Jyrki Nummenmaa and Eva Söderström (eds.)

Proceedings of the 6th International Conference on Perspectives in Business Information Research - BIR'2007

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Preface

Welcome to Business Informatics Research 2007 (BIR 2007) in Tampere, Finland. This is the 6th BIR conference and the first one to be hosted in Finland. Previous BIR conferences have been held in Rostock (2000), Berlin (2003), Rostock again (2004), Skövde (2005), and Kaunas (2006). BIR is known for an atmosphere that fosters discussion and interaction between participants, as well as spurring new research connections.

Information and Communication Technology (ICT) plays an increasingly important role in organisations and inter-organisational networks. The world is becoming increasingly complex in terms of requirements for the "right" connections, at the "right" time, with the "right" resources, all with an appropriate degree of flexibility and adaptability. Business and people daily activities are dependent on complex, distributed software systems operating in dynamic and often unpredictably changing environments. It is in this context that business informatics research is essential. BIR aims to be a forum for research results from senior researchers as well as from PhD students. We strive to have a mix of papers dealing with various aspects of the area of business informatics. This year's theme is making businesses, people and systems inter-operable and adaptive in highly interconnected and changing contexts.

The contributions to BIR 2007 consist of 13 full papers, spanning several topic areas in the light of the inter-operability theme. The conference also has poster presentations. All together, it is our belief that these contributions will significantly contribute to the interactive atmosphere of BIR conferences.

Once more, a warm welcome to BIR 2007!

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Table of Contents

A suggestion for improvement of program code generators

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Abstract*1*. This article analyses the principles behind construction and use of program code generators, identifies their limitations and suggests a way to achieve automatic configuration of program code generators, that has a potential to make their use easier and more widespread.

Keywords. CASE, MDA, program code generators.

1 Introduction

Program code generators are used in model based software development processes, such as MDA (*Model Driven Architecture*) or MDE (*Model Driven Engineering*), to automate the translation of abstract models to corresponding program code [1], [2].

This article analyses the principles behind construction and use of program code generators, identifies their limitations and suggests a way to achieve automatic configuration of program code generators, that has a potential to make their use easier and more widespread.

2 Use of program code generators

When used in model based software development processes, program code generators automate translation of program models to program code in desired implementation language and platform. This allows to save human work hours and avoid some implementation mistakes that would be done if corresponding parts of program model would be converted to program code by hand [6]. Usually program code, generated from models, is not complete and has to be complemented manually.

There are integrated program code generators that come together with modeling tools such *MagicDraw UML* or *ArcStyler* and standalone program code generators such as *OptimalJ* or *AndroMDA* that can be configured to interpret models expressed in some language [5].

1 The work is supported by Lithuanian State Science and Studies Foundation according to High Technology Development Program Project "VeTIS" (Reg. No. B-07042)

Some of integrated program code generators such as the one, embedded in *MagicDraw UML*, are not user configurable beyond selecting from a set of predefined implementation languages and platforms. When a non user-configurable program code generator is involved, the software development process can be described by the following steps:

- modeling the software being developed;
- generating the program code;
- manually inserting the missing code;
- testing and reverse engineering back to model.

Sequences of aforementioned steps are repeated as necessary until the resulting code does what it is supposed to do.

All observed standalone program code generators and some integrated ones such as the one embedded in *ArcStyler* are user-configurable. This means that users can introduce new implementation languages and platforms into a program code generator configuration or significantly modify existing ones.

When user configurable program code generator is used, software development process can be illustrated by the following algorithm:

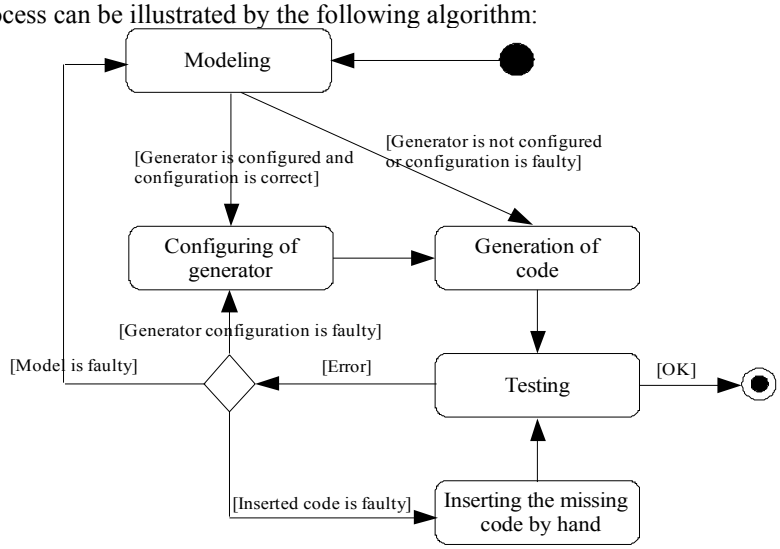

Fig 1. Software development process when user configurable program code generator is used

According to Figure 1 - when user configurable program code generator is used and user is not in possession of suitable configuration, it must be iteratively developed together with the rest of the program.

Vendors of user configurable program code generators usually ship them with predefined configurations for at least one programming language and one implementation platform. Predefined configurations can be used directly or serve as templates for user made configurations.

3 Construction of program code generators

In an abstract way, program code generators can be interpreted as rule engines [3]. A generator configuration consists from a set of rules. Each rule has a left-hand side, defining when rule should be applied and a right-hand side, defining what happens when the rule is applied. A generator, as a rule engine, manages such things as rule application, conflict resolution, rule application stages and so on [3].

When it comes to concrete implementation, generators can be classified as visitor-based and template-based [3]. Visitor-based generators interpret a given model by visiting it's elements in a predefined pattern, which depends on a modeling language being used, and performing code generation for each element visited [3].

Template-based generators use program code templates that specify parameterized representations of meta-model elements in a program code and additionally have constructs calling outside methods that perform the necessary processing of the model and inter-template bindings [3]. If some template language lacks constructs for aforementioned tasks, these tasks must be implemented in separate control scripts. [3] outlines frame-based code generation [4] as a distinct variation of template-based one.

