for each enterprise.

An e^3*value* model consists of a graphic part and a computational part. The graphic part is a diagram and the computational part is a spreadsheet with algorithms that can perform Net Present Value (NPV) estimations for the participating actors to assess their potential profitability in the business collaboration over a specific period. In the e^3*value* methodology, we model a collaborative network as a graph in which the nodes represent economic actors and the edges represent economic value transfers. In addition, an e^3*value* model shows how a consumer need is met by a set of economic exchanges between actors in this web [12, 24, 25].

3.1 E^3*value* Ontology

Consider the simple e^3*value* model (Figure 1) in which *Buyer* gives *Money* to *Seller* and receives *Good* in return. *Seller*, in turn, gives *Money* to *Transporter* and receives *Transport*. This simple model illustrates the following modeling constructs of e^3*value*:

– *Contract Period.* A value model describes economic exchanges during a specific period of time, which is called contract period. The contract period

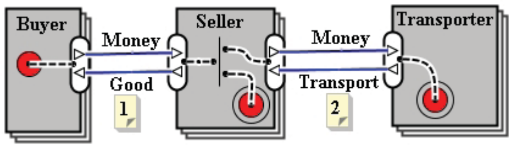

Fig. 1. A simple value model

should be specified in supporting documentation and the model will be used to analyze economic sustainability during this period only.

- *Actor.* An actor is an independent economic (and often also legal) entity with a specific interest in the collaboration (making profit, increasing utility, earning experience, ...). Actors in Figure 1 are *Buyer*, *Seller* and *Transporter*. The actor for whom the business web is made to satisfy his needs is called the *consumer*. We represent the consumer need by a bullet placed inside this actor (*Buyer* in Figure 1).
- *Value Object.* A value object is a service, good, money, or experience, that is of economic value to at least one actor and that is exchanged between actors. In our example value objects are *Money*, *Good*, *Money* and *Transport*.
- *Value Port.* An actor uses a value port to provide or request value objects to or from other actors. A value port is a conceptual construct indicating that during the contract period, an actor is capable of giving or receiving a value object. Value ports are represented by small triangles on the edge of the shapes representing actors.
- *Value Interface.* Value interfaces group value ports and indicate atomicity: if one value port in the interface is triggered in the contract period, all of them are triggered in this period (however the model makes no statement about when this will happen: this has to be specified in a corresponding coordination model). Value interfaces are represented by oval shapes surrounding the value ports.
- *Value Exchange.* A value exchange is used to connect two value ports with each other. It represents one or more potential trades of value object instances between value ports.
- *Value transaction.* The concept of value transaction is used to aggregate all value exchanges between two actors to indicate that all value exchanges should occur or none at all.
- *Market Segment.* A market segment is a set of actors that assign economic value to objects equally. They are shown as overlapping rectangles.
- *Dependency Path.* In most cases an actor has multiple value interfaces and these value interfaces can be related. A dependency path connects value interfaces of the same actor together, meaning that if one of the value interfaces is triggered the connected value interfaces also must be triggered [12]. A dependency path consists of dependency nodes and connections. A dependency node is a consumer need, an AND-fork (the sign in the actor *Seller*) or AND-join, an OR-fork or OR-join, or a boundary element (Bull's

eye sign). A consumer need is the trigger for the transfer of value objects. A boundary element models that no more value transfers can be triggered. A dependency is represented by a dashed line.
– *Transaction.* A transaction starts when the consumer need triggers and completes when all the value exchanges connected to that consumer need are triggered.

Figure 2, which is taken from [14], depicts the e^3value ontology for networked business models. Obviously, there is no notion of trust in the e^3value ontology. Consequently, the profitability analysis of the e^3value ontology is based on an ideal situation in which all actors are assumed to act trustworthy.

In e^3value methodology, after modeling a business case, the value model is attributed with quantitative estimations (for example, the number of consumer needs per contract period and the monetary values of exchanged objects) and a contract period. Then, the revenue of each actor in the specified contract period, is estimated by subtracting the amount of money which the actor loses from the amount of money which he earns during that period. Strictly speaking, the amount of money that a business actor loses in a specific period, is the amount of the monetary value of all value objects which he provides for other actors during that period and likewise, the amount of money that a business actor earns in a specific period, is the amount of the monetary value of all value objects which he receives from other actors during that period.

The result of this simple calculation is the first indication whether the model at hand can be economically profitable for each actor or not. However, even if the results show a profitable collaboration for all actors, it does not necessarily mean that the collaboration would be profitable in the real world. Because, this calculations are based on the assumption that all business actors are trusted and they all respect the agreements. Hence, to refine the profitability analysis and to make the calculations more precise, we need to drop the trust assumptions and then refine the profitability analysis by taking trust into account.

4 Trust Ontology for Business Collaboration Settings

Trust is a ubiquitous phenomenon in everyone's life. For example when we cross a street we trust the drivers to a certain extent that they follow the traffic rules. Trust exists inherently and latently in all our actions that we might even not be fully aware of that. This is the reason why it is overlooked in many cases and most of the time, people take it for granted. Nevertheless trust has a major impact on our decisions.

In business settings, trust plays even a more important role because in contrast to the social settings in business settings a misplaced trust might result in financial loss and after all, financial profit is the main thing that matters in business settings. Hence, we need to identify the trust factor and evaluate the financial risks that it might create and be fully aware of them before making a decision in the business collaborations. Nevertheless, trust is inevitable and in

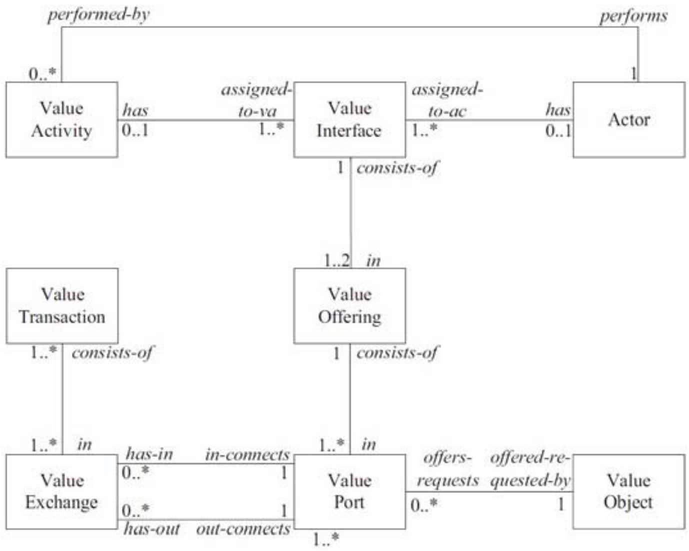

Fig. 2. The e^3value ontology for networked business models

doing any business activity, actors need to trust some other actors and as Kenneth J. Arrow [26, page 24] pointed out without trust no market could function and there is an element of trust in every transaction. In addition, as Luhmann [27] indicated trust reduces the complexity of interactions.

Here, we aim at designing a meta-model for trust ontology in business collaborations. To do that, we use the practical recommendation of a noble sociologist, Howard Becker [28] for designing middle-range theories and hypotheses in scientific research, which is describing case-study conclusions in an abstract way without referring to a specific case. This enables us to capture and articulate the core of the business case in more generally valid formulations.

Our goal is to extend e^3value ontology with the minimal ontology of trust to be able to usefully reason about trust in a business network. So, we do not want to express all possible meanings of trust, nor do we want to add to the literature on the meanings of "trust" one more bit of insight. We simply want to extend the e^3value ontology to make it more realistic in the intended settings, that of business networks.

By analyzing different business interactions in different case studies and also by studying the existing trust ontologies we identified the major trust related concepts in business collaborations. Then, by delineating the relations between those concepts, we developed a lightweight ontology which contains the minimal set of trust related concepts in business settings. The ontology is shown in Figure 3. The shaded concepts are those of the e^3value ontology and the rest are the new added concepts. For brevity, we exclude those concepts of the e^3value ontology which are not directly related to new added concepts. According to this ontology, a trust relation between two business partners is as follows:

A business actor (Trustor) trusts another business actor (Trustee) with a specific confidence (Confidence value). The confidence value is in the range $[0,1]$ *and it is calculated based on (1) the reputation (business profile) of Trustee or (2) direct trust (past experiences / collaborations between the two actors) or 3) indirect trust (the value of the trust of other business actors in the collaboration with Trustee i.e. collaborative trust). A combination of all these three factors is also imaginable.*

In fact, Trustor expects Trustee to accomplish a certain action during a specific period of time (Time Slot) with agreed upon quality/conditions. In a business collaboration context, this action is transferring a specific value object (Value Transfer) with explicit quality specifications in a specified time slot. There is a risk associated with every trust relation which means in case Trustee does not fulfill the agreement (transferring the value object with agreed upon quality), it will result in a financial loss for Trustor. The setting of the relation is described in the value model of the business collaboration.

The financial losses associated with the trust relations originate from the value objects and their monetary values. But, how can we calculate the financial loss associated with each business actor? One way to do it is to investigate each value exchange and evaluate the financial loss associated with that value exchange. Each value exchange indicates two business actors that are exchanging value objects with each other.

The financial loss which a business actor might incur, is the case in which that business actor receives a value object with less value than what he was expecting according to the agreements and the worst case is the one in which a business actor provides his partner with a value object according to the agreements, but his partner does not give him anything back. This happens because a business actor trusts another business actor but the trustee acts opportunistically.

The crucial question here is, how often does this happen and consequently how much loss should a business actor expect during the collaboration? According to the trustor's expectation, the probability of the trustee to act opportunistically is $(1-T)$, where T is the value of trust (confidence value) of the trustor in the trustee. Strictly speaking, the potential financial loss of a trust relation is $(1-T)*V$, where T is the value of trust (confidence value) and V is the monetary value of the agreed upon value object. Here we assume the total loss of value object V in case the trustor acts opportunistically, which is obviously the worst case.

In fact, this is not the worst case, because in some cases a business actor invests a considerable amount of money in the collaboration with another business actor in the hopes of many value exchanges. However, the other actor misuses the trust early at the collaboration or even at the very beginning and in this special case the financial loss of the trustor actor would be much more than the monetary value of the single lost value object.

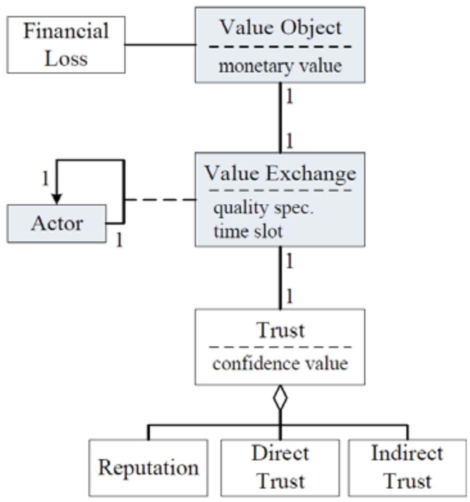

Fig. 3. Trust ontology in business collaborations settings

4.1 E^3value Ontology Enriched with Trust

After introducing the trust concept, we would like to explain the way in which it can be used with the e^3value methodology. To do that, we summarize our three previous papers which deal with the issue of trust in business collaborations.

The first step is to develop a method to assess/calculate and quantify the trust relations between actors in a business collaboration. To do that, in [29], we first modeled a collaboration with e^3value methodology and then analyzed the trust relations between the involved actors. After that, we explained the implications of trust relations on the coordination patterns and finally we introduced a method for measuring and managing trust relations between business actors in a collaborative network.

To measure the value of the trust of the trustor in the trustee, trustor uses (1) its own opinion based on reputation or past experiences and (2) the opinions of other direct partners of the trustee in the collaboration, because in case the trustee has a trust problem with any of its partners, it might break their relation and consequently the whole collaboration will collapse since the collaboration works only as a whole. Therefore, it is necessary for the trustor to take the trust of the direct partners of the trustee into account. For more details regarding the way in which we identify and measure the trust relations in a business collaboration interested readers are referred to [29].

After measuring and quantifying the trust relations, the next step is to refine the profitability analysis by taking trust into account. To do that, in [30], we analyzed the collaborative networks from endurability and profitability points of view based on the trust relations between the collaboration partners. The goal was to provide the partners with value models supplemented by extra information regarding the endurability and profitability of the collaboration so that the business actors would be able to decide on those collaborations which are more durable and profitable.

In [31], we discussed about the financial impact of trust in special value exchanges that the collaboration is purely based on trust. In those situations, the trustor trusts the trustee to act according to the agreements and the only way for the trustor to know about the trustworthiness of the trustee is to run inspections which cost money. To find a balance between the frequency of the inspections and the profit of the collaboration for each actor, we used game theory technique and therefore proposed a new method for adjusting the profitability analysis of the e^3*value* methodology in those special situations.

4.2 Discussion

In this subsection we briefly analyze the presented trust ontology (Figure 3) with those nine trust decision input factors enumerated by Viljanen [23]. Trust in our ontology is:

- **Identity based**: Identity of actors is known to each other.
- **Action aware**: The trustor trusts the trustee with a specific action (reciprocity in value exchange).
- **Business value aware**: The financial implications of trust in terms of potential loss or benefit are the major themes in our ontology.
- **Not competence aware**: We have no specific representation of competence of an actor to perform the value transfer as promised. Nevertheless we use a competence in a higher level. We claim that one of the reasons that makes a business actor trust another business actor in a collaborative network is the somehow related to competence because if the trustee does not act trustworthy, the collaboration would fail and it will lose the opportunity to another business actor.
- **Not capability aware**: In Viljanen's paper capability is defined as a form of an access granting token. This is not relevant in our ontology.
- **Confidence aware**: We explicitly define the strength of the belief that the trustee transfers the promised value object as *confidence value*.
- **Not context aware**: Viljanen defines context as the internal or external status at a particular point of time. In this sense our ontology is not fully context aware however we emphasise that the trust relation is valid for a specific period of time regarding a particular action and in a special business collaboration setting which is modeled in the e^3*value* methodology.
- **History aware**: In our ontology *past experiences* is considered as one of the factors in trust calculation.
- **Third-party aware**: In out ontology the trustor uses the opinion of the trustee's direct partners in trust calculation.

5 Conclusion

In this paper we discussed about the trust relation between business actors in a business collaboration and we proposed a lightweight ontology with the minimal set of concepts for trust in business collaborations. Here we presented the trust ontology in conjunction with e^3value business ontology however despite their differences the three main business ontologies (REA, e^3value, and BMO) share the core concept of value exchange between two business actors and therefore the trust concept can be added to the other two ontologies analogously.

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Towards a Framework for Schema Quality in the Schema Integration Process

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Abstract. In this paper we analyze and discuss schema quality in the schema integration process. In doing so, we apply a framework for evaluating the quality of a conceptual schema (e.g. conceptual database schema). In our analysis we combine quality factors and quality metrics with the schema integration process, which is often described as having four distinct phases: pre-integration, comparison of the schemata, conforming the schemata and merging and restructuring. As its main contribution, the paper offers not only new insights on how to improve the quality of the integration process but also a suggestion that the definition of a high quality schema differs between the phases in the schema integration process.

Keywords: Schema Quality, Model Quality, Schema Design, Schema Integration, Conceptual Modeling, Database Design.

1 Introduction

Quality of schemata is very important. We will therefore discuss where quality factors and metrics can be applied in the schema integration process. However, we will mainly focus on integrating structural aspects (e.g. concepts of an enterprise and their relationships to each other). We have therefore adopted quality factors, quality metrics and integration process models from the early conceptual modeling step of database design [1][18] due to the level of abstraction. Particularly, we will describe which of the metrics for quality factors introduced for schema development in general also play an important role during the integration process.

When doing conceptual modeling of schemata for databases as well as for enterprise models, it is important that the stakeholders, e.g. business users and data analysts, first design the schemata for each group of stakeholders (schema design) and then integrate these schemata into one global schema (schema integration). This is vital because the stakeholder schemata not only illuminate differences among user views but also because a global conceptual schema might instead mask these [25]. Schema integration is a complex, time-consuming and error-prone task [24] and is described in [2] as “the activity of integrating the schemas of existing or proposed databases into a global, unified schema” (p. 323). Schema integration not only refers to the process (in [2] the authors view it as composed of four phases), but also the product, as expresed by [9]: “The term integration represents both, a process and its results” (p. 112). The integrated schema (i.e. the product or result according to [9]) should be evaluated according to several quality criterion or quality factors such as completeness, minimality/simplicity and understandability [1][2][20]. However, these quality criteria/factors are not necessary valid for all schemata in all phases in the schema integration process; instead, one criterion/factor could influence another criterion/factor in a negative way [21] or even cause semantic loss [4]. In this paper, we therefore address schema quality within each of the four phases in the integration process. To do so, we apply the framework for evaluating and improving the quality of conceptual schemata described in [20][21][22].

Our research approach can be described as design science [13][29] and our main contribution as a method. By that we mainly mean new insights on how to improve the integration process (method).

This paper is structured as follows: in section two we address related work and in section three our research approach. In section four we address the schema integration process and in section five the applied framework for schema quality and the main contribution of this paper: an analysis on schema quality in the schema integration process. Finally, the paper closes with a summary and conclusions.

2 Related Work

Though quality is a feature of a software product or software artifact, it can be distinguished between quality of the product (artifact) and quality of the process. The quality of the latter of course supports the quality of the product and hence is only introduced for this reason. For the quality of conceptual schemata, a lot of work has been written that examines the quality of the product.

In [1], the authors name a list of characteristics a schema must provide (i.e. correctness, completeness, readability, comprehensibility, consistency, minimality, expressiveness, self-explanation and normality). In [17], the authors subsume this and other research work to a framework consisting of the three dimensions: “syntax”, “semantic” and “pragmatics”. In the [17], the listed characteristics are then related to these dimensions. The syntax-dimension reflects the aspect that a schema must be legal with respect to its vocabulary and grammar (i.e. meta-model). The semantic dimension relates the used terms and notions to the domain context. The chosen notions modeled by modeling elements must be legal and relevant in the domain, and they must be relevant and legal for the purpose for which the model has been built. Finally, the pragmatic dimension introduces the audience, namely the involved stakeholders who have to read and review the schema. A pragmatic quality is achieved if the audience can understand and follow the schema.

After evaluating several quality research papers for a conceptual model, [23] concluded that there is still a need for consensus. What does quality mean? Standards are needed, which are also accepted by the industry. Though standards are necessary, they must nevertheless be adapted to certain issues of conceptual models, ie. which type of model is used (data models, behavior models), and which language is required for a certain type of model (UML diagrams, ER diagrams for data models).

In [22], the authors conducted an empirical study about improving the quality of data models. Particularly, they focused on process quality for the development of data models, which was evaluated in a large Australian bank. Starting with an initial quality model framework that consisted of the model quality factors completeness, simplicity, flexibility, integration, understandability, and implementability, they concluded that integrity and correctness must be added as important factors influencing the quality data model. In the empirical study, it was also important, that the quality was checked throughout the model development process. In particular, quality-checking was not only made at the end of a phase but before, during and after model development phases (e.g. requirements definition, logical design).

In [7], the authors present a metamodel for measured and perceived quality characteristics of a conceptual ER schema. Afterwards, it is evaluated how good measures of four quality characteristics (clarity, simplicity, expressiveness, and minimality) work in practice.

Another framework is the “Guidelines of Modeling (GoM)” [3]. Six principles of modeling are introduced in this framework, namely correctness, relevance, economic efficiency, clarity, comparability and systematic design. These principles can be seen as general strategic and objective definitions for modeling. Based on these goals, the concluded modeling process consisted of the following steps: goal definition (i.e. what is the purpose of modeling), construction of an overall navigation and structural framework (i.e. this navigation and structural framework shall prevent loss in the many models that are constructed), modeling as such, and completion and consolidation.

In the remainder of the paper, we will restrict ourselves to the framework given in [22]. Particularly, we will describe how quality factors and their metrics can be applied in the schema integration process.

3 Research Approach

The research approach adopted within this work can be characterized as design science, see [12][13][14][19]. In design science research, the result is always an artifact, or more precisely stated as “The result of design-science research in IS is, by definition, a purposeful IT artifact created to address an important organizational problem” (p. 82) [13]. Furthermore, the artifact can either be classified as a construct, a model, a method or an instantiation [13][19].

In [13], the authors proposed seven guidelines that researchers should follow to reach good design science research results.