In the context of this article, it is important to consider abstract data flows necessary to perform program code generation [7]. These data flows are displayed in a following figure:

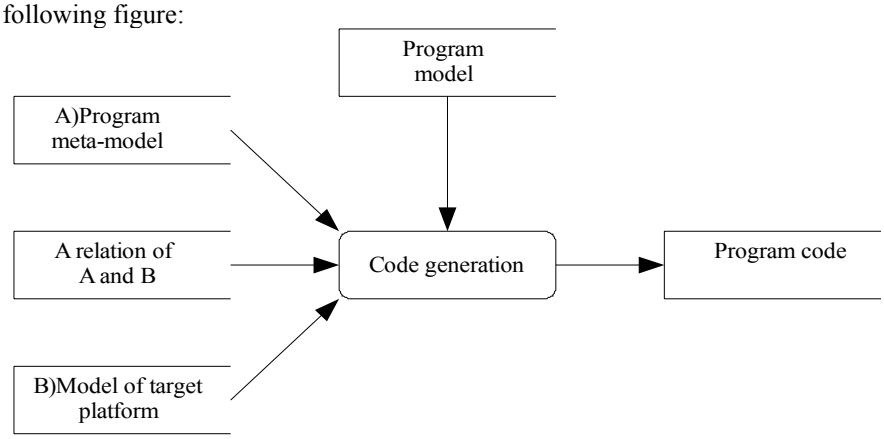

Fig 2. Data flow diagram illustrating an abstract program code generator

As can be seen from Figure 2, program code generator must posses information about:

1. Program meta-model. Information about a program meta-model is necessary for interpretation of program model.
2. Model of a target platform. Information about the target platform model is necessary for generation of code suited specifically for that target platform. An implementation language is considered a part of the target platform.

3. A relation between the program meta-model and the model of the target platform. This information is necessary to convert program model artifacts to target platform artifacts.

4 Limitations of program code generators

There are two limitations related with program code generators: it takes a lot of work to configure them and they require implementation platform expertise to make a correct configuration [6].

The cause of huge work, required to configure a program code generator can be seen in figure 2. For any non-trivial implementation, describing model of target platform and it's relation with program meta-model involves a lot of manual work [7]. This is further complicated by the fact that platforms changing and configurations are not directly reusable in different projects.

The requirement of implementation platform expertise to make a correct configuration is quite obvious, because if a user has no deep knowledge of target platform, he will be unable to create an accurate platform model in his mind and produce a correct translation from program model artifacts to implementation platform artifacts. In such case, user will have to make a lot of manual work in evolving his code generator configuration to the optimal state and this may discourage from using code generator at all.

5 Suggestion for improvement of program code generators

We suggest a method that would enable the automatic configuration of program code generator. This method would remove a lot of manual work currently required to produce a program code generator configuration an ease the process of evolving program code generator configuration to the optimal state.

An idea of the method is as follows: lets assume that user makes a model of software being developed and starts to implement it by hand. Program code generator would track user's implementation of program model, detect implementation patterns for program meta-model entities and their relations and automatically generate code for yet unimplemented parts of program model that are instances of recognized meta-model entities and their relations.

To achieve this, user-written parts of program would be reverse-engineered back to the level of abstraction held by program's original model. The reverse engineered model and the original model would be compared and corresponding elements detected. By analyzing reverse engineering traces, program code implementing those elements would be found, and patterns for implementation of corresponding program meta-model elements and their relations would be extracted. Those patterns would be used to automatically generate program code for yet unimplemented instances of program meta-model entities and their relations.

Currently, the concrete algorithms and methods for implementing the aforementioned steps remain to be constructed or devised.

6 Related works

There are a lot of works related with program code generation and a lot of program code generators [3], [5]. Currently those program code generators have to be configured by hand.

There are a lot of works in a field of reverse engineering [8] that may be helpful when implementing the proposed method. Examples of static and dynamic analysis of reverse engineered programs can be found in [11], examples of rule based reverse engineering are presented in [9],[10].

Some of semantic web related methods offer interesting ideas for managing information and describing software systems, such as the one described in [12].

All of these works should provide at least some stepping stones necessary to achieve automatic configuration of a program code generator.

7 Conclusions

An analysis of construction and use of program code generators allowed to identify that the limiting factors of their use are requirement to manually enter a big amount of information when configuring a code generator to the needs of particular projects and inability to easily evolve program code generator configuration to the optimal state.

This paper proposes to configure program code generators automatically by observing the user provided partial implementation of software system being modeled. It also describes the abstract method for achieving such automatic program code generation configuration.

Ability to automatically configure program code generators would ease their adoption in new domains and provide for easier development of optimal configurations.

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An Evaluation of a KM Diagnostic Instrument

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Abstract. Knowledge management is today an established approach to improve and renew organizations. The right use of information systems are often essential element in a successful KM strategy, however creating the right mix of KM activities and system is difficult and failures are frequent. Getting a good grip of the current situation and the special condition of the organization is therefore essential. In this paper we study an initiating questionnaire, taken from the KM literature, with a background in US management consulting industry. The aim of the paper is to evaluate the questionnaire, from a Swedish perspective. This is done with the aim to search for more general advice for anyone wanting to adapt and use such a questionnaire in their own situation. For this purpose, a number of applications of the questionnaire is presented and investigated. The outcome of the study is an initial assessment of the usefulness of the questionnaire and some recommendations for further use and research into the questionnaire. The usefulness seems to depend on the situation of persons that the questionnaire is given to. The analysis shows that the questionnaire seems to fit rather well to companies that were included in the study, especially on a management level. However, some possible problem areas were also discovered, the background, motivation and work situation of some personnel group could interfere with the effectiveness of the questionnaire.

Keywords: Knowledge Management, Evaluation, Questionnaire

1 Introduction

Knowledge management (KM), as an organizational activity, has many shapes and forms. The area ranges from the use of computer software to culture building activities and acquisition of patents. There seems to be a growing consensus, both in academia and business about the necessity of good KM practices. However, studies indicate that the level of user satisfaction with KM as management tool is very low [1, 2]. In 2001, KM came in as the least satisfactory among the 25 most used management tools, and in 2005 it is still close to the bottom of this set regarding user satisfaction. This would indicate a need for instruments to evaluate, assess and diagnose KM activities in organizations, as complement to studies of creation, distribution and use aspects of KM that have been emphasized in previous research. There are some signs of such a development taking place in the emergence of KM performance measurement frameworks, often using quantitative measures [3].