As mentioned in the introduction, the main contribution of this paper is to offer new insights on how to improve the schema integration process, classifying our contribution as a method. This means that we fulfill the first guideline: ***Design as an Artifact***. One problem within the schema integration process is to produce a high quality schema as its end product. In our analysis on schema quality in the integration process, we contribute to new insights on what a technology-based solution, a semi-automatic schema integration application, needs to take into account while integrating several schemata into one global schema. This means that we have fulfilled the second guideline: ***Problem Relevance***. In our analysis, we evaluate our research results using "Informed argument: Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artifact's utility" (p. 86) [13]. However, we do not claim that we fully have conduct all three cycles in what [15] describe as the relevance cycle, the design cycle and the rigor cycle, since no field testing has yet been carried out. Nevertheless, informed argument has still been used for evaluation and we therefore have fulfilled the third guideline: ***Design Evaluation***. In our analysis, we also give examples and relate how the quality factors could be mapped and used in the integration process, meaning that we have fulfilled the fourth guideline: ***Research Contributions***. We have also combined results achieved in the field of quality of schema development (product quality) with research about the schema integration process in order to give a framework in which integration process step, where a quality measure can be applied. This means that we have fulfilled the fifth guideline: ***Research Rigor***. In our analysis, we have worked iteratively, searching for the best combination of quality factors and quality metrics within the schema integration process. This means that we have fulfilled the sixth guideline: ***Design as a Search Process***. Presenting our results in this paper, we have also fulfilled the seventh and last guideline: ***Communication of Research***.

4 The Schema Integration Process

Our point of departure in this section is the work reported in [2]. In the paper, the authors divide the schema integration process into four distinct phases: pre-integration, comparison of the schemata, conforming the schemata and merging and restructuring. To grasp what schema integration is all about and to have a reference point while discussing schema quality in the schema integration process, each of the included phases with their in- and output will hereafter shortly be described.

4.1 Pre-Integration

Pre-integration is the first phase in the schema integration process. Input to this phase is a set of schemata, so-called user views, that have been designed by the stakeholders. This phase is also one of the least researched phases [26]. In [2] it is pointed out that in the earlier integration methods this phase was often overlooked.

In [26], the author mentions that pre-integration has three main tasks that should be carried out: translating all schemata to the chosen modeling language (canonization), checking for differences and similarities in each schema (intra-schema) and selecting the integration strategy. In [6], the authors proposed three additional tasks that should be carried out in the pre-integration phase: schema element name adoption, schema element disambiguation and introduction of missing relationships.

The output from this phase is a set of revised schemata, the definitions of schema elements and the chosen integration strategy.

4.2 Comparison of the Schemata

Comparison of the schemata is the second phase in the schema integration process. The input to this phase is the output from the following pre-integration phase. Comparison of the schemata has received a lot of attention within the research community and has been mentioned as an important [26] and difficult [8][16] phase. In [15], the author also points out that this phase has three main tasks that should be carried out: recognition of name conflicts, recognition of structural conflicts and recognition of inter-schema properties.

In [2], the authors state that a name conflict can either be classified as a homonym or a synonym conflict. In [1] and [26], one additional conflict was added to the list of name conflicts: reverse subset relationship or cyclic generalization. This type of conflict occurs when e.g. concept A is defined in schema 1 as a specialization of concept B and in schema 2 as a generalization of B.

In [2], the authors also state that a structural conflict can either be classified as a type, a dependency, a key or a behavioral conflict.

The last task to perform in this phase is recognition of inter-schema properties. Inter-schema properties are not really conflicts but instead describe specific dependencies between concepts such as hypernym-hyponym and holonym-meronym dependencies.

The output from this phase is schema element similarities, differences and inter-schema properties. However, this is not the only output since the input to this phase is also forwarded to the next phase due to information that might facilitate the work conducted in the following two phases.

4.3 Conforming the Schemata

Conforming the schemata is the third phase in the schema integration process. The input to this phase is the output from the previous comparison of the schemata phase. This phase has also received some attention within the research community and has been mentioned as the most critical phase [16] and the key issue [27] in schema integration.

In conforming the schemata, the input schemata are adjusted to resolve the recognized similarities and differences. How these similarities and differences are resolved strongly depends on the applied modeling language and whether the schemata are designed on the implementation dependent level or not. For instance, working with schemata on an implementation-neutral level, it is important that the resolution techniques do not delete any modeling elements without being 100% certain that the element is redundant or that it is possible to deduce an element from one or several other elements [5]. The recognized inter-schema properties are studied in this phase. However, the full value is not shown in this phase but instead in the following phase.

The output of this phase is a set of revised schemata, inter-schema properties as well as the input to this phase.

4.4 Merging and Restructuring

Merging and restructuring is the fourth and last phase in the schema integration process. The input to this phase is also the output from conforming the schemata.

In this last phase, the schemata are first merged into one global intermediate schema. The intermediate schema is then restructured since new dependencies might be needed and during this task the recognized inter-schema properties are used as guidance. Additionally, truly redundant schema elements might be recognized and deleted. However, if the stakeholders are not 100% certain that the element is redundant, it should be kept in the schema, as it could result in semantic loss [4]. This task results in a new intermediate schema.

The last task to perform in this phase is to check and verify that the schema fulfills the stated quality criteria [1][2] and/or quality factors meaning, applying a framework for evaluating the schema quality (e.g. [22]). According to our point of view, the research within schema quality that has been conducted until now has focused on this part of the design process and has assumed that the integration process has already been conducted with a satisfying result.

Finally, the output from this phase should be a high quality schema that can be viewed as input for a next, more implementation-oriented phase.

5 Schema Quality in the Schema Integration Process

In this section, we first give an overview of the adopted quality framework developed and described in [20][21][22]. We then analyze how the framework could be applied and adopted in the schema integration process as described by [2]. In doing so, we list each quality factor together with the metrics for each factor as described in [20]. We then analyze, motivate and describe why a specific metric should/could be applied or not for a specific quality factor in a specific phase in the integration process. We also comment on each quality factor as such and how it fits into in the integration process.

5.1 A Schema Quality Framework

The framework for schema evaluation was first proposed in [21] and later revised in [20]. The framework was developed for the ER modeling language and a comprehensive description of the development and evaluation of the framework is described in [22]. The final version of the framework as described in [22] is comprised of six entities: Quality Factor, Stakeholder, Quality Metric, Improvement Strategy, Quality Issue and Quality Review. However, in this paper we will mainly focus on the first three. The authors of [22] also state that Business User, Data Analyst, Data Administrator and Application Developer are the main stakeholders of the schema currently being evaluated. They also conclude that quality factors that improve schema quality are: Completeness, Integrity, Flexibility, and Understandability for Business Users; Correctness, and Simplicity for Data Analysts; Integration for Data Administrators; and: Implementability for Application Developers.

Each stakeholder should be involved in both the schema design and schema integration process. However, it should be noted that Business Users and Data Analysts focus on the earlier parts in schema design and schema integration, while data administrators and application developers focus on the later parts. In this paper we mainly focus on the earlier phase of conceptual modeling meaning, the implementation independent level with schemata that are implementation neutral. It is our opinion that the chosen framework is a good point of departure when researching schema quality of implementation neutral schemata within the schema integration process.

5.2 Schema Quality in the Schema Integration Process

The first and most important quality factor is ***completeness*** [20]. A schema is complete if it contains all user requirements (and nothing but the user requirements). Completeness is measured on the basis of four metrics: number of schema elements that are not part of the user requirements (M1), number of user requirements that are missing in the schema (M2), number of inaccurately defined modeling elements (M3) and number of mismatches with the dynamic/behavioral schema (M4) (see Table 1).

Table 1. Quality Factor 1 *Completeness* and the Integration Process

Metric	Pre-Integration	Comparison of the Schemata	Conforming the Schemata	Merging and Restructuring
M1	YES	NO	NO	YES
M2	YES	YES	YES	YES
M3	YES	YES	YES	YES
M4	YES/NO	NO	NO	YES

Before moving on to each quality factor a comment on the last phase is needed. All listed metrics for merging and restructuring are marked with YES. This should be interpreted as a traditional validation of the global integrated schema. In the examples in the following discussion, we therefore exclude this phase since, according to the framework, the schema under development should be evaluated based on all quality metrics.

In schema integration, it is important that each stakeholder schema fulfills the completeness quality factor within each phase. However, not all metrics are applicable in each phase and it should be noted that since we are working with intermediate schemata in the integration phase, the definition of completeness could vary depending on which phase is in focus. For instance, in pre-integration it is important that each stakeholder schema includes all requirements and nothing but the specified requirements (M1 & M2) and that intra-schema conflicts are resolved (M3). In comparison of the schemata, it is important that all similarities and differences between two schemata are recognized (M3) and resolved in conforming the schemata. If a dynamic/behavioral schema has already been developed, it can for instance in pre-integration be checked for any inconsistencies between the two schema types. However, as pointed out in [6], integration of the structural schemata should take place before integration of the behavioral schemata, making this metric unusable. The schema integration process is very complex as such and the dynamic/behavioral schema should therefore not be used in the second and third phase of the integration process to reduce the complexity.

The second quality factor is ***integrity*** and refers to if and how business rules and/or integrity constraints are represented in a correct way in the schema. Integrity is measured on the basis of two metrics: number of business rules that are not represented in the schema (M5) and number of inaccurately defined integrity constraints (M6) (see Table 2).

Table 2. Quality Factor 2 *Integrity* and the Integration Process

Metric	Pre-Integration	Comparison of the Schemata	Conforming the Schemata	Merging and Restructuring
M5	YES	YES	YES	YES
M6	YES	YES	YES	YES

In schema integration, the integrity quality factor can for instance be compared with recognition of dependency conflicts (M6). One problem that M5 might highlight is whether it is possible to specify all business rules using the chosen modeling language. For some business rules, modeling the structural part is not enough. One example of this is given in the update problem having the concepts of Product, Product.Quantity, OrderLine and OrderLine.Quantity. Suppose that we need to reduce the ordered amount for a specific product: we then need to decrease the specific OrderLine.Quantity for the ordered Product and at the same time increase the Product.Quantity value since we have more items to sell. However, there is no natural connection between Product.Quantity and OrderLine.Quantity. We therefore need to specify this in natural language text or describe the scenario using a modeling language suitable for the dynamic/behavioral part. A longer discussion and a proposed solution for the described problem are addressed in [5].

The third quality factor is ***flexibility*** and refers to how the schema could cope with future business changes. Flexibility is measured on the basis of three metrics: number of schema elements that might change (M7), estimated cost of changes (M8) and strategic importance of changes (M9). This quality factor is out of the scope of what we define as schema integration. We therefore leave flexibility for now and view it as a quality factor to include and use in relation to or after the last phase in the integration process.

The fourth quality factor is ***understandability*** and refers to how easy the schemata can be understood by the stakeholders. Understandability is measured on the basis of three metrics: how the users rate the understandability of the schema (M10), if the schema is actually understood by the users (M11) and how the application developers rate the understandability of the schema (M12) (see Table 3).

In schema integration, the stakeholders are an important source of domain knowledge and should therefore be involved during the whole integration process. Involving the stakeholders is important not only in manual integration but also in semi-automatic integration [6].

Table 3. Quality Factor 4 *Understandability* and the Integration Process

Metric	Pre-Integration	Comparison of the Schemata	Conforming the Schemata	Merging and Restructuring
M10	YES	YES	YES	YES
M11	YES	YES	YES	YES
M12	NO	NO	NO	YES

Understandability is therefore also an important quality factor and metrics M10-M11 are therefore applicable in all phases. It should be noted however that a user might *believe* that s/he understands the global integrated schema and therefore rate it high (M10). For this reason, it is important to combine metrics M10 and M11 since M11 addresses whether a schema is actually understood and not just if the schema is understandable.

The fifth quality factor is ***correctness*** and refers to whether the schema follows the rules of the chosen modeling language. Correctness is measured on the basis of three metrics: number of errors in relation to the rules of the chosen modeling language, (M13), number of errors in relation to the 1st, the 2nd, the 3rd and 4th+ normal form (M14) and the number of redundant schema elements between concepts (M15) (see Table 4).

Table 4. Quality Factor 5 *Correctness* and the Integration Process

Metric	Pre-Integration	Comparison of the Schemata	Conforming the Schemata	Merging and Restructuring
M13	YES	YES	YES	YES
M14	NO	NO	NO	YES
M15	NO	NO	NO	YES

The rules of the chosen modeling language should of course be applied (M13) since they dictate how the schemata should be constructed. However, our point of departure is that there exist schemata on different levels of abstraction implementation-independent and implementation-dependent and in this paper our focus is on implementation-independent. Therefore we do not deal with normalization, which is a task to perform in logical database design. Metric 14 is therefore not applicable in the integration process. The third metric (M15) for correctness is also marked with NO since the schemata is designed on an implementation-dependent level, where redundant concepts such as synonyms should be kept as long as possible in the integration process.

The sixth quality factor is ***simplicity*** and refers to the number of modeling elements in the schema. This quality factor is measured on the basis of three metrics: the number of concepts (M16), the number of concepts and connections (M17) and the number of schema elements (M18) (see Table 5).

Often it is possible to model the same phenomenon using different modeling patterns within one and the same modeling language (e.g. [5]) and according to the rules in the framework, the pattern and schema using the fewest modeling elements should be used. Metric 18 is marked with both a YES and a NO indicating that this specific metric is only applicable for schemata modeled using a modeling language that distinguishes between entities/classes and attributes and not for modeling languages that only focus on concepts and connections between concepts (e.g. ORM [10]).

Table 5. Quality Factor 6 *Simplicity* and the Integration Process

Metric	Pre-Integration	Comparison of the Schemata	Conforming the Schemata	Merging and Restructuring
M16	YES	YES	YES	YES
M17	YES	YES	YES	YES
M18	YES/NO	YES/NO	YES/NO	YES

The seventh quality factor is ***integration*** and refers to how consistent the schema is in relation to other data used within the organization. This quality factor is measured on the basis of four metrics: number of conflicts in relation to the 'master' organizational schema (M19), number of conflicts in relation to already implemented information systems (M20), number of data elements that are already stored in implemented information systems and projects (M21), and ratings from adjacent business areas whether the definitions of schema elements fit into the organization and not just the application being developed (M22) (see Table 6).

Table 6. Quality Factor 7 *Integration* and the Integration Process

Metric	Pre-Integration	Comparison of the Schemata	Conforming the Schemata	Merging and Restructuring
M19	YES	YES	YES	YES
M20	YES/NO	YES/NO	YES/NO	YES
M21	YES/NO	YES/NO	YES/NO	YES
M22	YES	YES	YES	YES

Different knowledge sources such as domain ontology, taxonomy and dictionary are often used to facilitate the schema integration process (e.g. [6]). The usage of such a knowledge source has similarities with the usage of the "master" organization schema and is therefore applicable in the schema integration process (M19).

In [2], the authors distinguish between schema (view) integration and database integration. The former relates to conceptual database design and the latter to design of a distributed database. Database integration results in a global schema in which all local database schemata are incorporated into "a virtual view of all databases taken together in a distributed database environment" (p. 324) [2]. Therefore M20 and M21 mostly refer to database integration, but if taking data already implemented in other information systems into account, these metrics are also applicable in the schema integration process (see YES/NO for phase 1-3).

Finally, viewing the database as being part of the organization and not as a standalone database encourages the rating from adjacent business areas (M22).

The eighth and last quality factor is ***implementability*** and refers to whether the schema can be translated during logical database design and implemented during the physical database design within the stated limitations. Implementability is measured on the basis of three metrics: rating risks in relation to the chosen technology (M23), rating risks in relation to the given schedule (M24) and estimation of development costs (M25). Because this quality factor is viewed as out of the scope of what we define as schema integration, we leave implementability for now and view it as a quality factor to include and use in relation to or after the last phase in the integration process.

6 Summary and Conclusions

In this paper we have addressed schema quality in the schema integration process. In doing so, we have combined the framework for schema quality developed and described in [20][21][22] with the schema integration process as described in [2]. In doing so we mainly focused on what is often referred to as the implementation independent level producing implementation neutral schemata. Focusing on the implementation independent level indicates that we have studied the problem of schema quality and process quality within the schema integration process from a new perspective, adding contributions to the research field of schema integration. As its main contribution, the paper not only offers new insights on how to improve the quality of the integration process but also suggests that the definition of what a high quality schema is differs between the four phases in the schema integration process.

As a next step, we plan to describe concrete tasks that should be performed to improve the schema quality within the several steps of schema integration.

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Reviving Language/Action Perspective in the Era of Social Software: Research in Progress

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Abstract. Language/Action perspective (LAP) was introduced by Flores and Winograd and their associates in the 1980th. This perspective, which is based on the speech act theory, has been originally suggested as guidelines for designing information systems. Though LAP had some success in designing commercial systems, it had never become widespread as a basis for systems design. This paper suggests reviving LAP, however, not as a tool for system design, but as a tool for analysis of communication models of systems designed on some other principles than LAP. The paper is focused on modern systems of social software type in which communication is based on the usage of shared spaces. The paper is a research in progress report that presents the main ideas, a research plan, and preliminary results achieved in its first two steps: (1) testing LAP for analysis of one system with shared spaces architecture, and (2) classification of atomic communication acts typical for business processes. The long term goal of the research is to create practical recommendations for choosing an appropriate communication model for particular business needs.

Keywords: Language/Action, LAP, speech act, business process, social software, groupware, communication, shared space

1 Introduction

The Internet boom brought into being a new generation of systems, usually called Social Software, that are aimed at facilitating communication between humans. Such systems, though built in more or less ad-hoc manner, widely use (explicitly or implicitly) the concept of shared spaces, which is well known in CSCW and groupware research, see, e.g. [1]. The ideas built in the social software started to affect the design of business-oriented systems, including Business Process Support (BPS) systems [2]. As a result, the use of shared spaces for communication and information exchange becomes a kind of a standard for contemporary information systems development. This trend requires research efforts to understand and evaluate different communication models that employ shared spaces. In the end, this kind of research should lead to creating practical recommendations for choosing an appropriate model for particular business needs.

Research discussed in this paper is aimed at analyzing communication models that can be implemented in business information systems that employ shared spaces. The practical result we are aiming at is a methodology for evaluating communication models provided by such systems. This methodology would help in finding gaps in communication functionality of a particular system and give directions on how they could be bridged. We limit our investigation in two aspects. Firstly, we focus on evaluating systems aimed at supporting business processes – BPS systems. Secondly, we limit our investigation to communication between people through the system, leaving all issues of man-machine interaction outside the scope of our research. The latter issues include, for example, user-interface design, usability, actability.

As a theoretical foundation for our work, we have chosen Language/Action perspective (LAP). LAP was introduced by the works of Flores and Winograd and their associates in the 1980^{th} [3,4]. This perspective, which is based on the speech act theory [5], has been originally suggested as guidelines for designing communication parts of business information systems [4]. Though this perspective had some success in designing commercial systems, it never became widespread as a basis for systems design beyond the organization that introduced it (i.e., Action Technologies). This perspective has been also suggested for business modeling (see, for example, [6]), and evaluation of information systems (see, for example, [7]).

Having a practical aim, our research falls into the category of Design Science (DS) [8,9]. The goal of DS research is finding and testing a generic solution (in terms of [9]), or artifact (in terms of [8]) for a class of practical problems. In this respect, our research differs from the main (and extensive) body of LAP literature. We are not trying to enhance LAP as a theory, but test whether it could be useful in practice in a specific area, namely, evaluation of communication models of information systems independently of whether they are built based on LAP, in an ad-hoc manner, or on a theoretical foundation different from LAP.

Though our primary aim is not connected to making a contribution to LAP theory, our research could be advantageous for the LAP movement. As it is justly concluded in [10], LAP being quite popular in academic circles, have not made its breakthrough in practice. [10] makes the following four suggestions for improving practical relevance of LAP:

"(1) observe real challenges in practice where LAP related ideas can be effectively applied so that they can show significant economic benefits, (2) build a focus on a few and prominent areas in which LAP related solutions can be developed that demonstrate user value, (3) strive towards areas where ideas can be softwired into platforms that enable continued learning and codification of knowledge. A good example would be e-commerce platforms that are reflective and capable of reasoning around ongoing transactions, (4) build alliances with critical members of the knowledge transformation networks including platform providers, solution integrators and different communities of practice."

We believe that our research, if successful, could contribute to a progress in the areas (1) and (2) above.

This paper presents research in progress, not results of completed research. Therefore, some parts important for a completed research, e.g., a section on related research are missing here. Our current plan to conduct this research is as follows:

1. Quickly investigate whether LAP could be useful in our undertaking. We use the case study approach for this end. More exactly, we investigate a working system that facilitates human communication via shared spaces as a platform to try LAP as a tool for evaluating the expressive power of communication models. To start with, we go through Searle's illocutionary points [5] to see whether all of them can be expressed in the communication model built into the system.
2. Identify and classify typical atomic communication acts completed in the frame of business process cases/instances, like reporting, or task assignment.
3. Identify patterns of combining atomic communication acts into "messages" that circulate between participants of a process instance. For example, task assignment might need to be combined with a status report so that a person who is supposed to execute the task could get all information he/she needs to complete the task.
4. Identify patterns of conversation consisting of several messages passed between process participants.
5. Test the presence of identified atomic acts, messages and conversations in practice of using contemporary systems that support business processes.
6. Combine 2, 3, 4 based on experience from 5 into a practical methodology of evaluation of communication capabilities of BPS Systems.

This paper reports our progress on the first two steps of the above plan. We consider the first step as fully completed, and the second step as almost completed.

The rest of the paper has the following structure. Section 2 presents our investigation of applicability of LAP for the chosen purpose. Section 3 presents preliminary classification of atomic communication acts in the frame of business process instances. In Section 4, we discuss the results achieved so far, and short terms plans for advancing the research farther.

2 Testing LAP for Analysis of Communication Models

The system we use in our initial test of LAP is a BPS system with shared spaces and collaborative planning (planning for each other) called ProBis. It was developed based on the state-oriented view on business processes [11] for a Swedish interest organization in 2003-2006, as described in [12,13]. Though the system is becoming outdated, it is still in use in this organization.

The reason we have chosen to investigate this particular system is purely practical. The authors have participated in the development and introduction of ProBis into organizational practice, and have been using it themselves for some period of time. Having intrinsic knowledge of the system speeded up completion of the first step of our plan.

2.1 ProBis Description

ProBis has no explicit data/information flow; all information exchange and communication is realized through shared spaces. A shared space in ProBis is presented to the end-user as a window separated in several areas by using the tab dialogues technique, see Fig. 1. Some areas of the window are standard, i.e. independent from the type of the business processes, others are specific for each process type supported by the system. Standard areas comprise such attributes and links as:

1. Name and informal description of a process instance
2. Links to the owner, and, possibly, the process team
3. Links to the relevant documents, created inside the organization, and received from the outside

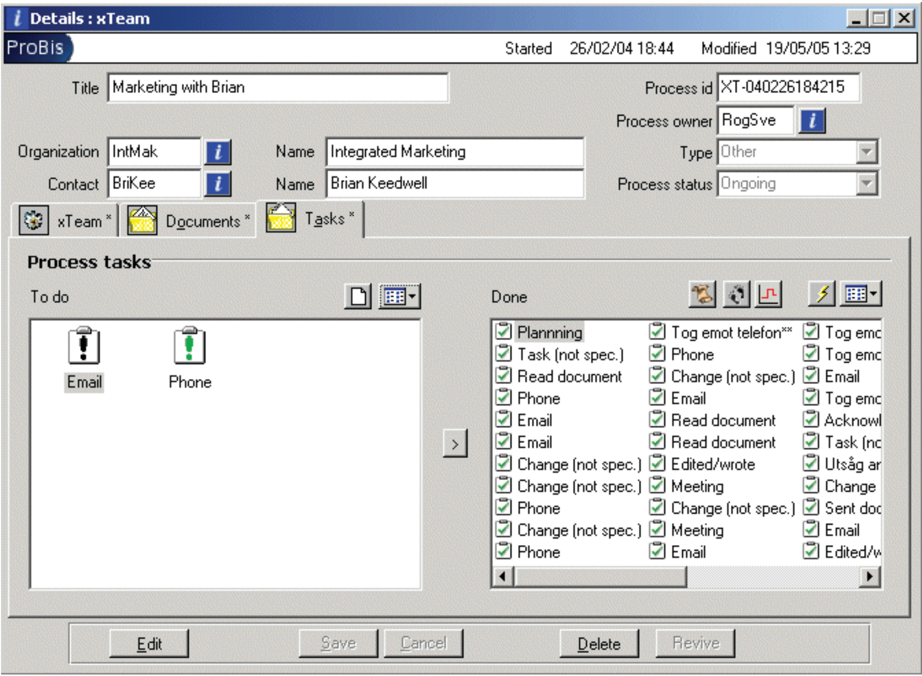

Fig. 1. Task area in the ProBis shared space

The standard part of a ProBis shared space includes also the task area (tab) that contains of two lists, as in Fig. 1. The *to-do* list (to the left on Fig. 1) includes tasks planned for the given process instance; the *done* list (to the right on Fig.1) includes tasks completed in the frame of it. A planned task defines what and when something should be done in the frame of the process instance, as well as who should do it. In ProBis, the process plan serves as a mechanism for issuing "invitations" to attend a particular shared space. All invitations from all process instances are shown in the end-user's personal calendar. From the calendar, the user can go to any shared space to which he was invited in order to inspect, change this space, or execute a task planned for him/her in it.

Process participants work with the shared spaces in ProBis in the following manner. A participant visits a shared space because a task has been planned for him/her in this space, or in the ad-hoc manner while browsing through the list of existing shared spaces (i.e., opened process instances/cases). When in the space, he/she can decide to make changes in it by changing the values of various fields, attaching new documents or persons to the shared space, etc. Any change in the shared space results in adding an event to the *done* list of the tasks tab (see Fig. 1). If the change is due to the execution of some planned task, the event represents a report on its completion, otherwise the event represents some ad-hoc activity.

When changing a shared space, a participant can make changes in its plan (to-do list) by adding new tasks, or augmenting or deleting the existing ones. When inserting a new task he/she can plan it for him-/herself or to any other person. The latter serves as an invitation for this person to visit this shared space.

As follows from the description above, the only way of communicating via ProBis is by assigning a task to the communication partner. This is done by filling a form as on Fig. 2. One chooses the task from the list, assigns it to another user of the system, and adds a textual description and some parameters, for example, by attaching a document that is already registered in the process. The task list is configurable and can be adjusted for each installation and process type.

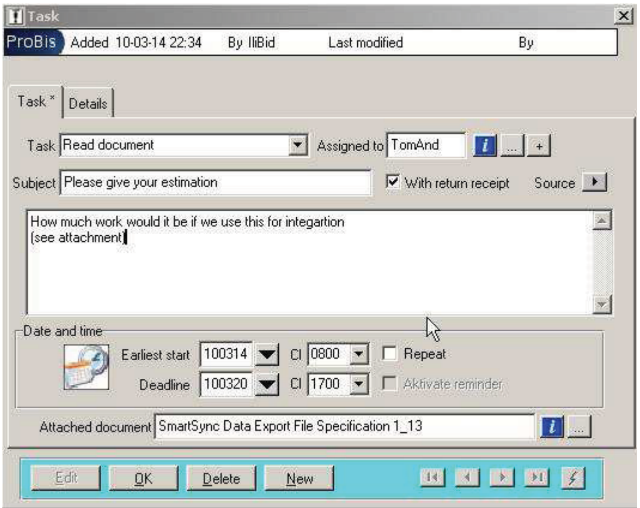

Fig. 2. Assigning a task to another user in ProBis

To document the completion of a task assigned to a particular user, the latter moves this task from the *to-do* list to the done list via drag and drop, or via pressing a button placed between the lists (see Fig. 1). A report form, shown in Fig. 3, appears. This form is automatically filled with parameters and the task description from the original task assignment. The user just needs to add a textual report on completion of the task, and possibly make changes in other parts of the shared space.

The scheme as described above seems to be a one-way communication. This is not true, however. Consider a situation where the user who has just completed a task wants to notify the user who planned it. Information about who planned the task is shown in the original task form (see Fig. 2.). Notification can be manually issued by planning a special *Attention* task to the "planner" as the last act of completing the assignment. The planner gets this *Attention* task in his/her calendar and can view it in a window similar to Fig. 2.

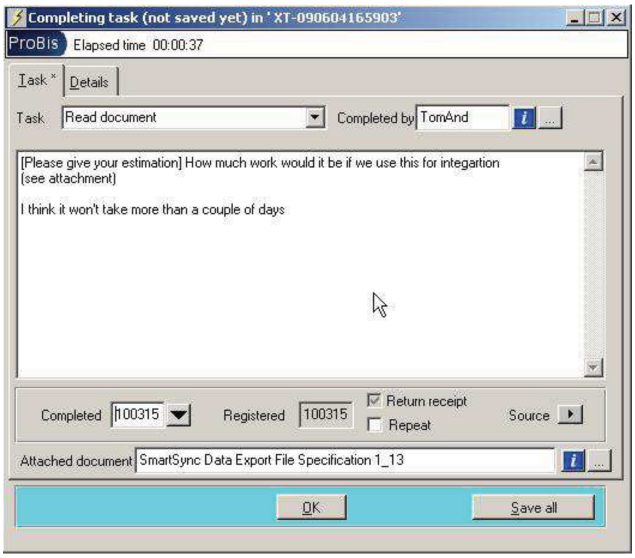

Fig. 3. Completing a task in ProBis

To provide the user with information about the context of planning, there is a special button *Source* in the window in Fig. 2. Pressing the button leads to the item of the *done* list that describes the event in which the planned task appeared in the *to-do* list. This item is presented in a window similar to Fig.3. The typical example of use for this button is when a user who has planned some task gets an *Attention* about its completion. Then, he/she can go directly to the completion report by pressing *Source*. There is no need to explain what *Attention* refers to when planning it, as the recipient of the *Attention* can go directly to the event that has caused this *Attention* to appear. In this way, many events in the done list can be causally chained to represent various "conversations" in the frame of the process case/instance.

The idea to introduce the *Source* button came from the following observation. From the time a person has got an *Attention* to the time he/she actually checks it many new event items can appear in the *done* list. The button gives a possibility to directly fetch the one that is relevant for the given *Attention*.

To simplify the attention scheme, a special check box is introduced in the task window (see Fig. 2) called *With return receipt*. When checked, a special attention-like task called *Receipt* is automatically planned as soon as the task is completed. This task is assigned to the user who originally planned the completed task.

To further facilitate communication, several more advanced features were added to ProBis. For example, there is a possibility to plan the same task to many users. Additional users can be added from the list with the "+" button (see Fig. 2), or can be fetched from a predefined group. Each user gets its own task in the calendar and will need to go and complete it independently from other users. Multi-user planning gives a possibility to easily raise attention of several people to some event that has happened in the frame of a particular process case/instance. Other advance features include automated planning (see [10]).

2.2 LAP Analysis of the Communication Model Built into ProBis

We use the notion of illocutionary points introduced by Searle [5] - objectives one can achieve with simple speech acts - to make rough analysis of communication capabilities built-in in ProBis. Below, we list Searl's illocutionary points and investigate how they can be expressed in ProBis:

- Assertive: Commit the speaker to something being the case - to the truth of the expressed proposition.
- Directive: Attempt to get the hearer to do something. These include both questions (which can direct the hearer to make an assertive speech act in response) and commands.
- Commissive: Commit the speaker to some future course of action.
- Declaration: Bring about the correspondence between the propositional content of the speech act and reality (e.g., pronouncing a couple married).
- Expressive: Express a psychological state about a state of affairs (e.g., apologizing and praising).

In ProBis, an *assertive* act takes place each time a user changes the shared space that is accessible for other users, for example, when he/she reports about a phone conversation with a customer in the frame of a business process case/instance by filling the form in Fig. 3. In addition to making changes, the user can raise attention of one of several of his/her colleagues to these changes by planning an *Attention* task to them. In the latter case, the *Source* button of *Attention* will lead directly to the report.

In ProBis, a *directive* act takes place each time a user plans some actual task for some other user. For questioning, there is a special task *Question* that works in the following way. When the user who gets a question moves this task from the *to-do* list to *done* list a form as on Fig. 3 appears. However, in this form the task name is changed from *Question* to *Answer*. The user writes his/her answer directly under the question and commits his changes by pressing *Save* button. An automatically planned task *Read answer* is then planned for the first user, who has planned the original *Question*. The latter can easily rich the answer by pressing the *Source* button on the *Read answer* task form.

Any actual task, like *Write a document, Attend a meeting, Phone call*, planned to a subordinate by his/her manager represent as kind of an order. If planned by a colleague, the interpretation of the act can dependent on the task in question, which we are not discussing here due to the lack of space.

In ProBis, a *commissive* act takes place each time a user plans some task for him-/herself in a shared space of a particular business process instance. When colleagues that participate in the same process see that something is already planned, they assume that the task is being taking care of, and would not do it themselves

In ProBis, the possibility to express certain *declarative* acts is incorporated in the structure of shared spaces. For example, a shared space can include a list of users that participate in a given process case/instance alongside with their roles. Adding a new user to this list constitutes a declaration that creates a new "reality" in which the user becomes part of the process team. To inform the user about the change of reality that concerns him/her particularly, ProBis automatically plans a new *Attention* task for this user (that he/she became a member of the process team).

As far as *expressive* acts are concerned, there is no special provision in ProBis for these acts. However, such provision can be made, by allowing to register expressive events like *opinion, apology*, etc, in the *done* list of Fig. 1.

2.3 Discussion

Based on the analysis in the previous section, we can make the following two interconnected conclusions:

- Even in its very general form - Searl's illocutionary points - LAP can be used for evaluation of communication capabilities of systems built on the principles different from LAP
- The communication model built into ProBis has enough expressive power to handle all five types of communication acts identified in the speech act theory

We consider these results as promising enough to continue our research according to the plan in section 1.

3 Classification of Atomic Communication Acts

In this section, we present our preliminary classification of atomic communication acts typical in the frame of process instances, which is the goal of the second step of the research plan drawn in Section 1. This classification has been built based on our own practical experience of process analysis, building business process support systems, and introducing them into organizational practice. At the next stage, this classification will be checked against other research works to obtain independent confirmation of its validity. During this check, this classification could be extended and modified.

Based on our experience, we identify the following areas of usage of communication in the frame of business process cases/instances:

- Reporting – knowledge transfer about the process instance state (assertive acts in the speech acts classification)
- Reflecting – exchanging opinions on the current state, and suggestions on how to proceed (expressive acts in the speech acts classification)
- Managing roles – assigning roles to participants of business process instances (declarative acts in the speech acts classification)

- Managing tasks – assigning tasks to participants of the business process instances, including self-assignment (a mixture of directive/commissive and declarative acts in the speech acts classification)
- Negotiating – requesting an authorization before assigning a role or a task for somebody or oneself, or asking for a change in already assigned roles and tasks. Negotiating also include agreeing to, or declining the requests. (A mixture of directive and commissive acts in the speech acts classification)

In each of these areas we identify a number of atomic communication acts that are described in more details in the subsections below.

3.1 Reporting

Report is a communication act that informs the recipient(s) about the development in the given business process instance. This act can be committed in various situations. For example, it can be committed as a reaction on the request for information from another process participant. It can also be committed after completing a task in the frame of the given process instance, or in connection to a task assignment act in order to provide a person who is to complete the task with the background information.

A report act, usually, has some dedicated recipients who need the information for their work, and the audience who might just be interested in this information (e.g., CC in case email is used as a media for communication). Reporting is always an assertive act in the speech acts classification.

We differentiate the following atomic reporting acts:

- Status report – report on what has being achieved in the process instance so far, how long are we from the goal set for the instance, what is planned for advancing the towards the goal, etc. Such reports could be prepared on the request from the management, or issued periodically to all process participants, or even to the external observers. A status report does not need to cover all details of the given process instance development, for example, it may contain information about a particular planned task.
- Task completion – report on the planned task completed in the frame of the process instance, for example goods sent to the customer (which ones and how much)
- Event report – report on the unplanned event, e.g. a customer calling back and complaining on the quality of goods received
- History report – report on the development in the process instance over some period of time, e.g. to update a participant on what has happened in the period of his/her absence

Besides the act of providing a report, this group includes *inquiry* – an act of requesting a report. *Inquiry* is a directive act in the speech acts classification. It presumes a response from the recipient(s) of the inquiry in the form of a report act.

3.2 Reflecting

Reflecting means expressing personal opinion on the situation, possibly, including suggestions on how to proceed with the given process instance. From the speech act point of view, a reflection represents an *expressive* act.

3.3 Managing Roles

Role assignment is a communicative act that gives the recipient some permanent role in the given process instance, or relives him/her from an already assigned role. A role can be assigned to somebody else, or to oneself. To assign a role (or relieve somebody from a role), one have to have a right to do so. Such right can be derived from the person's position in the organization and/or the already acquired role in the given process instance. Alternatively, one needs to negotiate an agreement of such assignment/relieve. An agreement may be needed from the person to whom the role is being (or has been) assigned (if it is not self-assignment) or/and from other process participants who might object or agree to the changes in the distribution of roles.

Role assignment is a declarative act according to the speech acts classification as it directly changes the state of the business process instance.

3.4 Managing Tasks

Task assignment can be of two sorts, an assignment to somebody else, and self-assignment. Task assignment to somebody else is a communication act of asking the recipient(s) to complete a task in the frame of a business process instance. To assign a task, a communicator needs to have a right to make an assignment. Such rights can be of three origins:

- The communicator has some management position over the recipient, in general or in the frame of the particular process instance, that gives him/her a right to "order" certain task execution, provided that the recipient has obligation to follow the orders according to his contract with the organization
- The communicator holds no management position over the recipient, but the task being assigned falls into the sphere of responsibility of the recipient according to his/her position within the organization, or his/her role in the particular process instance
- The communicator holds no management position over the recipient, but he/she has previously negotiated an agreement from the recipient, or/and from his/her manager

Task assignment to somebody else is a mixture of directive and declarative communication acts in the speech act classification. When it is an assignment of a relatively unimportant task to be completed more or less directly, the act is purely directive. No audience needs to be engaged in such communication act. However, if it is an assignment of an important task to be completed at some time in the future, the act besides being directive has also declarative nature. It changes the reality relevant to the given business process instance – a new element is introduced in the process plan. Such an act, normally have an audience (like a CC if email is used for communication), i.e. participants who need to know that the task has been planned, for example, for avoiding double assignments.

Task assignment to oneself also requires some rights from the communicator, which can be of three origins:

- The communicator has a right to assign him/herself this type of tasks according to his/her position in the organization or/and role in the given process instance
- The communicator has an obligation to assign himself a task of this kind when a situation warrants it (again, according to his/her position in the organization or/and role in the given process instance)
- The communicator has previously negotiated permission for self-assignment from some other process participant(s), e.g. management.

Task assignment to oneself is a mixture of commissive and declarative communication acts in the speech acts classification. It is a commissive act as it constitutes a promise to do something, and it is a declarative act because it adds a new item to the process instance plan.

Beside assignments, this group includes task retraction, task change and reassignment. Negotiation may be required before such acts can be performed.

3.5 Negotiating

This group includes a request for engagement, and response to it:

- *Request for engagement* is a question posed to the recipient inquiring whether he/she can think of committing him/herself to take a role or a task assignment (alternatively be relieved of a role or task assignment). A request can also be about permission to assign a role or a task to oneself (or relieve oneself from a role/task assignment). *Request for engagement* is a directive act in the speech acts classification. It presumes some action, e.g., a response from the recipient(s) of the request.
- *Response* is an act of *accepting*, *conditionally accepting,* or *declining* a proposal that comes in a request. This is a commissive act in the speech acts classification.

4 Conclusion and Plans for the Nearest Future

As follows from Section 1, the goal of our research in progress is development of a methodology for evaluating communication capabilities provided by modern information systems. As we pointed out in Section 2.3, our preliminary test of applicability of LAP for reaching the goal was quite positive. Therefore, we consider that it is worthwhile to continue our research according to the seven points plan drawn in Section 1.

Having drafted a preliminary classification of atomic communication acts typical in the frame of business process instances (step 2 of the plan), we intend to proceed to steps 3 and 4 of our plan. A single communication in the frame of a process instance can consist of several atomic communication acts, for example a report on a completed task, and a request to complete the next task. Step 3 of our research plan concerns identifying typical patterns of combining atomic acts into "messages" that are passed between process participants. A sequence of messages between the same participants can constitute a conversation (thread) inside a process instance. A typical example of a thread consists of a request to complete a task which is followed by a confirmation that it will be completed, and then by a report that it has been completed. Identifying patterns of conversations constitute step 4 of our research plan.

In addition to working on steps 3 and 4, we plan a literary study to get confirmation to our findings, which so far are based exclusively on our experience. We also expect to get ideas of what is lacking in and needs to be added to our model of communication in the frame of business processes.