In this paper we evaluate a diagnostic instrument for assessing KM related activities in organizations; a survey that is presented as practical tool that accompanies a "Knowledge management field book" [4]. The survey builds upon a rather common KM cycle model as used in consultancy practice, consisting of 140 questions that include anything from when and how IT is used to cultural issues related to organizational knowledge and learning.

Our research set out to assess the usefulness of this instrument outside of its original cultural and organizational context which is that of large US firms. As source of empirical material for the study we use a selection of Swedish companies, intended to cover a spectrum of businesses and company sizes ranging from departments in large, manufacturing Swedish industries to small SME's.

Considering the globalization of businesses and the need to assess and develop KM capabilities, it would be highly desirable if instruments like this prove to be useful across cultural barriers and yield meaningful and comparable results. The work is done with the intention that this Swedish experience should provide lessons for the conversion of the questionnaire also into other cultural settings.

2 Background Theory

2.1 KM Strategy Framework

Knowledge management is a broad area and many kinds of topics and aspects could be taken. In this paper we assume the context of a strategic planning process, implying an overall objective to produce of a set of KM-projects (initiatives, systems, etc) in which the organization should invest time, money and competences. To be successful, it is assumed that the individual KM projects need to be aligned not only with the business strategy but also with 'soft' aspects of the organization, such as leadership style, attitudes and expectations concerning sharing of knowledge and expertise, incentive systems and so forth [5]. The survey investigated in this paper is examined in its role as a diagnostic tool for assessing organizational factors in this broad sense. Embedded in the survey in its original context are a number of assumptions of what is important and 'good' regarding the measured factors. This is reflected in the way the survey results are added up to produce a score on the total KM performance, and also in the way the questions are asked – a higher degree of agreement on each of the questions are supposed to indicate better KM performance. However, we intentionally leave that aspect out of the picture in this paper, merely asking if the survey can be used as an instrument in Swedish organizations to give a useful view on organizational conditions relevant to choosing a KM strategy.

2.2 KM in Sweden

Previous research suggests that the Swedish approach to knowledge management has its own particular flavor. Alarik and Diedrich [6] made an interview study of a CEO's

of a number of Swedish companies working on a global market. The interviews where made with leading officers in areas like personnel, competence development and IT. The outcome provides us a profile of how KM is understood, pointing out a number of factors as significant. 1) An open social climate, where people feel secure and being an important part of the company. 2) Management should be emphatic, show trust towards employees and be good listeners. 3) Incentives and reward systems are needed for stimulating good behavior. 4) Creating and stimulating networks and networking among personnel. 5) Finding and placing the right person on the right position. The use of IT and the now "traditional" technical KM solutions is not emphasized in the investigated companies. Rather, it tends to be given a supporting role - the premises for successful KM results are characterized mainly by the 'soft' points indicated above. Another interesting finding was that specialized KM roles and a special knowledge management organization did typically not exist in these companies.

2.3 Knowing in practice and social learning

An important aspect when studying KM practices, where knowledge is created and shared, is to recognize the social dimensions of these practices. Here we draw upon the work of Orlikowski [7] and Wenger [8] to further our understanding of how people perform in order to better explain the outcome of our questionnaire.

The work of Orlikowski [7] focuses upon the processes of organizational knowing rather than knowledge as such. She sees organizational knowing as emerging from the ongoing and situated actions of organizational members as they engage the world, thus highlighting the role of human actions in knowing how to get the work done.

The work of Wenger [8] concerns communities of practice and social learning systems. He sees the knowing in practice as intimately coupled with the process of forming identities that may give information gained within the practice a coherent form of participation, thus forming a social learning system. The belonging to a social learning system can take various forms at various levels of interaction with it, such as engagement, imagination, and alignment. Engagement entails doing things together, talking and producing artifacts. Our experience of who we are, is shaped through the engagement in the practice, a sense of identity is established as well as what is doable or not. Imagination involves constructing an image of oneself, of one's communities and of the world in order to orient one self, to reflect on one's situation and explore possibilities. Alignment entails mutual processes of coordinating perspectives, interpretations and actions to realize higher goals. It is in combining the modes of belonging that learning-communities may come to exhibit specific characteristics of their practices. The combination of both engagement and imagination brings about a reflective practice. The combination of imagination and alignment provide us with the ability to act with respect to a broad and rich picture of the world. Through the combination of the modes of engagement and alignment we become able to better bring together different perspectives of the world and create shared/mutual meaning.

2.4 KM and National Cultures

Organizational culture is a central aspect of KM success. There are general studies that could us help us to understand our special conditions. Swedish culture has been characterized in studies by Hofstede [9, p. 54). Hofstede suggests four aspects of culture, which can be used to describe the culture of a nation. The four aspects include: power distance, individualism, genus, and uncertainty avoidance. We provide a closer explanation of these together with the analysis in section 5.2. All the measures of Hofstede are relative indexes, comparing countries to each other. There have of course been critiques against Hofstede's cultural indexes. However for this initiating test of the instrument we hope that these cultural indexes will be sufficient.

2.5 The KM Survey

Bukowitz and Williams [4] present a diagnostic tool, a survey, for the assessment of the current KM situation of a company. It is comprised of 140 questions that measure the respondent's degree of agreement with statements about how the company deals with issues of knowledge sharing and learning.

The questions are designed to indicate organizational performance in areas that relates to common ways of conceptualizing KM processes. These areas are modeled by the following seven constructs, each of which is addressed by 20 questions.