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Deconstructing abilities
– in search for an ability viewpoint

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Abstract. (Cap-) ability based planning is an emerging discipline within the enterprise architecture domain. With strong influences from military frameworks and competence based management, a focus on abilities offers a complement to traditional enterprise modeling approaches and a possibility to represent organizational knowledge from a result based perspective. Unfortunately, contemporary frameworks and practices provide varying and overlapping definitions and applications of the concept of ability thus creating problems for practitioners with experiences from strategic planning, architecture and enterprise modeling disciplines.
This paper presents a research effort and research in progress aiming at designing and developing an artifact, that enables description of and reasoning about an organizations or systems abilities. The developed artifact, an ability framework, includes a conceptual model. In subsequent work we plan to add a viewpoint, and method components. The artifact is designed to complement and integrate with existing and established concepts and offers a unique analytical tool for theoretical (comparative) analysis of ability based approaches that span across multiple fields of application and knowledge.

Keywords: Ability, Capability, Competence, Capability Based Planning, Competence Based Management, Enterprise Architecture, Resource based theory, Services, Business-IT Alignment, Enterprise Systems and Architectures.

1 Introduction

Trying to make sense, understand the inner workings of an enterprise, agency and organization is part of most people's daily activities. Many kinds of techniques, principles are used, such as mapping out how work is performed (process modeling) and which ends to strive towards (ends, goal modeling). An (cap-)ability description represents a particular kind of organizational knowledge reflecting an organizations' power, skill, means, or opportunity to achieving a result.

Techniques and practices with an element of ability appears in multiple domains, such as: military capability based planning (UPDM [5]) and enterprise architecture frameworks (TOGAF [6]), competence based management [16], service oriented architecture frameworks (SOA [13]) and as part of natural language since 1400 [20].

The cross domain usage has lead to a great number of conceptions of ability - "The term 'capabilities' floats in the literature like an iceberg in a foggy Arctic sea, one iceberg among many, not easily recognized as different from several icebergs near by." as formulated Dosi, Nelson, Winter in their book: "The Nature and Dynamics of Organizational Capabilities" [2]. These variations on a theme are supported by the authors experiences from participation in global, EU and national (standard setting) projects as expert and certified enterprise architect.

Within the military domain we find the following definition(s): "MODAF: A high level specification of the enterprise's ability. DoDAF: The ability to achieve a desired effect under specified [performance] standards and conditions through combinations of ways and means [activities and resources] to perform a set of activities" - UPDM v2.0 [5].

An author, Ron Sanchez [16], researching Competence based management offers a Capability definition: "repeatable patterns of action that are created through a firms management processes for coordinating its resource in processes for value creation.". Competence is another ability concept; "competence(s) – the ability to sustain coordinated deployments of resources and capabilities in ways that help a firm achieve its goals in its competitive context.".

A detailed comparison of the definitions and the work by authors in the domains, reveal both similarities and differences. The differences become greater when including relevant adjacent concepts such as process and goal.

This paper introduces research in progress with an overall aim at designing and developing an artifact – ability based framework that can be used for ability based descriptions, enterprise modelling, analysis, and indirectly for planning and management practices. We present early findings from a literature study exploring the conceptual foundation of the phenomenon ability.

The main contributions of the research are identified desiderata and requirements needed to be satisfied by an ability framework that complements and integrates well with existing work perspectives, enterprise modeling approaches, practices, methods and frameworks. Secondly an ability framework including method elements and a conceptual model that offers an analytical tool for theoretical (comparative) analysis of ability based approaches that span across multiple fields of application and knowledge.

In section 2 we introduce the research area with key research problems, questions and research approach. In section 3 we present artifact considerations and requirements. Section 4 introduces the first hypothesis of an ability framework artifact and in section 5 we discuss usage aspects followed by a summary in section 6.

2 Research Problems, Questions and Design

The research process and problem identification started with the authors experiences from participation in large-scale international standardization projects as an international expert. For the purpose of this paper we present an outline of key identified problems.

- Approaches, frameworks, theories including ability, use definitions of central concepts that are similar but not equal. Different conceptions reduce common understanding across work perspectives with consequences that learning and comparisons between approaches becomes more difficult.
- The separation of concerns between ability and related concepts (e.g. process, goal, service) are not well defined and also used inconsistently.
- Ability based descriptions are used in different contexts, satisfying many, varying and sometimes conflicting contextual requirements.
- Military applications of and requirements on capability based planning differ from market driven enterprises operating on (selected) and dynamic markets, producing products based on supply and demand.
- Frameworks and theories that incorporate the concept of ability are constructed based on specific, sometimes implicit, target audiences. This creates problems when using or merging together multiple approaches in an actual organization since approaches may not be complementary.
- Abilities can be located throughout an organization or system, which introduce tensions between the boundary of an ability and organizational design considerations (e.g. responsibilities, procurement, allocation of resources).

The research is scoped to focus on ability based views of organizations that, either incorporate or can be extended to support, organizational work perspectives that span across business and IT-departments and their concerns, i.e. a business and it-alignment (BITA) focus. Based on the identified problems (and opportunities) we have formulated the main research question as:

"How should a framework, that address a systems abilities, be constructed in order to, be used as an instrument (means to some ends), be applicable within different domains and (work-) perspectives and complement and enrich existing enterprise modeling approaches?".

Research design

The presented research aims at creating a small set of "things" or "sociomateria" that address research questions and provide new solutions that address identified problems. The research strategy follows design science traditions. The particular variant of design science research strategy was developed by Peffers et.al in 2007 [15] and was chosen based on the general direction of the research of using practical (man-made) frameworks as instruments for improving organizations or systems to be qualitatively better. Design science (DS) research in information systems (IS) is a paradigm with origins in engineering disciplines that focus on changing scientific and practical knowledge by designing artifacts (model, constructs, etc.) that are relevant to an environment, generalizable, satisfies business needs while preserving scientific rigor and validity. The research process is an adaption on Peffers general design science research methodology (DSRM) [15].

We apply DSRM in an iterative manner, where, in each iteration, focus shifts from problems, through designing artifacts, evaluation, to communicating of results. DSRM consists of the following 6 steps.

1. Define the specific business needs, research problem and motivate the value of a solution/artifact (section 2). This was the focus of initial studies.
2. Define contexts for, objectives and requirements on a better solution/artifact (section 3). This is the focus of the next planned second iteration, contextual literatures review.
3. Design and development a new or improved solution/artifact (section 4). In each iteration we develop or elaborate on an artifact hypothesis with respect to existing bodies of knowledge and practices.
4. Demonstrate the use of the artifact to solve one or more problems satisfying business needs. In section 5 we demonstrate the artifact by informed reasoning.
5. Evaluation, observe and measure the degree to which the artifact supports the solutions to the problem, including ethical factors. In the fourth iteration we plan to perform a major evaluation that involves experts from different fields of application. The fifth iteration focus on exploring methodological aspects of using the artifact. Here we also intend to perform at least one case study, observing and evaluating applications of the artifact. In the sixth iteration we address how the artifact relate to and integrate with existing bodies of knowledge and practices.
6. Communicate the problems and its importance, the artifact, its utility and novelty, the rigor of its design, and its qualities to researchers and other relevant audiences.

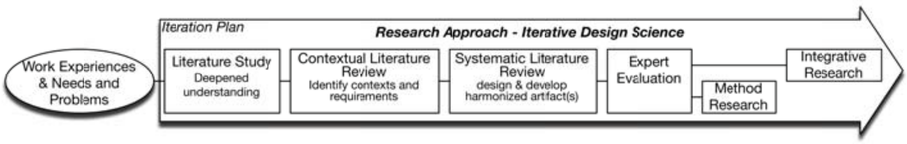

Fig. 1. Iteration plan for the research strategy

3 Artifact Objectives and Requirements

In this section we provide an outline of identified artifact and usage requirements. For the purpose of this paper and brevity we chose to describe selected sets of relevant requirements that has been extracted from studied literature and approaches [2], [4], [5], [6], [8], [9], [10], [11], [13], [14], [16], [18], [19], [20].

The conceptual model is subject to general design and quality criteria's as proposed by Gruber [7]: Clarity, Coherence, Extendibility, Minimal encoding and Minimal ontological commitment, and Moody and Shanks [12]: Completeness, Integrity, Flexibility, Understandability, Correctness, Simplicity, Integration, and Implementability.

The first set of requirements concerns the usage of an ability concept. These requirements provide usage contexts and has been identified and classified from references to or uses of ability in studied literature. For the purpose of informing the reader of the rather large and diverse set of forces on an ability framework, we provide a list of usage contexts.

Note: The abbreviation “uo” means that ability is unit-of or element in some context. Being a unit-of-planning (abbreviated as uo-planning) entails that ability is an entity/unit that is being planned, part of a plan, the subject of planning constraints.

Descriptive forces:

- Unit of Description, uo-Differentiae, uo-Position, uo-Communication, uo-Assessment, uo-Analysis, uo-Measurement, uo-Statement, uo-Attestation

Prescriptive forces:

- Unit of Planning, uo-Specification, uo-Realisation, uo-Work perspective, uo-Statement of Change, uo-Transformation, uo-Organisation, uo-Work product, uo-Command and Control, uo-Resource Allocation
- Unit of Lifecycle (conceptualization, design, manufacturing, deployment, execution, retirement, etc.).
- Subject of Instrumentation (information, guidance, recommendation, directive)

An initial ontological classification analysis, of reviewed articles and frameworks, revealed a number of important concepts and distinctions that serves are requirements on the conceptual model itself.

“having something (e.g. skills, knowledge, power) to do something or bring about something” is the key conception and relationships of being able.

"doing" – the concept of what enables being able, the mechanisms, processing, that may be formulated as abstract value creation, activities, routines, servicing, work process, use of effort, etc.

“result" – represents all phenomenon that can happen in a conjunction with a mechanism.

"result attributed to entity" - A result may benefit an organisational unit that performs a process or be (partially or fully) beneficial for another unit (system). The concept of service, servicing and co-creation of value are closely related to providing benefits to others.

"quality of ability" - An ability may exist to a greater of lesser degree, be better or worse, be abstract or concrete and exhibit qualities (e.g. capacity, sustainable)

"system/organizational alignment" – abilities, doing and result may be aligned with specific systems but may also transcend boundaries.

"indirect ability" – non-doing oriented entities such a piece of land constitute an indirect ability to produce oil since a production mechanism is not present.

"vantage point" - an ability may be viewed from within (internal), internal in relation to the environment (market,...) (inside-out), or from the environment looking in (outside in).

"relationship structures and mechanisms" – internal structures and mechanisms (within ability) have an impact on results (e.g. culture, learning, communication, coordination, integration of resources management and organization of work).

"2nd order ability" – abilities may operate on other abilities in order to acquire, build new or leverage existing. Staying competitive in changing markets condition may require such dynamic capabilities.

"specification – realisation"- an ability description may serve as specification to more concrete solutions. Strategic planning may strive towards establishing fit between an intended ability specifications and emerging realisations.

"characteristics of participating entities" – the relevance, nature and qualities of ability depends on the characteristics of involved entities. A sustainable ability in a stable market (environment) is different from ability in an uncontrollable market.

We plan to present the complete sets of identified requirements at the end of the current iteration.

4 Design and Development of an Ability Framework

In this section we outline the proposed Ability Framework artifact. This first design and development attempt represents a first initial hypothesis of content and structure. For the purpose of this article and brevity we focus on describing two key parts of the framework, conceptual model and ability viewpoint leaving other parts for continued research and papers. (e.g. method components, guidelines, principles, rules, recommendations, templates and theoretical alignment specifications (how the artifact relate to other concepts, theories and approaches)).

A conceptual model provides a body of formally represented knowledge, concepts, terms and a language that allows for discussions, reasoning, achieving common understandings relating to the central idea of the ability of systems or organizations.

We have chosen to investigate a conceptual deconstruction of ability phenomenon in order search for a minimal subset that captures the essence of ability and can be used to re-construct other ability concepts. The conceptual model is organized into smaller, internally consistent mini languages - Micro Ontologies and Theories (MOT) and bridged together with a Context Ontology and Theory (COT)[17].

The Ability Viewpoint, provides a knowledge organization structure that is commonly used in Enterprise Architecture (EA) frameworks, ISO 42010 [8]. The author was part of the Swedish ISO team developing this standard.

Systems thinking and theories approaches offers a set of central ideas and concepts, such as system, environment and mechanism, that can be used to represent markets, firms, strategic business units, departments and other parts organizations as system-of-system within environments. By adopting a systems thinking approach in the conceptual model we are able to reduce the number of additionally developed concepts, e.g. increase clarity quality.

The System MOT consists of concepts drawn from M. Bunges - CESM [1] (Composition, Environment, Structure and Mechanism) systems approach. The System MOT is defined as: System Model(s) = <Entites (s), Environment(s), Structures (s), Mechanism(s)>, Entities: the set of parts/entities of system, Environment: the collection of environmental items that act on system or are acted upon by system, Structure: the structure, or set of bonds or ties that hold the entities of system together, Mechanism: mechanisms, or characteristic processes of system. A mechanism may be abstract, concrete known or unknown, causal in nature, non-causal, intended, emerging, etc.

The Ability MOT forms the centerpise of the conceptual model where we provide definitions of ability and related fundamental concepts.

- A system is *Able* when there exist, or can be added, at least one Mechanism that *can* bring about some Result.
- A system possesses *Ability* if it is in a state of being Able.
- A *Result* is a phenomenon that can happen as part of a happening of a Mechanism.
- A Mechanism is said to *Bring About* some Result during happening.
- A set of Result is organized in a set - *Results*.
- Ability and Result are bound by spatiotemporal regions

In the following diagram we illustrate the concept of Ability in relationship to a system and environment. In a) we illustrate ability using a specific symbol that express ability. In b) we present an alternative expression of ability where results are partially located outside the symbol. In c) we include system and result concepts.

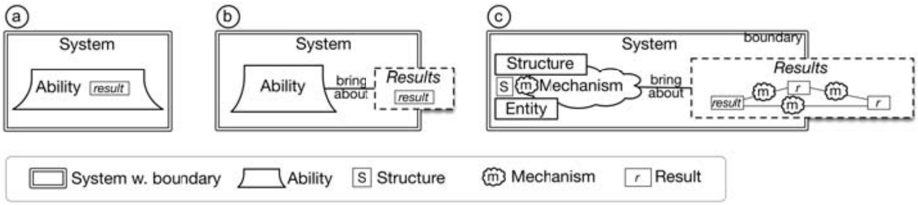

Fig. 2. Illustration of ability and related concepts

The Result MOT provides a language for representing *Result*(s) phenomenon. The result forms a key part of any ability and results are represented differently by authors, comes in many variations and with different qualities. Results can be partially ordered (e.g. qualitative comparable (better, worse, equal), low-order vs higher order, supported by vs supported). A particularly interesting result ordering scheme is a Ladder. A Ladder is a partially ordered set of result, ordering relations and mechanisms.

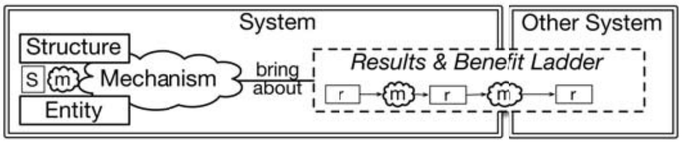

Fig. 3. Illustration of laddering of results

The Process MOT is an extension of the System MOT that introduces mechanism related concepts and provides an integration point to concrete enterprise terminologies and process modeling approaches. A *Process* is specific kind of mechanism where the inner workings of the mechanism are performed by *Performer's* (entities that can bring about changes in state) (e.g. humans, IT-Systems, machines, organizations', energy). A performer is an *operant* that operates on *operand's* (entities).

The Resource MOT is an extension of the System MOT that introduces entity related concepts and provides an integration point to resource-based approaches.

The Perspective MOT provides concepts that link systems, entities, qualities to people, their work oriented perspectives, situations and viewpoints.

The Ability Viewpoint provides an overall frame for the conceptual model by bridging all MOT's together with a COT and enables specializations of existing concepts, additions from relevant bodies of knowledge. The ability viewpoint is designed to be tailored by a specific organization to fit their usage requirements.

In this section we have the outlined the fundamental elements of the artifact under design. The focus is on the conceptual model.

5 Using the Ability Framework to Address Problems

In this section we outline how the artifact assists in addressing identified problems.

Ability modeling as an Enterprise discipline
The conceptual model and a focus on abilities offer an important complement to traditional enterprise modeling approaches. An ability is neither solely process (how) nor agent (who) or ends (why), but a combination. An ability viewpoint offers an abstraction away from the specifics of how and why, with focus on results and benefits (e.g. outcome based management and management by objectives by Drucker [3]). As such it offers tools to identify and discuss aspects that does not follow current value creating flows (e.g. assymetries, [11]) and organizational boundaries (e.g. pricing process [4]), and can function as specification that can be realized by others.

Integration with existing bodies of knowledge and practices
The chosen design of the artifact allows for fairly straightforward integrations with existing bodies of knowledge and practices. Process modeling may be integrated by extending the Process MOT, Services modeling by adding a mechanism "Servicing" and goal modeling by adding a result type "Goal fulfillment" together with a "support" partial result ordering relationship. The separation of concerns promise to simplify practitioner's problems of not understanding the differences between ability and more familiar and mature bodies of knowledge.

Theoretical and comparative use
The conceptual model provides a small toolbox that can be used for theoretical and comparative analysis purposes. An example is comparisons between ability concepts; Capability may be defined by adding a capacity quality to ability and a core competence definition may be based on abilities defined in relation to the market (environment) and by adding a sustainable quality. An example of multiple ability concepts is found in Mansour Javidan's work where he has elaborated on

competences, capabilities and strategic hierarchies [9]. Another example is ability hierarchies that can be represented as system-in-system structures.

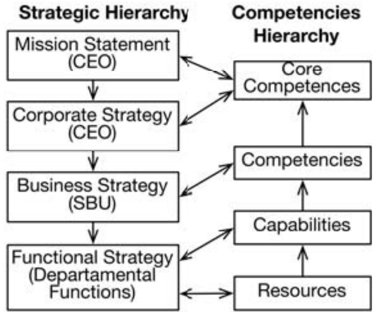

Fig. 4. Competences, capabilities and strategic hierarchies

A third example relates to the concept of dynamic abilities that are by many considered as a necessary addition to resource based theories of a firm. The conceptual model contains several entities and structures that enable dynamic analysis. 2nd order abilities/processes and may be viewed as operants operating on other abilities/processes, the operands. Such dynamic abilities/processes build, leverage, maintain other abilities/processes and are important to consider in environments that are characterized as volatile and uncertain. Secondly dynamic abilities may be further elaborated on and represented by sub-mechanisms and structures. Here Pavlou and Sawy [14] have identified sensing learning, integrating coordinating as important dynamic capabilities.

An important analytical tool is the laddering concept. Laddering or benefit ladders are commonly use in marketing and for value analysis [19] and relative orderings amongst result can be used for qualitative analysis and theory comparisons. The first three ladders illustrated in the following diagram are frequently used in the marketing domain. The fourth relates to software qualities. The fifth organize doing some work in relation to being efficient, effective and satisfy a stakeholder. The last provides an interpretation of a benefit perspective on Kaplan-Norton's Strategy map [10] .

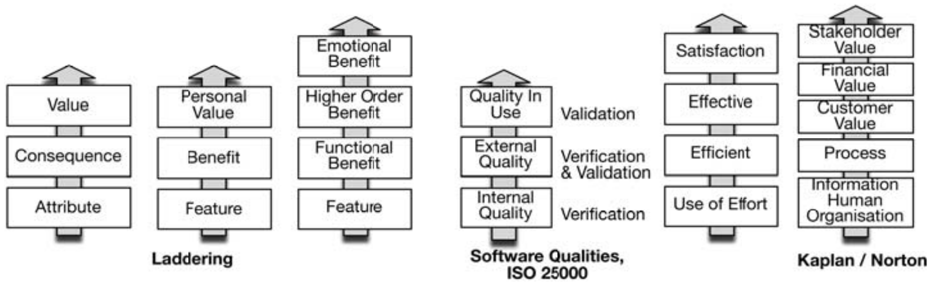

Fig. 5. Laddering examples

Deconstructing services into servicing

Service constitutes a longstanding phenomenon in many domains of application. The ability framework provides integration points with services approaches and theories, and may be used to analyze them. By using a minor reformulation the service definition used by Vargo, Lusch in their Service Dominant Logic theory and approach [18], together with laddering and a separating of the system that the servicing mechanism relates to from the system where the benefits/values occur we have functioning and service(s) analysis model. (adapted definition "servicing is the use of effort for the benefit of other or self"). What could be observed is that the separation of systems indicates that there is need for some transfer mechanism in order to relay benefits from servicing. This observation supports the existence of interface, interaction, integration and information oriented service framework (I-Services).

6 Summary

The purpose of this paper is to present an ongoing (design science) research effort aimed at investigating the nature of abilities of system and the role of ability based modeling within enterprise and modeling approaches and disciplines. The presented material represent early work and findings that provide a base for the next steps of the research strategy where this initial hypothesis is transformed into a formalized artifacts, demonstrated, evaluated and communicated. The results, findings and conclusions are furthermore planned to be supported by triangulation through use of multiple research techniques, such as investigation of cross-domain ability approaches, comparisons with adjacent, related theories and framework and finally comparison with adjacent methods.

We believe that the early results from the literature study, requirements analysis and design activities show great potential, where the conceptual model can be used for theoretical (comparative) analysis, and that ability based analysis complements traditional kinds of enterprise modeling. The viewpoint and system approach provide integration points with organizational work perspective concerns and promise to increase understanding and uptake of ability based points-of-view.

During the later stages of the conceptualization work an unexpected relationship was encountered between the concepts of mechanism, laddering and servicing. We intend to explore this interesting and promising link closer in upcoming research efforts and papers. Early findings indicate that by considering results relating to transactions and goods as lower order benefits and emotional values as higher order benefits we can use the ability framework to analyze differences and similarities between goods and service dominant logic approaches [18].

The next step is to conclude the literature study and to start the next iteration, a more extensive contextual literatures review.

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The Application of EM for Knowledge Flow Analysis and the Development of an Educational IT Ecosystem

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Abstract. Knowledge flow is invisible but plays an important role in educational processes. A wide range of accessible information technology (IT) for educational purposes as well as the potential for new technologies allow people to learn throughout their lives. Accelerated IT development and short amount of time for learning activities emphasize the requirement for continuing education and the synergy between accessible technologies. Analysis of knowledge flow becomes important during the learning process within an educational information technology (IT) ecosystem. Learning objects within IT are the major medium that enables knowledge to pass between teacher and learner. The developer of an educational system can identify factors that may impact on the learning process more successfully by using enterprise modeling The objective of this article is to apply the enterprise modeling approach to the analysis of knowledge flow in continuing education. The proposed approach can be applied not only to educational institutions but also in business organizations. The digital ecosystem approach is implemented in the model to support the knowledge flow analysis within educational and business processes.

Keywords: Enterprise Modeling Method, Information Technology, Continuing Education, Knowledge Flow Analysis.

1 Introduction

Analysis of knowledge flow within the educational system has become more important during the development of information technologies (IT). The main characteristic of an educational system is its organization which is controlled by knowledge flow within learning processes. Other qualities are that they are selective and are continued within and are certain limits self-regulating [Skyttner, 2005]. The lack of a comprehensive approach to using technology for educational purposes means that there is a limited approach for linking technologies used for teaching purposes, to the learning content and the learner's portfolio. Consequently there is a need to apply the principles of ecosystems in the development of teaching systems. User portfolio and technology communication are an important obstacle to be taken into account in the analysis, design and evaluation of teaching systems. Knowledge flow is invisible but plays an important role in educational processes and can enhance creativity and competitiveness of knowledge-intensive business processes.

The focus of this paper is on educational IT ecosystems in continuing education. A wide range of accessible information technology (IT), as well as the potential of new technologies allow people to learn throughout their lives. The necessity for life-long learning defines turbulent change and the rapidly-changing demand for new knowledge and skills. Current IT development and the short amount of time for learning activities emphasize the requirement for continuing education. The objective of this article is to present practical experience of enterprise modeling applied to the analysis of knowledge flow as well as the requirements for the development of software prototype. The ecosystem approach matches more precisely the needs of the learner to become and remain competitive in the ever-changing world. The aim of the applied approach is to support knowledge flow analysis in an educational IT ecosystem according to the learning situation, learner needs and the available technology in a specific time, place and learning situation.

The following sentences briefly outline the main points of the paper. The concept of knowledge flow analysis is analyzed in Section 2. Section 3 describes related work. Section 4 reflects enterprise modeling for knowledge flow analysis while section 5 provides the conclusions.

2 Concept of the Knowledge Flow Analysis

The aim of this section is to discuss the main concepts of particular research. The main concepts analyzed in this section are: knowledge flow, an educational IT ecosystem, continuing education service providers and consumers, the learner's portfolio and learning processes.

Knowledge flow in the context of knowledge-intensive teamwork is the passing of knowledge within a team [Zhuge H., et al., 2006]. Knowledge flow begins and ends at a knowledge node [Zhuge H., et al., 2006]. A knowledge node is either a team member or a role that can generate, process, or deliver knowledge [Zhuge H., et al., 2006]. From the organizational perspective, knowledge flow is defined as a method that supports knowledge accumulation and sharing [Uden L., Damiani E., 2007]. In the context of an educational IT ecosystem, knowledge flow is the passing of knowledge between knowledge nodes which are between the continuing education content provider and the consumer of education. The provider of the continuing education content is teacher in the education institution or another professional in this field. The consumer of the content is student.

Continuing education is a broad concept which includes all of the learning opportunities which any person wants or need outside basic and primary education. It extends beyond the completion of formal studies and into the less formal area of adult education [Stale G., Cakula S., Kapenieks A., 2011]. In the context of this paper, continuing education is defined as the active and informal learning process of adults, using different learning options, content accessibility, applied methods and IT solutions according to learning needs, learning solution, style and accessible technologies.

An Educational IT ecosystem is a term developed from digital ecosystems. A digital ecosystem is a self-organizing and adaptive digital infrastructure that supports an organization or communities working together to create and share of knowledge [Uden L., Damiani E., 2007]. An IT ecosystem for educational purposes is an adaptive digital infrastructure that supports the learning process in an organization [Stale G., Madsen P., 2009]. The digital infrastructure consists of digital components which comprise software components, applications, services, knowledge, business processes and models as well as training modules. An educational IT ecosystem in the context of this paper is defined as a digital environment which supports the continuing education process according to the learner's needs and competences. Competence includes knowledge, skills, attitudes, values and experience to solve particular problems, obstacles or barriers [Karampiperis P., 2006].

A learner's portfolio contains the results written and record of previous education and competences in a particular field [Yang T.C., et al., 2012]. The portfolio reflects the level of competence within a subject or area of knowledge.

Figure 1 represents the concept of knowledge flow. According to Figure 1, knowledge content is provided by the knowledge provider – a teacher or other professional. The knowledge content is the learning object which is delivered through the internet in the knowledge space. The knowledge repository collects knowledge metadata for the educational IT ecosystem to provide a knowledge flow analysis.

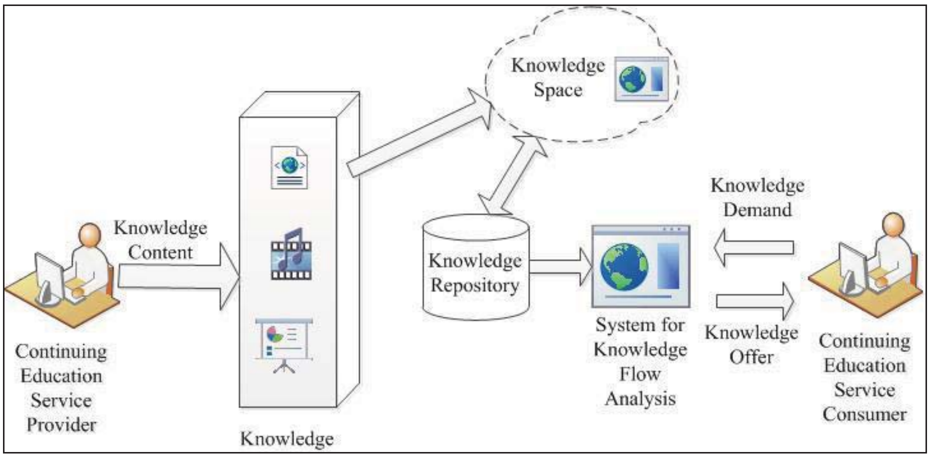

Figure 1. The concept of knowledge flow

The main concepts have been discussed in this section. The next section describes related work in this field.

3 Related Work

There are three main categories of work related to the IT ecosystem approach. The first category concerns is supporting a more effective learning process – the application of a learning ecosystem approach. The second concerns the analysis and modeling of knowledge flow. Third is the technological support of the educational process.

First area includes Educational Modelling Language (EML), a learning design specification [Whitman L., Huff B., 2001] and an education-oriented development framework [Jing, M., Li, X., Bin, Q., 2008], digital ecosystem paradigm for IT course development [Chin L. K, Chang E., Atkinson D., 2008] and an e-Learning ecosystem [Uden L., Damiani E., 2007] where the research describes the behavior of a learning ecosystem.

Koper and Tattersall described the necessary preconditions for the learner to become active in the learning process [Koper R., Tattersall C., 2005]. They are:

- the development and delivery of educational courses which include role-plays and game-playing, where multiple users perform a variety of interdependent tasks;
- the provision of problem-based learning courses where teams of learners collaborate in problem-solving and teachers have assessment, coaching or monitoring roles;

- the application of learning community approaches based on social-constructivist principles, where the design of the learning environment stimulates collaboration and the sharing of knowledge and resources;
- the application of performance-supported approaches, where learning tasks are assigned depending on the knowledge gaps assessed;
- the development of courses which can be adapted according to pedagogical models, learning processes and learning needs, preferences and the learning style of consumer
- the application of peer coaching and assessment approaches, where learners support each other.

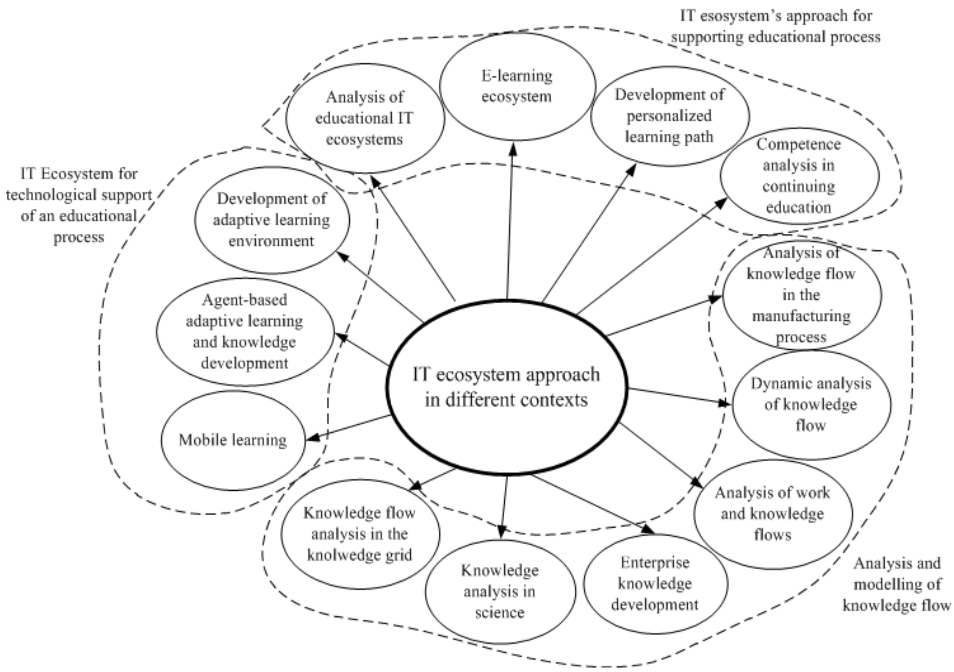

Figure 2. Fields of related work

From the learning ecosystem viewpoint there are models developed [Chang V., Guelt Ch., 2007], [Quinones, M., et al., 2008], [Guetl, C., et.al., 2005] where the main conceptual parts of learning ecosystem have been described. Chang described a learning ecosystem consisting of biotic abiotic units. Biotic units are learning communities, stakeholders, teachers, tutors, content providers, instructional designers and pedagogical experts. Abiotic units are the learning utilities, the learning environment which includes the learning media and technology [Chang V., Guelt Ch., 2007]. The significant part of a learning ecosystem is the learning ecosystem conditions which are determined by external influences such as the evaluation of knowledge, educational goals, learning tasks, cultural and social aspects, as well as the expectations of society, private industry and business organizations, the government, public service and not-for-profit organizations. The significant areas of interest in the learning domain are relationships and interactions related to the information flow as well as knowledge transfer and transformation [Guetl, C., et.al., 2005].

The second part of related work includes analysis and the modeling of knowledge flow in different contexts [Fan I., Lee R., 2009], [Huggins R., Johnston A., 2010], [Leistner

F., 2010], [Park H.W., et al., 2011], [Zhuge H., 2006]. The results describe knowledge flow principles and application domains. The aim of this particular piece of research work was to develop an enterprise model for knowledge flow analysis in an educational IT ecosystem. This model could meet the challenge of supporting learning organizations with appropriate technological and content solutions to support knowledge sharing and management, and the life-long learning process in learning communities.

The third related field is the technological support of the educational process [Jing M., et al., 2008], [Peter-Quinones M.A., et al., 2008]. The main problem defined in the related work was that, in many cases, the software applications on all the user's devices were designed to be functional copies of each other, often with an emphasis on keeping their form and function consistent with the same application on other device platforms. In one part of the related work [Jing, M., Li, X., Bin, Q., 2008], the idea of a personal information ecosystem was presented, as an analogy to a biological ecosystem which allows us to discuss the interrelationships between users' devices. A complementary approach defined the IT ecosystem as an interconnected system within which computing services were requested and delivered [Driscoll M.P., 2005]. The components of the ecosystem included any and all items that were required to conduct these service-based transactions, including, but not limited to, handheld - mobile phones, PDAs, laptops, etc., desktop computers, in-home networked appliances, networked printers, servers and storage devices, networking equipment and data centers. Defining an IT Ecosystem in this way highlights the interconnections and interdependence of the components within the system.

4 An EM for Knowledge Flow Analysis

Enterprise modeling enables a common understanding of all the pertinent aspects, the clear description of problems in an educational IT ecosystem and the requirements for knowledge flow analysis. It also enables the definition of various design alternatives and a mechanism to analyze these options for design implementation at strategic, tactical, operational and technological levels [Whitman L., Huff B., 2001].

The following methodologies were chosen as benchmarks [sown in Table 1]:

- the Yu methodology – strategic relationship development [Horkoff J., Yu E., 2009];
- the EKD (Enterprise Knowledge Development) – an enterprise modeling method [Bubenko J.A., Kirikova M., 1999], [Persson A., 2001];
- the Keith A.Butler method – for business process modeling and software requirements definition [Buthler K.A., 2000];
- the BPR (Business Process Redesign) – a method aimed at business process redesign and optimization [Gao Sh., Krogstie J., 2009];
- the Business Process Management Systems – a method for business process analysis from organizational, functional and behavioral viewpoints [Carvalo J.P., French X., 2009];
- the DRM (Decision Relationship Model) – reflecting actors, processes, input flows und decisions [Shahzad K., Zdravkovic J., 2009];
- the Service-Driven Information Systems Evaluation – this provides an analysis of business processes and abilities to use resources accessible to enterprises [Arni-Bloch N., Ralyte J., Leonard M., 2009];
- the Zachman Enterprise Architecture; this is a two dimensional classification scheme for describing different characteristics of an enterprise which consists of different characteristics of the final product [Zachman, 2006].

Table1.Benchmarking of the Methods used for the Analysis of Knowledge Flow and Development of an Educational IT Ecosystem

Methodology Criteria	**Business Process Management Systems**	**DRM (Decision Relationship Model)**	**Service-Driven Information Systems Evaluation**	**Zachman Enterprise Architecture**
Defining goals	-	+	-	+
Defining processes for comparing with goals and recourses	-/+	+	+	+/- excluding relationship between models
Possibility to define knowledge gaps	-	-/+	-	-
Definition of hierarchical structure	-	+	-	+
Define requirements for a CE system	-	+	+/-	-
Defining goals	-	+	-	+
Defining processes in comparing with goals and recourses	+/-	+	+	+
Possibility to define (reflect) knowledge gaps	+	+/-	-	+
Definition of hierarchical structure	+	-	-	+
Define requirements for CE system	+	+	+/-	+

The Enterprise Knowledge Development (EKD) method has been chosen as the Enterprise modeling method. The use of enterprise modeling methods and an "ecosystem" approach to knowledge flow analysis within the educational IT ecosystem provided a wide range of options to implement a more dynamic analysis of educational processes and supports definition of requirements for the development of a prototype to support these processes. Figure 3 shows a developed model for knowledge flow analysis within an educational IT ecosystem.

The EKD methodology is one of the enterprise modeling methods that was developed some years ago and is increasingly used by business consultants. This method has been the subject of research in a number of multinational European projects, including the 7th framework programme. It has proved its effectiveness both in the business and public sector by providing a framework for stating, modeling, and reasoning regarding pertinent knowledge in difficult problem situations which typically occurring in organizations and society.

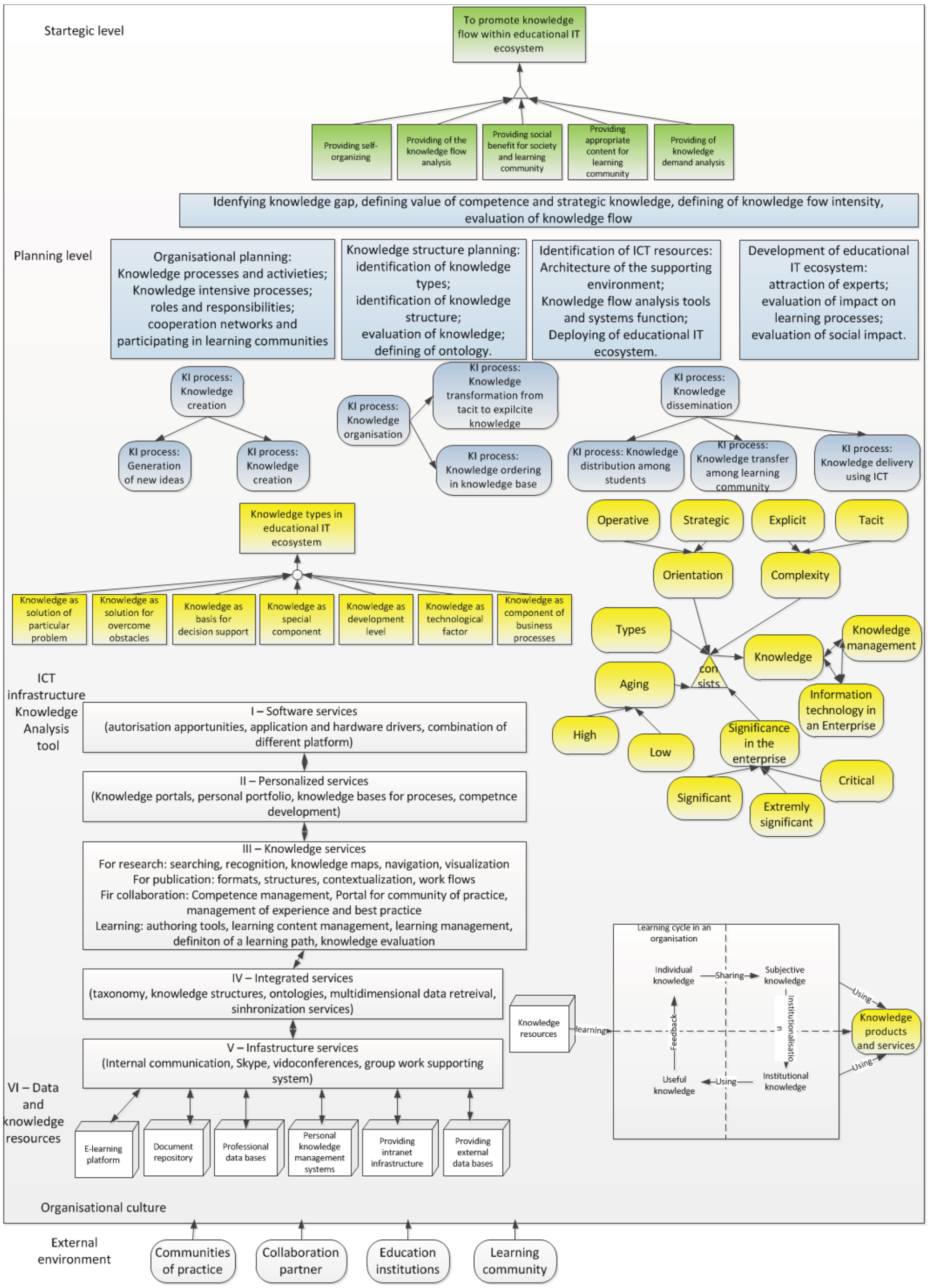

Figure 3. A Model of a Knowledge Flow Analysis within an Educational IT ecosystem

The EKD aims at setting an organization's vision, mission and goals, providing guidance in restructuring in changing different processes. EKD methodology has been expanded in this article by providing different levels of the model.