1. *Get* – IT has provided access to much more information than before. The challenge for organizations is to provide individuals and teams with tools enabling the right information to be found when needed. Examples of survey statements addressing this construct are: "People only request information when they really need it", and "when people are given the task of searching for information they are able to fulfill the request".
2. *Use* – new sources of knowledge and insights require organizations to establish an environment that stimulates creative use of information. Examples of survey statements for this constructs: "office space is not used as a symbol of status or seniority in our organization", and "anyone who has a good idea can get support to follow it up".
3. *Learn* – dealing with how open the company is for learning, how it deals with lessons learned and failures. Examples of statements: "In our organization failure is considered an opportunity to learn"; "people admit when they fail".
4. *Contribute* – covering questions how people contribute with personal knowledge and their attitudes towards collaboration and sharing of ideas. Statements relating to this constructs are, for instance, "people are members of multiple communities, making it easier to transfer knowledge across the entire organization"; "face-to-face interaction is used to strengthen electronic communications".
5. *Assess* – How the organizational contribution of the knowledge assets is assessed and measured. Examples of questions: "people know what metrics are used to monitor the knowledge management process and its results"; "we recognize that knowledge is part of our asset base".
6. *Build/Sustain* – How the knowledge assets are developed and managed for future competitive power. Statement examples from the survey: "our formal and

informal values are aligned"; "our organization treats people like assets rather than costs".

7. *Divest* – This relates to the fact that knowledge assets are not free to keep and maintain for the organization. From the organizational point of view the question is to determine how and when to dispossess knowledge assets that will be unnecessary for sustaining competitive advantage. Examples of statements: "we apprentice our people to other organizations to determine if we need to acquire new skills or expertise"; "we may refuse to work for a customer if doing the work does not build knowledge that we can use in other ways".

Together, the questions cover a very broad area of the KM spectrum. Considering previous research indicating specific Swedish ways of dealing with these issues, our evaluation focuses on two aspects of the survey; 1) are the questions relevant for Swedish organizations (possible to understand and give answers to), and 2) internal reliability, i.e., are the questions addressing the intended constructs in our intended context of use, here Swedish organizations.

3 Research Strategy and Empirical Method

To achieve the research objectives for this paper, the work was divided into three major phases. First, a start up phase, here the survey was reworked (translated) into Swedish and an initial analysis of the relevance of the questions were made. This phase included preparations for evaluating validity and reliability of the survey. We chose to work with two classes of reliability estimation, parallel forms and internal consistency reliability. In the second phase the survey was applied on a number of companies, providing the project with empirical material. The third phase concerned an analysis of the empirical material.

Phase 1: startup

The translation of the questions was done in collaboration between the authors in a series of group sessions. A lot of debating was generated around many of the survey questions; it was not very difficult to translate but we had a sense that things were lost in translation, referring to rather academic phenomena that we feared was not among the things that people in Swedish organizations recognize. This prompted considerations about how to best prepare for assessments of validity and reliability, and suitable approaches were discussed with researchers external to this process. Two main reliability estimates were chosen. First, the parallel forms estimate, in which the questions relating to each of our seven constructs are randomly divided in half, thus, producing two surveys that are assumed to be equivalent. The outcome of this process was some remaining doubts about the usefulness of the survey, including the large number of questions concerning the formulation/language used. This resulted in a slight change of plan, from doing a larger survey directed towards some hundreds of companies to a smaller pre-study. This smaller pre-study is reported in this paper.

Phase 2: data collection

The empirical method, in short, includes two case studies where the survey has been used. The first one was aimed at chief officers, with responsibilities for personnel. The CEOs came from a number of smaller companies. The second one was

aimed at ordinary staff members of two different departments of a larger company. The practical distribution and collection of empirical material was performed by students groups under the supervision of the authors.

Phase 3: analysis

Two approaches for evaluation were taken, internal (consistency of the questions) and contextual (relevance of the questions).

For the internal evaluation of the survey a split-half technique was used. This is a rather basic technique used to discover systematic problems among the questions. Here we work with a parallel forms test and only perform a pre-test. By using split-half reliability we create an instrument that is intended to be used as a single measurement instrument. The 140 questions were divided into two groups, with 70 questions in each. If the two halves correlate, no major deviations between them should show. The contextual evaluation consisted of two analyses of the two target groups' respective organizational situations, with regard to how they perceived and received the questionnaire.

4 Empirical Case Studies

The empirical material consists of two sets of survey studies, where each set was split into two halves. The first set was directed towards a group of CEOs distributed amongst small and medium sized companies within the Kronoberg region of southern Sweden, and the second set was directed towards a group of the staff at one of the major manufacturing company within the same region.

The results from the comparisons of each of the respective set's halves are presented in their respective tables, see table 1 and 2 below. The figures in column 2 and 3 of each table shows how the two different split-halves score per section of the questionnaire in relation to the highest score possible to achieve i.e. when they fully agree with the statements presented. The figures may be interpreted as percentages.

4.1 CEO Survey

The CEO survey was conducted at a number of small and medium sized consultancy or manufacturing companies with head offices and markets in the Kronoberg region in southern Sweden. The study targets managers having a distinct responsibility of personnel. The purpose of the survey was to investigate the perception of the management towards ideas, attitudes and practices concerning knowledge and competence. The survey was conducted by students over a two-year period, 2005-2006. In total 12 number of companies were investigated and 23 questionnaires were distributed. The questionnaires were somewhat unevenly distributed between the managers in the different companies. 15 managers were given the split-half 1 questionnaire and 8 were given the split-half 2 questionnaire. All of the questionnaires distributed were gathered. In table 1, we compare the outcome of the two split-halves and to what extent they differed in any way.

Table 1 – Comparing split-halves of the CEO survey

KM Perspective	Split-half 1 15 surveys	Split-half 2 8 surveys	Differences
1. Get	0,772	0,7425	0,0295
2. Use	0,668	0,7175	-0,0495
3. Learn	0,816	0,7325	0,0835
4. Contribute	0,687	0,7225	-0,0355
5. Assess	0,729	0,7925	-0,0635
6. Build/Sustain	0,691	0,7175	-0,0265
7. Divest	0,657	0,715	-0,058

As seen in table 1, the scores from the different section were relatively high, between 66% - 82% and the differences between the two halves relatively low, between 3% - 8%. In 5.1.1 we look closer on the possible reasons for this outcome.

4.2 Staff Survey

The staff survey was conducted at a larger manufacturing company in Sweden in the region of Kronoberg. The survey was performed at two departments in co-operation with the heads of the departments. The work was conducted as a bachelor thesis [10]. Here we try build on that material for further analysis and conclusions on certain aspects of that survey, i.e. finding out how well the instrument performed.