The Figure 3 shows a strategic level where goals are reflected and planning level where processes and concepts are shown. The next level shows the requirements for information and communication technologies and the knowledge analysis tool. The final level shows data and knowledge resources. Figure 4 reflects a conceptual model for the a prototype of an educational IT ecosystem to support the knowledge flow in the learning process. Knowledge flow analysis is implemented in the knowledge support system by analyzing the competence level of the student and matching to an appropriate learning path. A learning path is constructed depending on the learning objects.

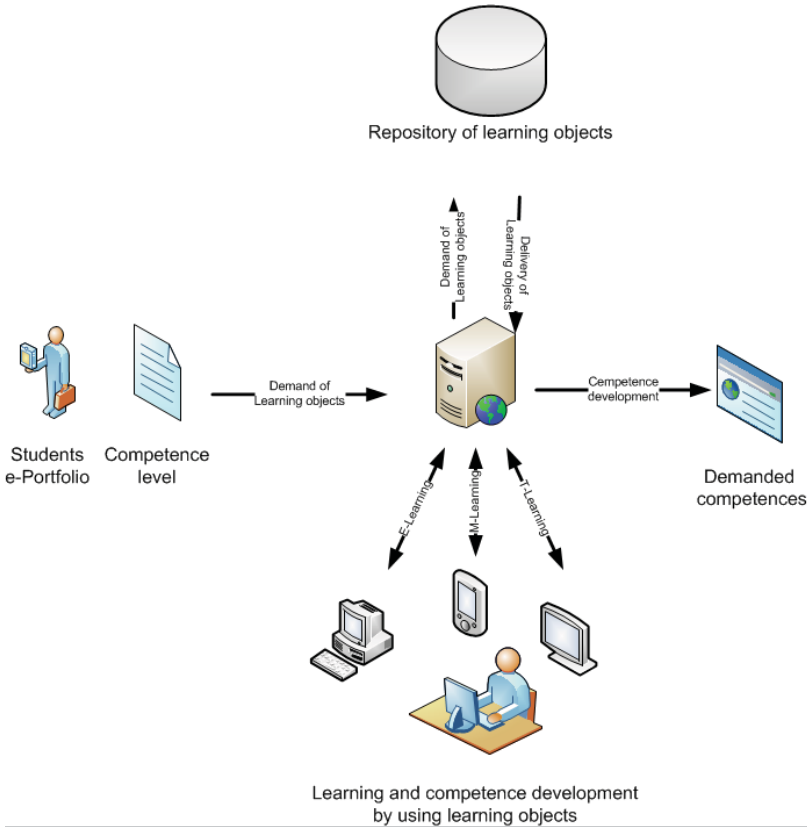

Figure 4. Conceptual Model for the Prototype of an Educational IT Ecosystem

Figure 5 and Figure 6 show a prototype of the software for a knowledge flow analysis in an educational IT ecosystem. Figure 5 shows the main screenshot form of the prototype. It demonstrates a competence field where the users can demonstrate their competences within particular subject. A meta-competence field is also shown. Meta-competences are defined by the study of the research done within 6th Framework Project [Berlanga A. J., et al., 2008]. Figure 6 shows the screenshot from the module for a knowledge flow analysis within business processes. An appropriate learning path is shown to the user after the definition of the student's competences, business processes and knowledge flow. The learning path is analyzed according to the user's initial competences, business processes and knowledge flow.

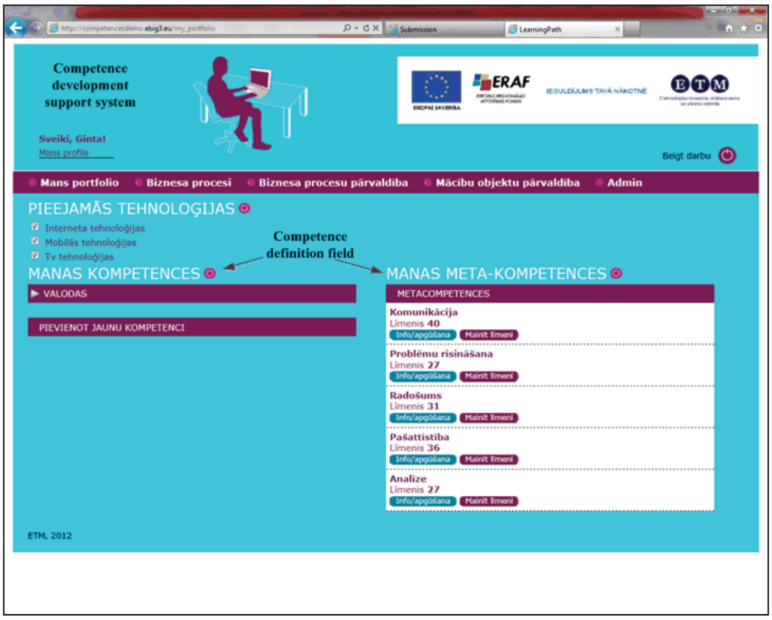

Figure 5. A Prototype of Educational IT Ecosystem - competence definition level

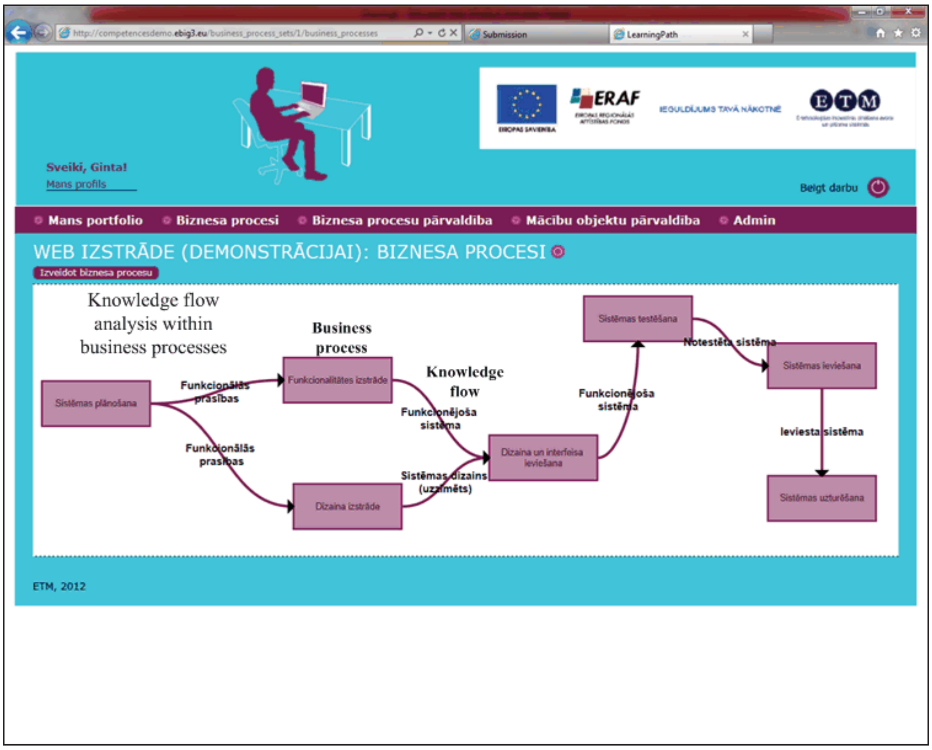

Figure 6. A Prototype of an Educational IT Ecosystem

(level for knowledge flow analysis)

5 Conclusions

Theoretical study was carried out during the research process for the knowledge flow analysis and the requirements definition of the educational IT ecosystem. Research on related work has shown that there is wide range of research done in the theoretical aspect of the e-learning ecosystem field and supporting a learning process through the provision of technologies. But, there is luck of knowledge flow analysis in educational processes. Appropriate software could offer a learning path to students for time-consuming learning process with technological solution according to the principles of the educational IT ecosystem.

The use of the Enterprise Modeling Method for the analysis of knowledge flow in continuing education provides a wide range of options to implement a more dynamic learning process in learning communities. EKD methodology also provides core support in the development of an educational IT ecosystem. The definition of different levels also provides a more structured analysis and also supports the detailed development of an educational IT ecosystem.

This paper has described a model for the identification of the knowledge flow and the gap which exists within educational processes and the learning path for competence development to meet an organization's needs and requirements.

Future work will be focused on the more specific and detailed development of the software prototype for knowledge flow analysis within the educational IT ecosystem. This will be done not only from the perspective of service consumers but also from the provider's point of view.

Acknowledgment

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Enterprise Modeling for Respecting Regulations

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Abstract. The paper reports on experience in creating an enterprise model compliant with the Latvian Accounting Law. The focus is on a possibility to represent parts of the law in the form of business processes. The issues that the law considers together with the information on processes are organized in related sub-models. The main elements of the enterprise model sufficient for representing issues prescribed by the regulations are presented and discussed. The suitability of the de facto business process modeling standard BPMN 2.0 for representing regulations is examined.

Keywords: business process, compliance, BPMN, enterprise modeling

1 Introduction

Different types of regulations [1] are to be taken into consideration when organizing enterprise business processes. At a high level of abstraction regulations can be divided into the following categories [2]: mandatory regulations, which are issued by governing bodies; “good to have” non-mandatory regulations such as various industry standards; and internal regulations, which are chosen by an enterprise to be followed in its performance. From the enterprise point of view, the first two types of regulations are regarded as external regulations. Internal regulation may depend on (or mirror) external regulations as well as they may be independent.

In the scope of this paper we are examining and analyzing only external regulations that are mandatory for enterprises. The purpose of the research is to represent the law as parts of business process model that can be used by enterprises in designing and managing their business processes [2]. Using the law mirroring parts of business process models would prevent enterprises from multiple efforts of translating regulations into business processes. It is also necessary to maintain the business process linkage to the specific structural parts of the regulation to ensure regulation change monitoring and thus facilitate up-to-date business process compliance with the regulations.

The goal of the paper is to contribute towards the enterprise modeling method that would provide enterprises with business process patterns, which precisely and completely conform with valid external (issued outside the enterprise) regulations. For achieving this goal we have analyzed the relevance of currently popular process modeling language - Business Process Model and Notation (BPMN) – for modeling of external regulations. BPMN is the standard for representing in a very expressive graphical way the processes occurring in virtually every kind of organization [5]. Moreover, it is the de facto business process modeling standard [5] and currently is implemented by more than 70 applications [3]. According to [4] BPMN is a plenty construct-rich process modeling language that could be successfully adopted for modeling of procedural aspects of regulations. In the scope of this paper we attempt to verify how BPMN 2.0 language constructs overlap the core elements of regulations based on the developed meta-model of regulations. The comparison is empirically approved by the case study creating an enterprise model process patterns for the Latvian Accounting Law. Based on the obtained results, we can conclude that BPMN 2.0 cannot fully support modeling of regulations, because of its limitation concerning structural modeling. For modeling of regulations in full extent, it is necessary to represent not only the procedural nature of regulations, but also the constraints on data content, organizational structure, information systems functionality, etc.

In this paper we envision a solution which is based on the set of inter-related models each focusing on a specific aspect of regulations: processes, data, organizational structure, events, information systems, and rules. A collection of these models is sufficiently complete to describe the regulations in useful way. Proposed approach is similar to enterprise architecture modeling approaches, as it also captures the structure and dynamics of an enterprise as collection of multi-level and inter-related artifacts, i.e., diagrams, documents, and models [6]. We provide the comparison of proposed approach with enterprise modeling method EKD (Enterprise Knowledge Development) [7] that is a representative of the Scandinavian strand of enterprise modeling methods. We have found considerable similarities between EKD and our approach; hence this enterprise modeling method has been selected for comparative evaluation.

The remainder of the paper is organized as follows. In Section 2 related work is outlined. In Section 3 core elements of the regulations are presented and compared to meta-model of BPMN 2.0. In Section 4 the empirically faced limitations of BPMN 2.0 are illustrated. Section 5 contains the enterprise model proposed for regulations modeling and its comparison to the enterprise model used in well-known EKD method. Brief conclusions are presented in Section 6.

2 Outline of Related Works

In [9] authors provide a high-level architecture of the document analysis and change detection system which is used for the retrieval of regulations and document analysis and preparation for their linkage to business processes. Another related field is legal informatics which addresses the linkage between business process models and legal documents in order to create traceable law models [10]. The Legal Knowledge Interchange Format (LKIF) is a semantic web based language for representing legal knowledge in order to support modeling of legal domains and to facilitate interchange between legal knowledge based systems [11].

The more recent approaches towards achieving compliance strive to provide some level of automation through automated detection. For instance, in [12] proposed an approach that has a preventative focus. At first, the approach allows a formal representation of control objectives in formal language for representation of compliance requirements (using FCL-Formal Contract Language). Then, control tags should be defined from FLC expressions, and used to visually annotate and analyze typical graph based process models. However, it remains unclear, how to linkage process model with the source of controls to be able to detect changes in controls timely. As well as, the effect of controls is analyzed only form the process perspective, leaving other aspects of enterprise (e.g., data model, organizational model, information systems model, events model) unattended.

ArchiMate standard [13] provides a graphical language for the representation of enterprise architectures. However, the current ArchiMate 2.0 specification does not address business policies and rules concepts modeling. Very often business rules and policies are based on legislation and regulations. Because of this limitation to address business rules and policies ArchiMate 2.0 is not used as a basis in this research.

In this paper we focus only on the regulation based view on the enterprise, i.e., we examine what enterprise architecture (model) and what capabilities of business process modeling language are needed if we represent the regulation in a form of enterprise/business process models.

3 Core Elements of Regulations

In [1] regulations are defined as directives published by a legislature. Compliance of business process models to these directives is mandatory. In this paper we use softer interpretation of term "regulation". We consider regulation as a directive or guidelines that are mandatory for or chosen to be followed by an enterprise. This complies with the definition of a regulation given in [8]. The certain part of regulation may be related to the particular business process model part that represents the regulation in terms of business processes. For process modeling the candidate is BPMN 2.0 modeling language as it was recognized the most appropriate for compliance modeling [4]. Visualizing the content of regulations, we may obtain the business process patterns that may be made publicly available for the enterprises. It is necessary to provide mappings between core elements of regulations and corresponding elements of process modeling language to have a linkage between the regulations and their visualization. For this purpose we provide the meta-model of core elements of regulations (see Figure 1). The core elements of regulations were obtained empirically from modeling the Latvian Accounting Law [13] and are built to conform to Bunge, Wand and Weber ontology [14] concepts that define the things to consider when developing information systems. The developed meta-model of regulations is compared with simplified BPMN 2.0 meta-model (see Figure 2) which is based on the standard specification of BPMN 2.0 [3]. Simplified BPMN 2.0 meta-model consists of only those elements that could be useful for representation of regulations. The results of comparison are summarized in Table 1. They reveal that BPMN 2.0 has several limitations if considered as a business process modeling language for modeling regulations. Some empirical illustrations of these limitations are provided in the next section.

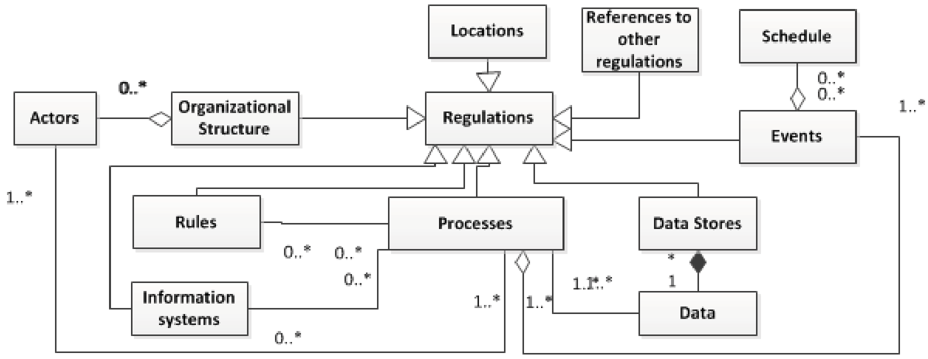

Fig.1. Meta-model of core elements of regulations

Table 1. Comparison of core elements of regulations with BPMN 2.0

Regulation elements	Description	BPMN elements
Processes	The sequence of activities required to be performed to comply with the law	Activity, Control Flow, Gateway
Events	Something that happens at a given place and time	Events (is not possible to specify user-defined events)
Schedule	Dates and times at which things are required to occur	Not supported (does not show the events ordered according time axis)
Actors	Roles that are required to take part in specific processes	Pool, Lane (does not allow to model inter-relationships between actors, and their authorities and permissions)
Organizational structure	Organizational entities that are required to take part in specific processes	Pools, Lanes (does not allow to model inter-relationships between organizational entities)
Data	Collections of facts processed during activities as inputs or outputs	Data Object, Message (does not allow to model inter-relationships between data objects and attributes of objects)
Data stores	Registries for storing and accessing data	Data Store (does not allow to model the content of data store, data visibility and access permissions)
Information systems	Software applications that assist a human performer to carry out an activity	Pool, Lane (does not allow to model the functionality of information systems and inter-relationships between them)
Rules	Definitions, operations, constraints and statements that resolve either true or false	Business Rule Task (is not possible to show the internal structure of regulation and links with other regulations)
Locations	Geographical and spatial locations of the enterprise, data stores, and information systems	Not supported
References to other regulations	References to linked and derived regulations	Not supported

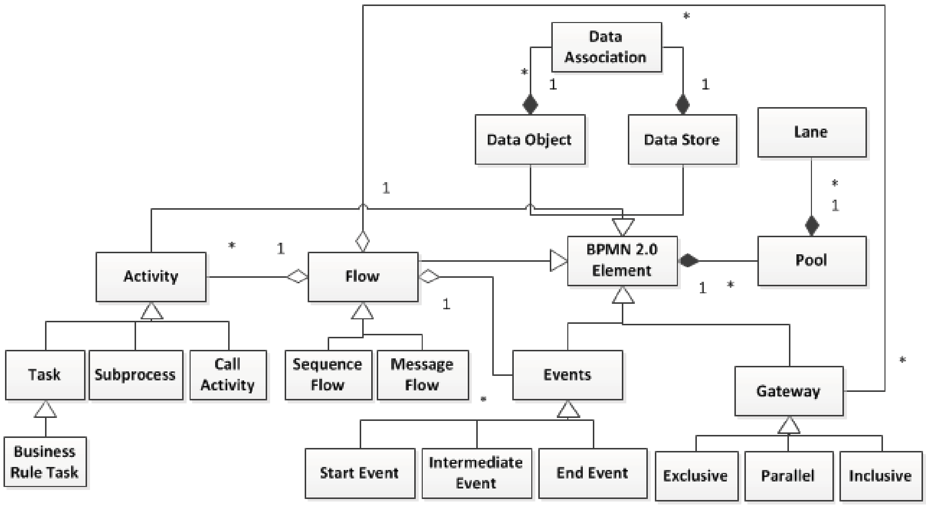

Fig.2. BPMN 2.0 simplified meta-model

4 Limitations of BPMN 2.0

Limitations of BPMN 2.0 detected in the previous section were verified empirically by carrying out the controlled experiment in the project where the Latvian Accounting Law [15] was modeled. The following BPMN 2.0 limitations were identified:

1) BPMN 2.0 does not support data structure modeling apart from process model. In the context of regulation modeling, thus it is not possible to specify constrains on the content, visibility, and access permissions of data objects. For example, in Figure 3 the fragment of governmental regulations that sets the inventory procedure is shown. In the business process model the sequence of inventory activities is represented, but constrains on the content of the source documents are not supported (see Rule 1).

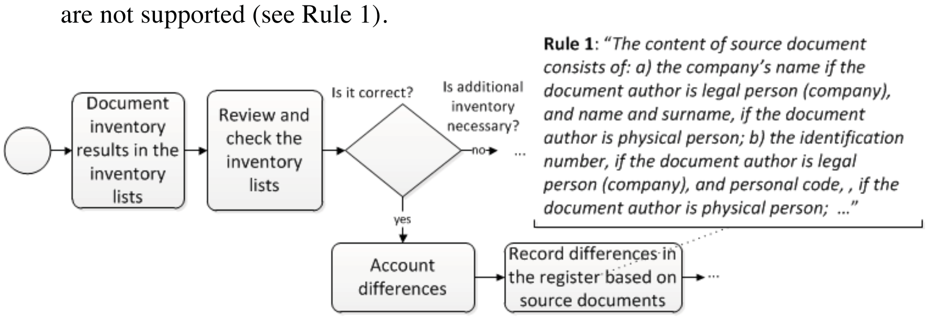

Fig.3. Missing regulations on data structure

Regulations prescribe permissions, authority, obligations, and competencies of actors that perform the activities. Currently the inclusion of organizational perspective in BPMN 2.0 is limited, i.e., actors and organizational units could be modeled in pools and lines without additional information. For example (see Figure 4) Rule 2 specifies the generalization of class “head of the company”, including all possible sub-classes. And Rule 3 defines the responsibilities of the role “Head of the Company”. This information is not included in the model.

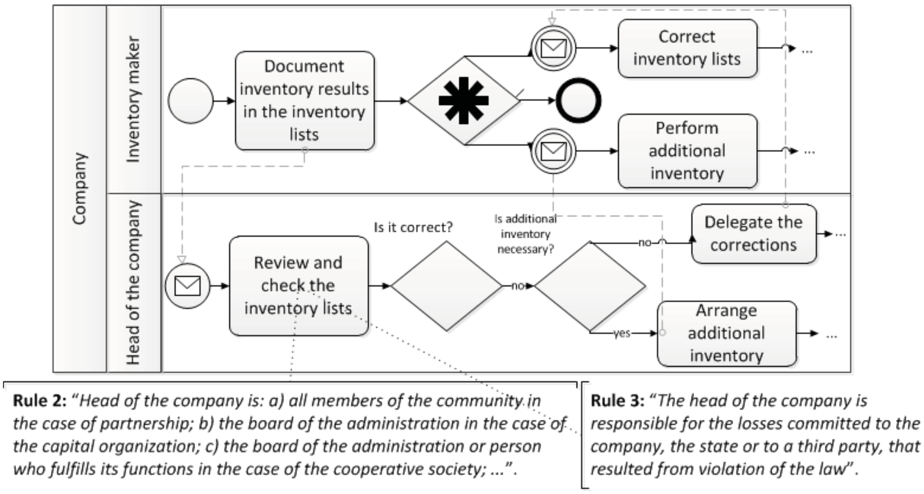

Fig.4. Missing regulations on organizational structure

2) BPMN 2.0 provides modeling primitives for standard event types, e.g. Message, Signal, Start, and End, but this is not enough in the case of regulation documentation. The main mission of offered event types is modeling of executed processes. However, it should be possible to specify user-defined pre- and post-conditions, in order to force the analyst to model the activities as lawful sequence of events and state changes of the data objects. For example, see Rule 4 in the Figure 5 where the first activity of accounting process may start only if certain pre-conditions are fulfilled. There are two possibilities how to model this regulation with BPMN 2.0 language.
   - We can use *Parallel Multiple Event* object that indicates multiple ways of triggering the process or activity [3] as it is shown in the Figure 5. It means that multiple activities or events are enabled in parallel, and have the potential to occur at the same time. This could be appropriate language construct for modeling pre-condition, but unfortunately this may lead to misunderstandings. Event objects denote starting point of activity execution, i.e., when activity should be started. But we should model just pre-conditions of activity not the triggering conditions.
   - The language construct appropriate for modeling pre- and post-conditions is *Parallel Event-Based Gateway*, where the occurrence of all subsequent events starts a new process instance. But this language construct is used to denote several inclusive or exclusive paths of process execution. That means it is not possible to model conditions that should be fulfilled in parallel. Other limitation is that *Event-Based Gateways* are configured by having outgoing *Sequence Flows* target an *Intermediate Event* or a *Receive Task* in any combination [3].

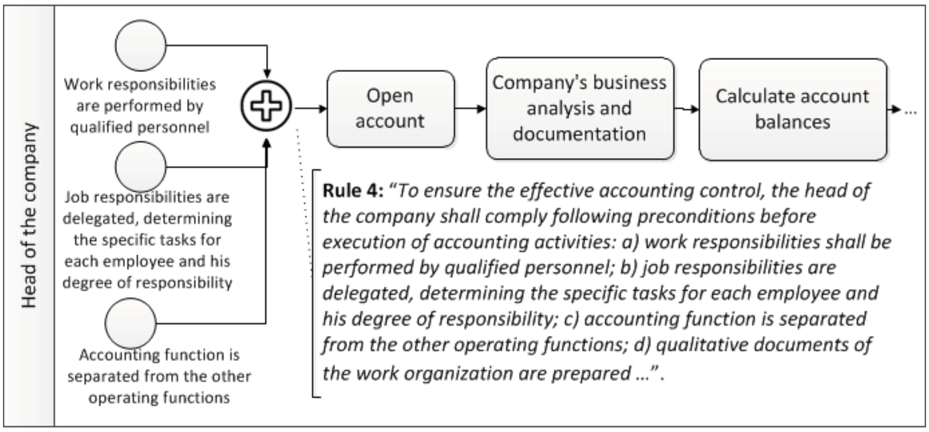

Fig.5. Using Parallel Multiple Event object for modeling regulations on pre-conditions

3) BPMN 2.0 does not allow to model constrains on information systems, registers, warehouses and their geographical location in full extant. Using Data Store object it is possible to model information that is retrieved or updated in the data stores (see Figure 6), but modeling constructs that could be used for inclusion of information systems (software applications) in process model are missed. In addition it is not possible to represent the content of data store that is prescribed by the regulations. For instance (see Figure 6), Rule 5 specifies how long the documents in archives should be saved, while Rule 6 constrains the language that should be used in the registers. As well it is not possible to represent the mandatory functions of software application that should be used to perform certain activity or general set of functions that should mandatory provide the software application. For instance, Rule 7 specifies that the accounting software program must provide certain functionality and data formats (see Figure 7).

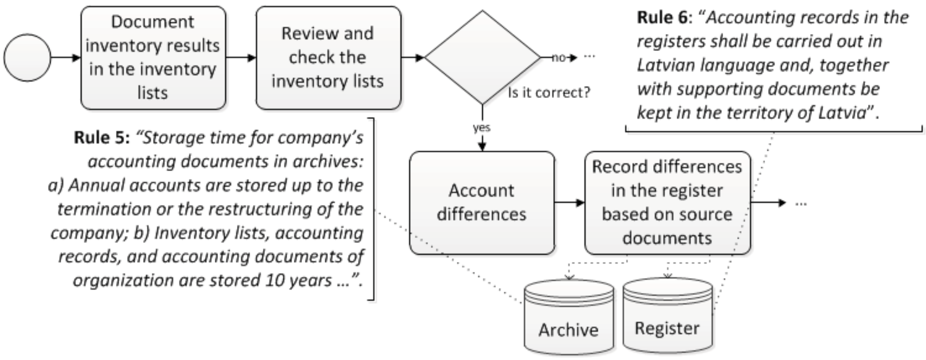

Fig.6. Missing regulations on data bases

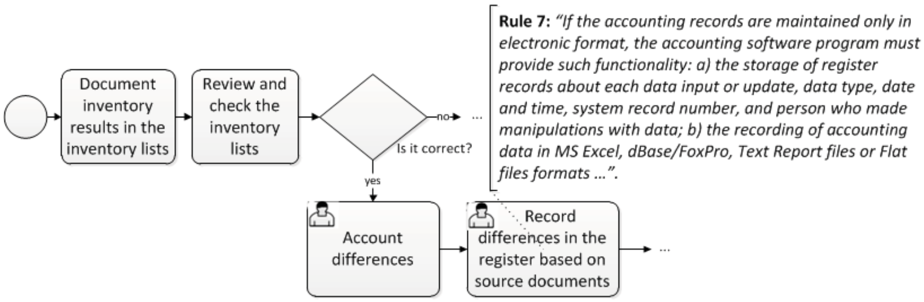

Fig.7. Missing regulations on information systems

4) Regulations describe dates and times at which things are required to occur, thus modeling language should provide representation of the time/dates. BPMN 2.0 includes special type of event *Timer* that could be used for this purpose, but, in addition, it may be preferable to obtain separate diagram with events ordered according time axis similar to Gantt chart. For example (see Figure 8), Rule 7 constrains the starting data of accounting period, but Rule 8 specifies the lawful duration of this period.

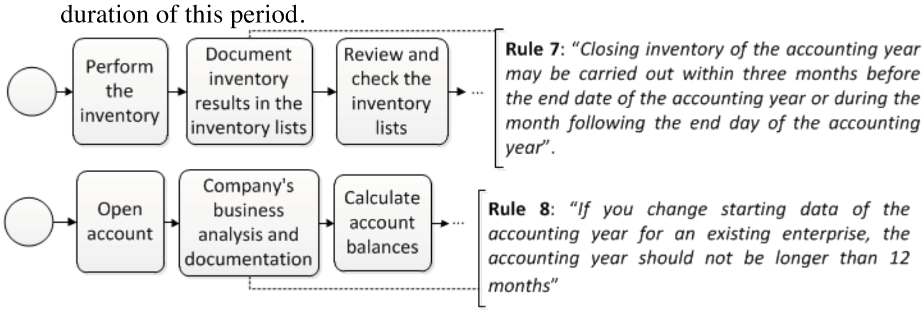

Fig.8. Missing regulations on time/dates

5) Ordinary the process model expresses actions that should be carried out, but on the other hand regulations may describe illegal actions that are not allowed to perform. None of process modeling languages (including BPMN 2.0) directly provides such a possibility.

5 Inter-related enterprise models for capturing of regulations

In this section we describe the proposed architecture (enterprise model) for regulations modeling. For complete and precise modeling of regulations it should be provided the parallel development of several sub-models using inter-model links. The ability to trace fulfillment of regulations throughout the enterprise is dependent on the use and understanding of these inter-model relationships. Each of these sub-models emphasizes the certain aspect of the regulations according to the particular enterprise architecture artifacts. We distinguish the six sub-models:

- *Regulations Model* that defines and maintains explicitly formulated rules, consistent with the source documents such us governmental law and corresponding to them regulations. On the one hand, this model helps to deal with conceptual linkages within one regulation and across several regulations, as well as with their legal hierarchy. On the other hand, it clarifies the linkages between the organization's structure, performed business processes, used information systems, and processed data artifacts;

- *Business Process Model* that defines enterprise processes that are constrained by regulations, the way they interact and the way they handle information as well as material. Business Process Model clarifies, which activities the organization should perform to manage the organization in compliance with regulations;
- *Organizational Model* that describes how different actors and organizational units should be related to each other and what permissions and obligations they have corresponding to the regulations;
- *Data Model* is used to strictly define the "things" and "phenomena" described in the regulations. Data Model represents enterprise concepts, attributes, and relationships as well as what rules and constraints that monitor these objects and concepts;
- *Information Systems Model* where attention is focused on the technical systems that are needed to support the business processes of the enterprise. This model clarifies questions, such as: what are constrains on the information system to be used, which functionality information system should perform, with what other systems it should be integrated, what data formats are mandatory, etc.;
- *Events Model* that provides a convenient way to explicate time relationships between people, places and actions, i.e., Event Model defines events ordered according time axis, activities triggered by events, geographical location and involved actors.

The modeling elements of the sub-models are related between themselves within a sub-model *(intra-model relationships)*, as well as with components of other sub-models *(inter-model relationships)*. Figure 9 shows *inter-model relationships*. The ability to trace regulations throughout the enterprise is dependent on the use and understanding of these relationships. The central role plays two sub-models, namely, Regulations Model and Business Process Model. All other sub-models are associated with these two models. For instance, the structural relationships between performers of activities in Process Model are clearly defined in Organizational Model. In the same way, temporal and spatial relationships between events and activities in Process Model are particularly specified in Events Model. In addition each sub-model have links with Regulations Model to clarify which parts of the regulation correspond to which part of the business process, data, organization, information systems or events. Links between the sub-models make the model traceable.

To manage rules which are included in Regulations Model and still keep the linkage to their original source, one more link (*external relationship)* is required. External regulations issued by the government usually are available in the web pages of the governmental institutions. There are also web portals providing search facilities of the regulations by such criteria as issuer, type, subject, free text search and other criteria. Therefore we propose solution that has been developed in our previous researches [9]. The main idea is to identify and annotate document structural elements that could be referenced with *external relationship* by element of Regulations Model using direct URL's (see dashed line in Figure 9). Thus we gain the ability to reference specific part of the document (title, chapter, section, article, sub-article), that should be directly applied when implementing business process. This link between the rules of Regulations Model and their original source is captured by the elements in other sub-models via *inter-model relationships* (see bold lines in Figure 9).

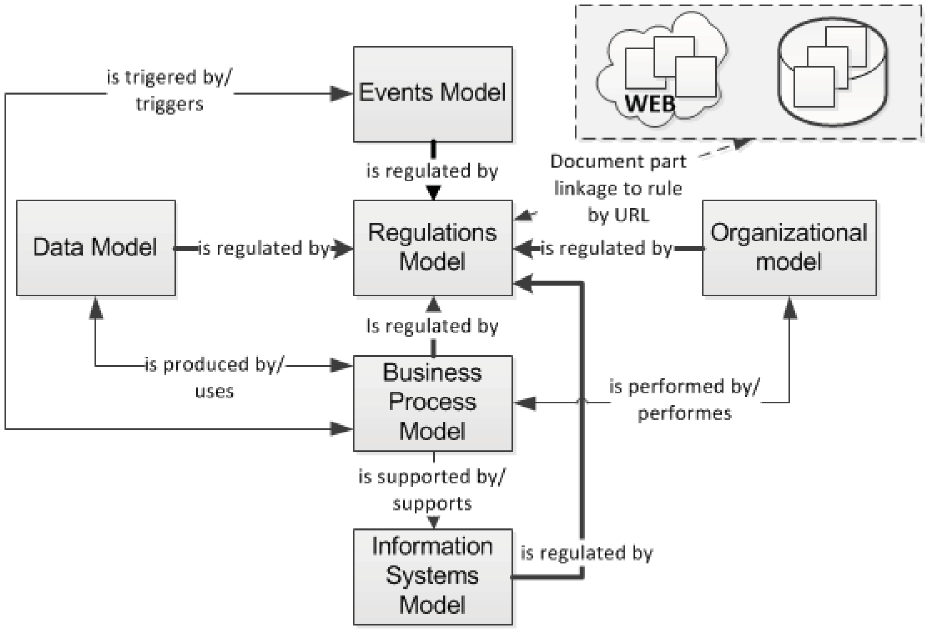

Fig.9. Regulation modeling using the inter-related models

The proposed approach is verified according the enterprise modeling method – EKD [16], that is Scandinavian strand of enterprise modeling methods. Figure 10 on the right (see B) represents the EKD sub-models with their inter-relationships, and on the left – the proposed sub-models with appropriate links.

There are obvious similarities between Data Model and Organizational Model of proposed approach and corresponding models in EKD (Concepts Model and Actors and Resource Model). These models have the same focus and modeling primitives for representation of structural relationships between elements (e.g., generalization, composition, specialization). Moreover, the meaning of Business Process Model in EKD is very close to the model proposed in our approach. Differences are related to the syntaxes and quantity of used modeling primitives, because BPMN provides more expressive notation than EKD Business Process Model. Information System Model in our approach differs from the Technical Component & Requirements Model in EKD as in our case this model specifies constrains on the functionality of information systems, but in EKD it specifies the needs (requirements) of information systems. We have proposed the new model, namely Event Model, instead of Goal

Model in EKD. This model portraits constrains on the events and timing. Relationships between sub-models are different, too; because in our approach the emphasis is on structural and behavioral aspects of regulations, where the most important are Process Model and Regulations Model. In EKD there are more inter-model relationships, as the main purpose is to capture as much knowledge about enterprise as possible.

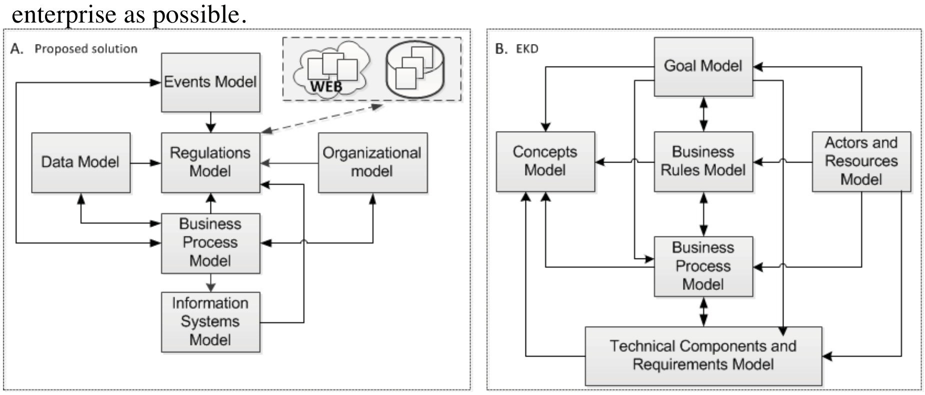

Fig.10. Comparison to the enterprise model used in EKD: A. inter-related set of proposed models for modeling of regulation; B: EKD inter-related models [7].

6 Conclusions

The paper reports on enterprise modeling experiment that is based on representation of regulations as reusable business process model parts. The experiment showed that for proper positioning of the parts it is necessary to represent in models not only the process per se, but also other related information available in regulations. The paper proposes the enterprise model suitable for modeling regulation. The comparison of this model to a well known enterprise model helps to see that the enterprise model has to include an events model as one of its sub-models for regulations modeling purposes.

The paper contributes with clearly described and illustrated limitations of BPMN 2.0 in its applicability for regulations modeling. It is a matter of future research to overcome these limitations, since due its popularity the BPMN is still the main candidate for modeling regulations in situations where models are developed for public use.

The research experiment described in this paper is limited to one law and its related regulations only. Further experiments with other regulations may reveal some new requirements for enterprise and process models. The general aim of the research is to provide reusable business process model parts (that mirror regulations) in cloud [2] in order to enable easier enterprise business process compliance to regulations.

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Linking Strategic Innovation to Requirements: a look into Blue Ocean Strategy

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Abstract. Business Strategy encapsulates an organisation's intentions towards the achievement of its vision. As such, business strategy frames the overarching business roadmap towards the accomplishment of strategic goals driven by competition, by own capabilities, or by innovation. Consequently, such a roadmap needs to be considered when building systems aimed at supporting the functionality of an enterprise. Introducing business strategy to system's design using models facilitates the propagation of strategic notions to development techniques and methods. This study focuses on bringing a business strategy formulation driven by innovation into system requirements; specifically, relating Blue Ocean Strategy to the notions of i*, an established goal modeling technique within requirements engineering.

Key words: Business Strategy, Business-IT alignment, Requirements Engineering

1 Introduction

Alignment between business and IT has been extensively addressed in research - there exist approaches that consider business strategy in a holistic manner [1, 2, 3] but also specifically through distinct business strategy formulations [4, 5]. From an IT perspective, business strategy should function as an initial frame within which IS development takes place; ergo provide initial organisational rationale to a system.

Strategic planning is the process during which a strategy is defined by analysing the current status of an enterprise and the competitive environment in which it resides. Good planning is driven by three different aspects [6]; the resource based view, where strategy formulation is driven by the capabilities of the enterprise; the industrial organization view, where the positioning is the main driver; and the Shumpeterian view, where radical innovations are in focus disrupting the environment in which the firm operates, thus giving opportunities for taking advantage over companies whose capability to innovate is lower. The first two views have been traditionally dominant both in research and practice, with formulations such as Strategy Maps and Balanced Scorecards (SMBSC) [7] and the Value Chain [8] respectively. Primary focus has been on value creation by improving how products and services are offered in respect to competition aiming at differentiation, low cost. or focus [8]. Efforts to link such business strategy formulations with requirements have been already proposed, such as mappings between SMBSC and i* [9], a goal modeling technique used in requirements engineering, informally in [5], and semi-formally in [10].