The distribution of the questionnaire was sanctioned by the head of the departments, and was viewed as part of the departmental work. The survey was presented at department meetings and the questionnaires were handed out to the participants. A rather high turn was expected, and 75 % was collected. This is of course acceptable in general, but maybe it could have been even higher. The two departments differed a bit, one consisted more of blue-collar (manual) workers and the other hade more white-collar (office) workers. In total 32 questionnaires were distributed and 24 were collected. In table 2, we compare the outcome of the two split-halves and to what extent they differed in any way.

Table 2 – Comparing split-halves of the staff survey

KM Perspective	Split-half 1 11 surveys	Split-half 2 13 surveys	Differences
1. Get	0,609	0,517	0,092

2.	Use	0,633	0,454	0,179
3.	Learn	0,531	0,482	0,049
4.	Contribute	0,529	0,44	0,089
5.	Assess	0,456	0,418	0,038
6.	Build/Sustain	0,696	0,486	0,21
7.	Divest	0,524	0,415	0,109

There are some differences to be noted between the departments, but no clear pattern other than what could be seen in the combined analysis, showing that the first split-half scores are relatively higher in some sections. As seen in table 2 the scores from the different section were relatively lower than those compared to table 1, between 42% - 70% and the differences between the two halves relatively high, between 4% - 21%, with a more distinct variance between the sections. In 5.1.2 we look closer on the possible reasons for this outcome.

5 Results

The evaluation is divided into an internal and a contextual perspective.

5.1 Internal Evaluation

Here we look at our two studies, first separately and then in context of each other. We compare the results of the two halves of both the surveys in order to uncover any weaknesses in the instrument and its applicability.

5.1.1 The Split-half Test – CEO's

The outcome of the comparison between the two sets of surveys (distributed to the CEO's) shows that there is a rather good consistency between these sets. Having a look at table 1 we see, as has been noted in section 4.1, that the two halves correlate very well judging from the differences of scores. Even though the halves were unevenly distributed, the number distributed of each of halves was deemed to be sufficiently high as not to affect the overall results. Had there been any one major deviation, which there was not, it would have affected the end result very little.

As is shown in the table 1 the scores were not only high but evenly distributed amongst all of the section of the questionnaire. The scores ranged from between 66% - 88%, and lie well within the limits considered appropriate by Bukowitz and Williams [4] related to their original questionnaire. When they performed similar investigations, as ours, they received results between 30% - 70% with a mean of 55%.

There was in general not noted that any section was deemed more important than any other. This could reveal to us that managers are aware of the complexity of KM activities and have a good understanding of what they involve, as well as their importance, individually and in relation to each other.

From the surveys of the CEOs there were not explicitly gathered any reactions from the respondents pointing upon how they experienced the questionnaire, if they found the questions difficult understand or how the perceived their rationale. This is probably due to the fact that the purpose of the survey was not to evaluate the questionnaire as such, but to use it as an instrument for assessing the attitudes of the companies involved towards, and their level of awareness of, KM initiatives. However, judging from the high percentage of responses received from this group and the high scores given within each section of the questionnaire see table 1, there appears to be no trouble in understanding and being motivated in filling out the questionnaire. This could of course be explained by the fact that the group of respondents were highly aware of the importance of paying attention to the issues dealt with within the questionnaire and also showing a high degree of formal schooling, thus more accustomed to the format of the questionnaire.

5.1.2 The Split-half Test – Workers

Josefsson and Tideman [10] draw the conclusion that the instrument has some problem when used on this group of people. The comparison between the different halves showed some interesting results. One of the halves (the second split-half) has a lower mean and also has more completely blank questionnaires. For example, the second split-half has 20% of blanks, while the first split-half has just a few blanks. The main reasons, given by Josfesson and Tideman [10], include perspectives like: who is asked and their background, the issues discussed and the language used.

A detailed study of the material shows a difference in the population that answered the second split-half. These people where older and had longer time of employment.

There are three areas that have lower turnout, i.e. more blanks and lower means. These are “divest, build and assess”, which have a more explicit management perspective to them. It is within these questions that more blanks and lower means than among other groups of questions.

The sheer number of questions, 70 per split-half, might also contribute to a lower mean. For example, the KM aspect “Get” had a high number of questions among the last 10 question of the questionnaire, and did get a lower mean. The long questionnaire may have contributed to this very outcome.

Comments on the questionnaire were gathered explicitly through a commentary page at the end of the questionnaire. Even though Josefsson and Tideman [10] point out that the number of such commentary pages gathered was not high, it was still possible to draw some conclusions. They point out that most of the commentaries are related to the language and the manner in which the questions were formulated. The language used seems to have bothered the respondents. Concerning the language, there was a higher degree of difficult questions noted in one of the halves, the second split-half. This was pointed in the commentary section of the questionnaire; where free-text questions gave the respondents room to give their thoughts on the questionnaire. The commentary section included comments like: “difficult language, to long sentences, hard to understand the meaning”, and so on. The questionnaire was

perceived to have sentences that were too long, with difficult words, thus making the questions hard to interpret. Some respondents within the group had wanted the questions formulated in a more straightforward manner or perhaps that they should have been better adjusted to the different departments. There where also an additional comment in an informal interview with one person with an up-to-date education in business administration, who thought the questions were good and generally interesting.

Josefsson and Tideman [10] partly agree with the critique above as they also found the language too academic and sometimes difficult to interpret. They found that the questionnaire was perhaps not well adjusted to the two departments of the company. However, they state that the generality of the questions is such that they should be applicable to most Swedish organizations

Examples of problematic question can unfortunately not be given as they were all formulated in Swedish, and translating them back to English would loose some of the meaning and flavor that could indicate why they were perceived as problematic. Some indications to the problems perceived of the questions may be seen in table 2. The relative high discrepancies between the two halves, as compared to table 1, and the lower scores received within the respective sections of the questionnaire may point in this direction.

One thing to take note of is that the group of workers examined was not a homogenous group, there were differences noted between the different departments although no clear pattern to this was discernable. However, the two halves of the questionnaire was distributed evenly between the subgroups of workers at the different departments, thus no subgroup was overly represented within one half. The subgroup of office workers had a higher proportion of senior males, with longer service time at the company, and the subgroup of manual workers had a higher proportion of younger females. However nothing conclusive could be drawn from this distinction, not even level of education.

5.1.3 Comparing the two Studies

There is a limited value of comparing these two rather different studies. The CEO study is made in a number of companies, while the staff survey is made in one larger company. However, the fact that there is a clear difference between the two groups is a potentially important issue for future research. The CEO's seems to have a more favorable view of the KM situation in their company then the ordinary staff. This might be rather unsurprising given the topic of the management of knowledge and that it is designed to be a task for managers.

That the reactions from the group of workers towards the questionnaire seem to differ from how the group of CEOs perceived it may be explained by such cultural factors as discussed in section 5.2.2. They could also be explained by such factors as level of education, most workers had no formal higher schooling, and the level of awareness concerning the importance of paying attention to such issues as were revealed within the questionnaire. The latter could perhaps be due to that these issues were regarded as being within the provenance of management. The group of workers as a whole had in general a lower level of formal education as compared to the group of CEOs. The questionnaires gathered from the staff survey had a higher proportion of blanks, i.e. not answered questions, in comparison to the CEO survey. This could

perhaps hint at differences in attitude towards the questionnaire in general, as discussed in section 5.2.2, when compared to the group of CEOs.

5.2 Contextual Evaluation

In this section we look at the effectiveness of the questionnaire in relation to the situation that it was used in.

5.2.1 Knowing in Practice and Social Learning

The questionnaire used as an instrument for assessing the attitudes towards knowledge management seems better suited to the CEO group. The original instrument constructed by Bukowitz and Williams [4] was targeted for managers and well tested. The scores of table 1 reveal to us the high acceptance it received within the CEO group. There could of course have remained questions concerning whether it suited Swedish companies and function in Swedish cultural context. It is not obvious that one can take an instrument such as the questionnaire, constructed under other cultural contextual conditions and transfer it to another. But, again the scores of table 1 reveal to us the opposite. The instrument works well in a Swedish cultural context, at least at an organizational managerial level.

In the case of the staff group the situation is quite different. One can expect them not to be as acquainted to the format of the questionnaire and familiar with the issues as it is not directly constructed to target workers and office clerks. But, even though we have some evidence hinting that it might be questionable to use this instrument on groups of people such as members of the staff, it is still necessary to understand why it would not function well in order to adjust for that in future studies. It could be the case that aspects are missing from the questionnaire, that had they been considered might have provided us with an instrument more relevant and relatable to the members of the staff group, thus yielding higher scores.

To shed some light on this we turn to the work of Orlikowski [7] on knowing in practice and the work of Wenger [8] on communities of practice and social learning systems. From the work of Orlikowski [7] we come to understand that from the workers point of view issues of competence, skillfulness, sharing and learning is a matter of situated social learning. According to Wenger [8], the belonging to a social learning system can take various forms at various levels of interaction with it. He distinguishes between the following modes of belonging: engagement, imagination, alignment, and especially their combinations. These combinations of modes must to some extent be addressed throughout the questionnaire in order to cover issues that are both relevant for and relatable to the members of the group of workers. So the question is if the statements of the questionnaire do cover issues related to these combinations of modes. Going through the statements of the questionnaire of each activity section we find that roughly half of the statement may be considered as more social or practice oriented, expect for the section Asses. It contained mostly statements that could be viewed as highly formal or organization oriented. This section also got one the lowest score of all the other sections. Most of the statements of the other sections that could be considered social or practice oriented seem to relate more to the mode of engagement or its combination with imagination, a reflective

practice. It seems that the questionnaire may have been biased towards managerial organizational concerns of working together and learning from experiences.

An example of a statement that could be viewed as related to a reflective practice is: "Reflecting on lessons learned from work experiences is an established practice in our organization". However, it belonged to the section Learn and this section did not get an especially high score as compared to the other sections, see table 2. Maybe it is the way the statements are framed that is the greatest hindrance in this case or that there are too many formal or organization oriented statements. The possibility of problems concerning how statements are framed has been discussed in section 5.1.2. Another example of a question that could be seen to target a reflective practice is: "People apply the ideas they developed in past work situations to new ones". Such a statement as this does indeed target a reflective practice, but it also reveals to us a view of knowledge as a commodity that may be articulated and transferred. This does not rhyme well with the perspective of "knowing in practice" of Orlikowski [7] as well as Wenger's [8] social learning systems.

There are indeed examples of statements aiming to target other combinations of modes. An example of a statement that could be considered target to the combination of imagination and alignment is: "People know what metrics are used to monitor the knowledge management process and its results". This one belongs to the section Assess, which got one of the lowest scores, see table 2. Even though we clearly see that the statements target the understanding of things going on, the "why", it is not clear if the group of workers perceive such a statement as being directly related to the concerns of their own practice. If indeed knowledge management activities should be and may be part of the everyday practice, then why did the activity section it belong to receive such a low score?

It seems that maybe too many statements of the questionnaire are formal or organization oriented, taking a commodity perspective of knowledge. Those that do seem to be more social or practice oriented seems to be framed in a manner that may not easily be relatable to the group of workers. All of this may indeed make it difficult for members of the staff to perceive the questionnaire both relevant and relatable to their own concerns. This is something that must be considered in future research.

5.2.2 KM and National Culture

In "Culture of organizations" Hofstede [9] put forward some traits of Swedish culture. Here we work with three aspects of culture, power distance, individualism, and uncertainty avoidance. The genus perspective we do not use, because the ground material do not offer this aspect.

Low level of power distance, Sweden scores the low number of 31, ranking 47 among investigated countries. Three questions are used for assessing this value, 1) employee is afraid of manager, manager is autocratic, employer preference about work place, i.e. if they prefer an autocratic manager or not [9, p. 25]. The simple analysis here might be that an impersonal questionnaire might be seen as a way of creating a power distance. This might be a reason for the skepticism towards the questionnaire among the staff, while the managers seemed to think the instrument was ok.

Further on, Hofstede looked at an *individualism / collectivism dimension* of culture. Here, Sweden came out as a clearly individualistic country. Three questions were

used to investigate each aspect. Individualists thought it important with personal time, freedom to control work situation, challenges in work. The collective approach valued: job training, physical work condition and use of skills. The three questions indicate that a Swedish worker expect a high degree of freedom and control over their work processes. Following on the same note as in the previous analysis, the questionnaire increases the ability of manager to control the worker. This should again concur with the outcome of the survey, which is a rather high level of not answering or disagreeing.