However, no such effort exists for business strategy formulations of the Shumpeterian view. Such effort would enable the linkage of strategically innovative intentions and requirements. Although strategic initiatives do not change constantly, though they are monitored and altered regularly due to today's rapid changing business scene, modelling business strategy allows for establishing and maintaining a strategic frame in IS development. Therefore, the goal of this study is to link a business strategy formulation belonging to the Shumpeterian view, to a technique used in requirements engineering. The purpose is to facilitate the relationship between strategic innovation and IS development supporting such innovation. Such linkage constitutes a frame for IS development because it captures strategy and expresses it using a requirements' notation, thus enabling the use of strategic intent when deriving system requirements contributing to the alignment between business and IS development.

Specifically, Blue Ocean Strategy, BOS [11] is used, a business strategy formulation that has recently attracted attention due to successful innovative solutions. One such case is the one of Apple introducing their online music store iTunes, thus revealing a blue ocean in digital music [12]. Blue Ocean shifts strategy from value creation, to value innovation, where old things are no longer done, i.e. either new things are done, or similar ones in a fundamentally new way, while pursuing differentiation and low cost simultaneously. i* [9] is used due to its known support expressing social intentionality and rationale enhancing the early phase of requirements engineering [13].

Section 2 provides an overview of Blue Ocean Strategy along with a proposed conceptualisation of the formulation in the form of a meta-model and related constraints. Section 3 provides the conceptual relationships identified between the BOS meta-model and the i* meta-model [10] along with an illustration using a case from the airline industry. Section 4 provides a discussion on the usage of proposed relationships, as well as it outlines the directions of the future work.

2 Modeling Blue Ocean Strategy

2.1 Overview

Blue Ocean Strategy [11] aims at competing where there are no competitors by challenging industry's structural conditions and therefore, the objective is to redefine the problem an industry is focused on rather than finding solutions to existing problems. It moves from value creation, doing similar things in an improved way, to value innovation, which means stop doing old things and either start doing new ones or do similar ones in a fundamentally new way, while pursuing differentiation and low cost simultaneously. The core elements of the formulation are the strategy canvas and the four-actions framework (structured of the eliminate-reduce-raise-create factor grid).

The strategy canvas offers a graphical representation of the current state in a known market by identifying the range of factors an industry competes on and invests in (horizontal axis), as well as their offering level to buyers (vertical axis). A factor is a feature or benefit identified as essential to the provision of the product or service a company offers to buyers. A basic component of the strategy canvas is the value curve capturing a company's relative performance across the aforementioned competition factors of a given market (Figure 1).

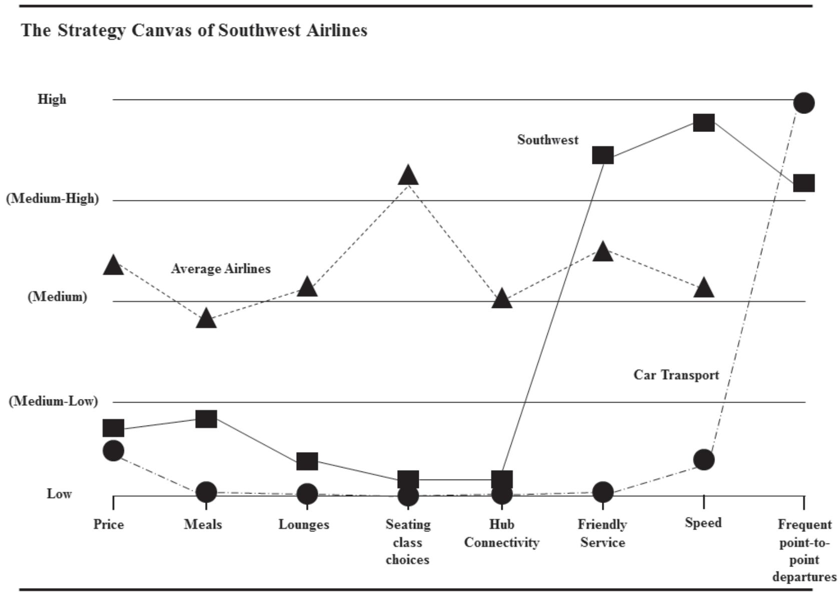

Fig. 1. The strategy canvas captures an industry's current state, in dotted and in dashed lines and the result of the four-action framework, a new value curve in solid line (adapted from [11]).

The four-actions framework challenges current strategic logic along the eliminate-reduce-raise-create factor grid and by driving chosen changes on the factors, creates a new value curve. Eliminate and reduce aim at dropping the current cost structure by looking into which of the factors that the industry takes for granted should be eliminated, and which factors should be reduced well below the industry's standard, respectively. Raise and create strive for how-to in terms of lifting buyers value and creating by looking into which factors should be raised well above the industry's standard and which factors should be created that the industry has never offered respectively.

Blue Ocean Strategy Meta-model (BOSMM) Our conceptualisation of Blue Ocean Strategy is based on its original formulation presented in [11] and focuses on the main constructs and their underlying concepts, while methodological aspects, such as the process of building a Blue Ocean Strategy, are reflected through the outcome, i.e. the strategy itself:

- BlueOceanStrategy class captures the strategy and carries three attributes being its main characteristics. Tagline captures the strategy's clear message/slogan with great commercial potential, Focus confirms whether the strategy is focused, as indicated by the strategy canvas, and is captured through a boolean variable, and Divergence shows whether the new value curve is different than the existing one(s), also captured by a boolean variable. The class adheres to the following constraint: Focus must be true and Divergence must be true when comparing NewValueCurve to IndustryValueCurve.
- Enterprise captures the organisation for which Blue Ocean Strategy is formulated.
- Resource captures the enterprise's offering to buyers, while Service and Product capture types of resources offered to buyers.
- Factor captures the key competing factors. This includes both the factors an industry currently competes on as well factors introduced to shape a blue ocean. Each factor carries an offering level attribute that captures the offering that buyers receive; high means buyers receive more and thus the enterprise invests more in that factor. For price, high offering level means a higher price.
- ValueCurve captures a graphic depiction of a company's relative performance across its industry's factors of competition.
- NewValueCurve captures a value curve capturing the value curve created by applying the four-action framework. This class adheres to the following constraint: an instance of NewValueCurve always ConsistsOf more instances of Factor than the ones that Shape instances of IndustryValueCurve due to the create action of the four action framework that introduces factors that existing market play does not capture.
- IndustryValueCurve captures a value curve where the industry currently competes on; it's used to build the new value curve and to confirm it constitutes a blue ocean strategy (evidence for comparison on focus and divergence).
- StrategyCanvas captures both the current state of play in a known market space, as well as the desired one. This class adheres to the constraint: an instance of StrategyCanvas includes at least two instances of ValueCurve, where at least one must be an instance of IndustryValueCurve and at least one must be an instance of NewValueCurve.

2.2 A reference model for i*

Since the introduction of i* in 1995 [9] several variants of the notation have emerged [14, 15, 16, 17, 18]. For this study the i* reference model [13] is chosen,

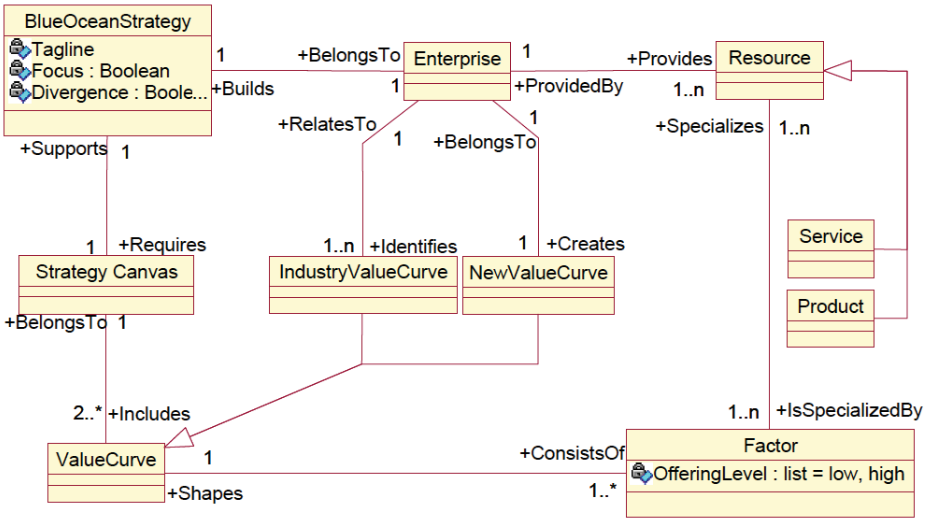

Fig. 2. The Blue Ocean Strategy meta-model (BOSMM).

because it allows the use of the aforementioned variants of the notation and to the best of the authors' knowledge it is the most comprehensive i* reference model, thus minimising the risk of excluding i* variants (e.g. the unified model of [19] captures only the original i* [9] and [15]). Additionally, this model has been built considering the possibility of new i* variants emerging and as such it is open to accommodate them by not being strictly restrictive considering the existing variations of certain concepts from different i* variants.

3 Mapping Blue Ocean to i*

Mapping Blue Ocean Strategy to i*, requires the concepts of BOSMM presented in Section 2 to be mapped to the concepts of the i* reference model when possible. When not possible, the lexicon of the reference model terms for i* is used to propose a basis for mapping:

– Enterprise from BOSMM is mapped to i*.Actor because it carries out actions to attain goals and may depend on other actors to attain these goals. An enterprise carries out actions to attain their goals, expressing their blue ocean strategy and depends on other enterprises to attain these goals by comparing their value curve with existing ones (from enterprises constituting the industry) which effectively express a desired state, thus a set of goals related to each factor that altogether constitute the value curve. This mapping also allows the use of actor with relationships is-part-of and is-a, therefore, when further refining enterprise actors within can be identified.

– BlueOceanStrategy is related to the parts of the SD and SR models relevant to blue ocean strategy. Therefore, it can be mapped to the derived SR, which includes a goal expressing the strategy's tagline, along with a task to achieve this goal, the resource offered to buyers and the set of goals and soft-goals stemming from the factors of the new value curve.
– Focus and Divergence are i* dependums expressed as goals for the tagline for blue ocean strategy, being focused and being divergent. Depender is the Enterprise to whom the new value curve BelongsTo and dependee is the Enterprise to whom the existing value curve RelatesTo. Focus and Divergence are true only if compared to existing value curves, thus making the enterprise dependent to other actors to confirm focus and divergence for blue ocean strategy.
– Factor is mapped to two i* elements: Goal and Soft-Goal. For a value curve, factors express a desired state to be achieved without neither specifying how nor being able to validate their satisfaction. This desired state is aligned with the definition of a goal or a soft-goal in i*, the former strictly referring to a desired state without knowing how to achieve it, the latter without being able to define their achievement a priori as true or false [13]. Such goals and soft-goals express enterprise intention in i*, therefore, formulating these should include both the factor itself as wells its offering level. For Southwest the goal Low Lounges be Provided is achieved by the task Provide Low on Lounges which uses the resource Lounges (Figure 3).
– Goals and soft-goals can be then decomposed in i* according to how factors are planned to be provided (not captured by the Strategy Canvas), thus capturing how they can be achieved. When mapping factors to goals and soft-goals, one should always check whether there exists a resource related to that factor, as it would influence that factor's analysis through decomposition in i*. In this case, a relevant task would be defined in i* and consequently through task decomposition, appropriate resources would be modeled.
– Resource is mapped to i*.IntentionalElement with Resource as IntentionalType but only for resources provided to customers, thus in a traditional i* model this would be the physical or informational entity provided by the enterprise to buyers, constituting the line of business for the enterprise.
– NewValueCurve captures the intentionality and rationale within the enterprise, which in i* is captured through the SR model apart from the goal expressing the tagline, the task being means to this goal and the resource required by this task. A new value curve of an enterprise is related to an SR model of this enterprise including its factors as goals or soft-goals.
– IndustryValueCurve captures the intentionality and rationale within the enterprise, which in i* is captured through the SR model. The existing value curve is mapped to an SR model of the actor enterprise other than the Enterprise for which blue ocean strategy is built, and includes the factors as goals/soft-goals that shape it.

Mappings are summarised and illustrated by the BOS of Southwest Airlines in Table 1.

Table 1. Proposed mappings

BOSMM	i*	Example for Southwest Airlines
Enterprise	*Actor*	*Southwest Airlines, Average Airlines and Car Transport are captured as actors in i* (Figure 3).*
BlueOceanStrategy	*SR model*	*The SR model for the actor Southwest Airlines.*
Focus and *Divergence*	*Dependum*	*Southwest depends on Average Airlines and Car Transport for its blue ocean strategy expressed by the goal: Airline Service with "The speed of a Plane at the Price of a Car-Whenever You Need It" be Provided to be focused and divergent thus good blue ocean strategy (Figure 3).*
Factor	*Goal* and *Soft-Goal*	*The factor "Price" from the strategy canvas becomes: i*.Node.Label:LowPriceBeOffered is-a i*.IntentionalElement.IntentionalType:Goal.*
Resource	*Resource*	*For Southwest the resource is Airline Services.*
NewValueCurve	*The SR model of the enterprise with its factors.*	*Southwests goals and soft-goal within its boundaries in figure 3 capture their offering; Southwest's NewValueCurve.*
IndustryValueCurve	*The SR model of other markets from the strategic canvas with their factors.*	*Existing value curves capturing the offerings of Average Airlines and Car Transport expressed by factors as goals/soft-goals, within the actors boundaries (Figure 3).*

The aforementioned mappings are operationalised into an i* SR model for Southwest Airlines including the dependencies to other actors that compete on existing offerings (Figure 3). i* addresses the early phase of requirements engineering aiming at understanding the rationale for a system and provides the modeling features to capture strategic rationale. The strategic rationale of BOS scopes the refinement around system goals by defining the highest level of goals set by the organisation. It is within that scope that systems serve some purpose. Capturing that scope allows the understanding of what needs to be done by the organisation. For example, the strategic offerings proposed by an enterprise, such as the goals and soft goals for Southwest Airlines.

Thereafter, organisational actors influencing the goals set as well as their achievement can be identified, intentional elements (goals, soft-goals, resources, tasks) can be refined (the SD model) [20]. For example, within the organisational boundaries of Southwest Airlines all actors influencing the goals and soft goals set need to be identified, as well as all their dependencies.

Furthermore, actors can be refined to capture their intentionality and provide means of analysis for achieving something by identifying workability of achieving that something by decomposition of tasks and means-ends links, by checking viability of achieving that something based on some quality conditions, etc. For example, goals and soft goals set need to be decomposed through means-end and contribution links into goals, soft goals, tasks, and resources, similarly to the goal "Low lounges be provided" of Southwest Airlines (Figure 3). These decompositions eventually allow identifying, and establishing dependencies with, actors who can accomplish a goal, carry out a task, or deliver some needed resources.

This early phase of requirements is input to the late phase of requirements. For example, [21] proposes a set of guidelines to map i* models to UML use case diagrams, where the use of i* to derive use cases allows traceability and evaluation of the impact into the functional requirements of the intended system; use cases are derived from the actors' perspective, as well as from the explicitly captured actor dependencies of i*.

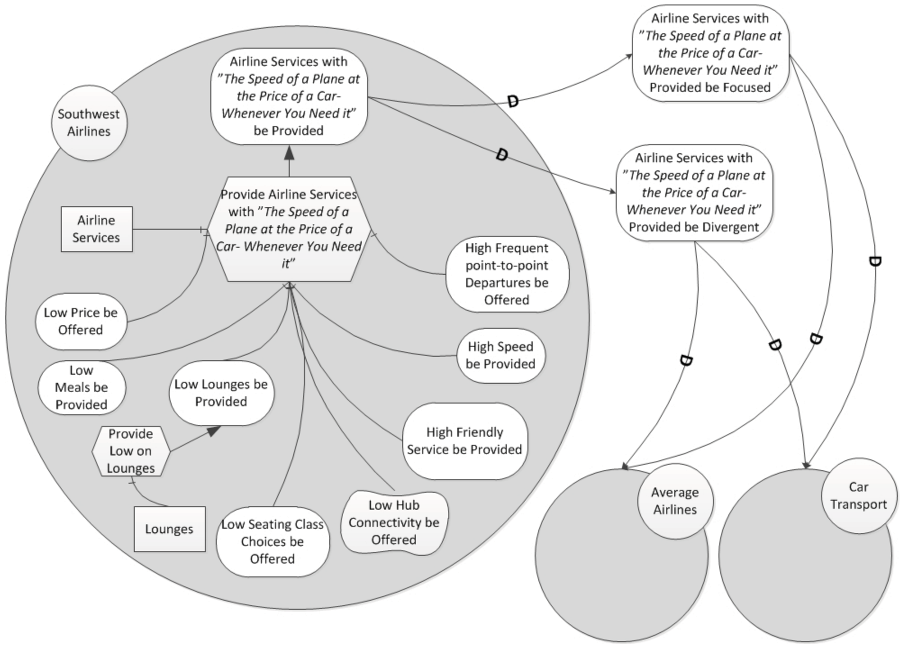

Fig. 3. The Blue Ocean Strategy of Southwest Airlines in i*.

4 Discussion and Future Work

The goal of this study was to map a business strategy formulation belonging to the Shumpeterian (i.e. innovation) view, exemplified by Blue Ocean Strategy, to a technique used in requirements engineering, exemplified by i*. Model-based mappings between the two formulations were created to facilitate both informal and semi-formal relationships of the two abstractions. Conceptualisations of i* already exist, and a wide-used one in the means of a reference model, has been chosen. However, no conceptualisation existed for Blue Ocean Strategy; therefore, such conceptualisation has been built into a set of defined notions and associations between them in the form of a conceptual model (BOSMM) aimed at decreasing ambiguity thus allowing model-level mappings towards i*. Consequently, the concepts of BOSMM have been mapped to i* and exemplified by a BOS from the airline industry, Southwest Airlines.

The proposed mappings constitute the main contribution of this work because they provide an initial set of strategic innovation rational serving as a frame for developing systems aimed at actualising such strategic initiatives. Thus they provide information systems development with an early-phase requirements model expressed in i* that captures the strategic rational within which the system of interest is developed.

Mapping Blue Ocean Strategy to i* leverages from the notation's ability to identify links between the actors and intentional elements. Once Blue Ocean is laid out as an i* model, all possible links provided by the notation, means-end, decomposition and contribution can be identified revealing relationships that could not otherwise have been foreseen (e.g. dependencies, conflicting goals, negative contributions, etc.). Moreover, using the i* reference model [13] for the proposed mappings allows for exploring concepts from other variants of the notation or proposals that can be relevant to strategy. For example, Formal Tropos [16] includes temporal aspects formally expressed allowing the assessment of temporal synchronisations between actors, or precedence and preference rules [22], also relevant in business strategy formulations like Blue Ocean. Such use of i* can provide an additional assessment mechanism for business strategy from the IS perspective.

Additionally, contribution of this work lies also on the conceptualisation of Blue Ocean Strategy. BOSMM can be linked to other enterprise models allowing business-IT alignment efforts to leverage from such model-based linkage. It enhances traceability between business strategy and the system-to-be, which in turn allows (by considering cause/effect relationship) their fine-tuning. Also strategy communication among actors is enhanced allowing a better understanding of IS capabilities and the solutions IT is capable of providing, which supports business strategy formulation. Furthermore, BOSMM supports the integration with business strategy formulations facilitating the other two aspects of strategic planning (i.e. resource- and industrial organisation views) as mentioned in the Introduction of this study, allowing them to complement each other and IS to support such integration. An effort in this direction has been reported in [23], where well-established business strategy formulations from the aforementioned strategic planning perspectives, SMBSC and the Value Chain, have been integrated into a Unified Business Strategy Meta-Model (UBSMM).

Steps forward in this work have many possible directions as this is a first proposal for such conceptualisation and mappings. From one side more depth in the current work can be pursued, while on the other hand further extensions can be also derived.

The contributions of this study can be further assesses for correctness, both BOSMM and the mappings to i*, through structured reviews with practitioners. For example involving business strategists in the conceptualisation process of BOS. Additional case examples can be conducted to allow for more the assessment of the proposed mappings towards a distinct system being developed, resulting into additional iterations for the refinement of such mappings. Both on the semantic level, correspondences between a real BOS and BOSMM, and the syntactic level, model checking for BOSMM, as well as the pragmatic level, practitioners' interpretation of BOSMM.

The proposed mappings can be extended further than the i* reference model towards particular variants of the notation. Real case evaluations to reflect strategic innovation from Blue Ocean Strategy to system-to-be requirements will be beneficial for the mappings. Another possible direction of this work is within business strategy modeling by using BOSMM to explore its integration capabilities with other business strategy formulations and various enterprise architectures.

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