The third aspect that Hofstede proposes is *uncertainty avoidance*. Again three questions are used to measure the aspect: job stress, rule obedience and expected time on job. Swedes score low in this index (to avoid uncertainty is not important to them), meaning that they do not feel stressed at work, think that rule obedience is not so important and are looking forward to changing jobs. In the relative index Sweden comes in at position 49/50 out of 53 countries. Generally these people are not interested in rules and are ready to move on, and could be expected to be less interested in this type of development project. The questionnaire increases the ability to create rules for KM activities. The questionnaire also indicates the beginning of longer projects. Both these aspects seem to be at odds with the cultural profile. The findings and analysis by Hofstede is corroborated in the study of Alarik and Diedrich [6].

6 Concluding Discussion

A number of questions have been answered in this paper. However, what might be more important, a number of further question have risen due to these reported investigations.

6.1 Summary of Results

In this paper we have tackled the problem of a diverse and complex theory/practice situation of KM, by looking at a questionnaire that is hoped be helpful for the evaluation of KM in organizations. Two main issues were at hand, if the questionnaire would fit into a Swedish context and if the questionnaire was internally consistent. The second issues were also important regarding the high number of question and if it could be possible to work with subsets of the 140 questions without losing the precision of the analysis.

Generally the questionnaire was directed to managers, and the outcome in the CEO study indicates that it also works under the Swedish conditions. What is more interesting is that the staff study was not so successful. Here we find the most important finding of this paper. An instrument that works well for one personnel group might not do that for others, as explored in depth in section 5.2.1. The easy solution is to use different sets of questions, but then we get the problem of connecting the answers between different subsets, thus a problem of interconnecting KM initiatives.

6.2 Issues of KM Assessments

The analysis of this paper shows some promising results, however some critical questions on a more general level must be raised.

First, a basic assumption of the questionnaire is that every question implies a good practice. Look at other basic research of the KM field, for example Hansen, et al. [11] who presents the theory that different KM strategies is needed for different competitive strategies. Naturally, one could expect different profiles to emerge from the questionnaire, but it is not an answer to the question "what is the right KM mix for our company". What is needed is a questionnaire that contains a number of profiles, which expects low agreement with a number of the questions.

This leads to the next issue, what is it managers and others really telling us when they answer. Is it how they think it should be, or how they think it is or is it how they want other to believe it is? There is a danger that the answers become a test on what manager's think is good and their wish to want appear as good might dictate their answers. The rational answer to this worry is that the managers are rational and know that correct answers are necessary for making the questionnaire useful. However, people are not always rational, and even with the best intentions it might be hard to overcome biases and hidden personal assumptions. The way to go is probably the rather complex questionnaires with a lot of questions, just like the investigated one. What are missing in that questionnaire are KM profiles, that recognizes that one cannot and should not be "good" at everything at the same time. This will not result in good KM practices. The use of the questionnaire in the staff groups could be discussed in similar direction. Although the solution might be the opposite, i.e. more specialized and containing shorter list of questions. The need of KM activities, which would be classified to be good, is probably dependent on the specific works situation.

Here we discover the depth of the challenge as discussed in 6.1. To develop an integrated KM plan, the evaluation instrument must both accommodate the complexity of many KM profiles and also be scalable to more narrow uses in certain work situations.

6.3 Future Research

The outcome of the study shows both the need of instruments for evaluation of the KM situation in a company and that the investigate instrument seems possible to use. The key problem was if it was possible to build further on the consult-instrument that has been studied. There is a potential for further development of this idea, however much work remains. The future studies should have two directions.

First a theoretical direction should be taken, where the questionnaire is analysis and updated for the development of KM theory. It should in that process be ensured that a number current KM strategies can be measured using the instrument. An aspect of this process should also include a re-translation to English. This would provide extra review of the instrument and further insure that the problems of language and translations are minimized.

The second direction should be empirical, and would include a use of statistical measures (for example Cronbach measure for reliability, Cronbach, & Shavelson,

[12]). The goal would be to create an instrument that is possible to scale down to create smaller subsets, which would be more accommodating for different groups of staff.

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Traceability of Business Rules in Model Driven Development

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Abstract[1]. Most tools designed for the BPM market still do not support smooth migration of business models to IT models. More importantly – it is almost impossible to reverse or update business models from IT models if needed. The Model Driven Architecture (MDA) tries to solve these issues by providing different levels of abstraction: Computation Independent Model (CIM), Platform Independent Model (PIM) and Platform Specific Model (PSM) levels. In this paper, we are discussing how business rules are transformed through abstraction levels in MDA architecture. We are presenting an easily customizable method to transform business rules efficiently, encoded in OCL, both to a business rule language that is close to the natural language and to an implementation language. In other words, we are presenting transformation principles for business rules between PIM to CIM and PIM to PSM levels.

1 Introduction

Every organization has a different set of business rules, however, after many years of research it is still an open issue how these rules should be retrieved, managed and used in software systems. For this reason industry has formed a completely new Business Process Management (BPM) market for automating, improving and reengineering business processes. Systems offered by leading BPM vendors are devoted for modeling, simulating and improving existing business processes or creating new efficient ones. It is important to emphasize that these tools are designed for business people, not the IT staff. After business process modeling, analysis and improvement is finished, the gathered data is usually transferred to the IT department so that the real modeling of the software system can be started. This usually implies additional re-gathering of requirements and partial re-modeling of the same things that were already modeled in business models. Also, if business models change, IT models should be changed as well, i.e. in some sense they have to stay synchronized for businesses to be able to use them. This is a hard to manage and an error-prone task.

The Unified Modeling Language provides a foundation for the Model Driven Architecture (MDA). The purpose of using MDA is to support creating models of high

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abstraction level which can be reused when migrating projects to different platforms and technologies. MDA proposes several model abstraction levels, where Computation Independent Models (CIM) are transformed to Platform Independent Models (PIM) and these are transformed to Platform Specific Models (PSM), and the latter are finally transformed to code. MDA models are the central part of software development process [2] and must be precise across all its levels. Traceability is one of the main requirements. Also, it should be possible to reverse code back to PSM, PIM and CIM models. OCL enables creating precise models that can be transformed to rich code (not only skeleton of classes or interfaces) and reversed back to precise models.

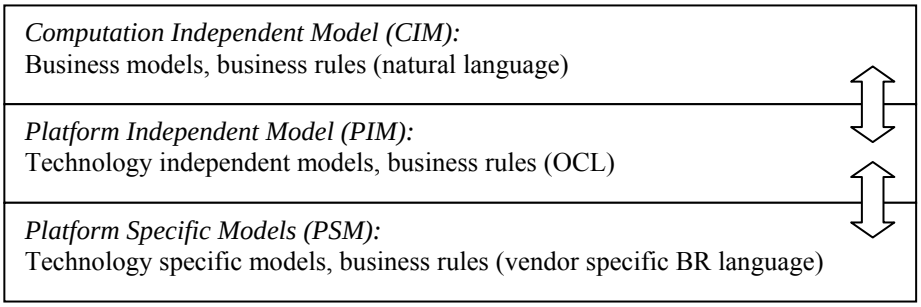

Fig. 1. Business rules in MDA architecture

The OCL language was initially created as a constraint language for UML. Starting as of UML 2.0 it became part of UML standard [3]. The scope of usage of OCL was broadened to specifying queries, referencing values or defining business rules [2]. However, OCL is too complex for business people. They need a language which could be closer to natural language, because business rules usually use natural language and depend only on business vocabulary, allowing business people to understand these rules. MDA states, that business models and business rules are stored in CIM level, platform independent models are stored in PIM level, and vendor specific models are stored in PSM level (Fig. 1). As depicted in Fig. 1, OCL can also be used for specifying business rules. However its traditional scope is enriching software systems models, not business models. In other words, it specifies business rules in a lower abstraction level and usually has its counterparts encoded in natural language in business models in CIM level.

In this paper we analyze how business rules encoded in OCL can be efficiently transformed back to business rule language that is close to natural language. For the sake of simplicity we will take a very simple metamodel for such business rule language thus enabling to concentrate on the conceptual idea of effectively transforming OCL expressions to BR expressions. One of the simplest illustrations of usage of the proposed method could be transforming of the OCL operator "=" to the elements of structured business rule expression. Equality operator can be transformed to expressions "equal", "must equal", and so on, depending on the context, i.e. OCL operator "=" has different flavors in BR expressions depending on the surrounding context. The proposed method is designed to deal with such situations. Besides BPM tools, the method would be useful for defining business rule templates devoted for capturing constraints in UML CASE tools. Currently, there are lots of researches on that type of

templates going on but all of them are based on CIM–level Business Rule Languages, or PSM-level languages implemented in Business Rule Engines.

Although we concentrate on transformation from OCL to Business Rule Language (BRL) in this paper, the proposed method is not restricted to transforming OCL to the BRL language expressions – it can be adopted for any transformation from OCL expressions and has no vendor-specific details.

The rest of the paper is organized as follows. In section 2, related work associated with evolution of BPM and OCL CASE tools is presented. Section 3 presents generic principles proposed for improvement of code generation from OCL expressions. Sections 4-6 describe the method of assigning attributes to AST tree nodes and analysing contexts during code generation, illustrating it with an example. Finally, section 7 draws conclusions and highlights the future work.

2 Related work

UML is usually used for modeling of software systems. However, it is difficult to use it for modeling of different domains. For example, system engineers have faced the recent effort from OMG SysML group. Embedded systems engineers will be provided with the OMG MARTE profile which is still not finalized. OMG's BPMN (Business Process Modelling Notation), which is offered as the business modeling notation for business people, is not based on UML and it becomes difficult to transform BPMN and BPEL models to software models and vice versa because no standard is defined for this. That means that BPM tools are doing this (if doing it at all) in a vendor-specific way.

Oracle Business Process Analysis Suite [26] allows the business and IT community (process owners, business analysts and architects) to perform process modeling and analysis, simulation and publishing of process models. The BPA Suite supports the execution and monitoring of these process models with Oracle BPEL Process Manager and Business Activity Monitoring (BAM). Integration of these tools with Oracle SOA Suite enables not only analyzing business processes but also transforming them to working software systems.

Intalio|BPMS Designer [27] is a process modeling tool that can be used by business analysts to model business processes according to the BPMN notation and provides additional graphical tools such as a data mapper that allows IT Engineers to fully implement these processes without having to write any code.

Proforma ProVision [28] consists of several tools. ProVision's Workflow Models provides a method for visualizing business processes performed in the organization. They provide a picture of how work is accomplished, who is responsible, and the complexity of the process. ProVision's association matrices can link critical goals to business deliverables and business processes. This serves as a cross-checking mechanism to ensure a complete set of goals, business deliverables and business processes have been identified. Also, ProVision contains an "Interpreter" which translates any model into simple English. The ProVision simulator provides an approach for calculating process timing and analyzing a process's activity-based costs.

Based on simulation results it is possible to identify opportunities to gain process efficiency and effectiveness.

Corel iGrafx Process [29] is a process analysis and simulation tool that enables complex processes to be understood, modeled and improved. The tool supports tracing, simulation and analysis of processes specified in BPMN.

Lanner WITNESS [30] is a business simulation system, giving ability to model business processes, simulate the implications of different business decisions and understand them.

Pegasystems SmartBPM Suite [31] is a rules-driven BPM suite, intended to help businesses planning, building, and process management solutions through their lifecycle. PegaRULES Process Commander is the core of the SmartBPM Suite, a thin-client collaborative environment for both business and IT. Process Analyzer leverages a data warehouse of both historical work and simulated data, with analytic tools to improve processes. The tool also supports process simulation and enterprise integration using service-oriented architecture.

As stated above, most BPM tools are doing a great job when existing business processes need to be improved or business processes are required to be built from the ground up. Some tools, like Oracle BPA suite and IBM WebSphere Business Modeler combined with Rational Software Architect offer transformation of business models to software models. However, none of them offer synchronization capabilities for business rules between business and software models so that it would be easier to maintain these rules and updating one model would imply changes in other models.

The OCL language, which is a part of UML standard, can be used for specifying business rules in software models. Tools supporting OCL fall into the following categories: supporting OCL syntax checking; supporting evaluation of expressions (such tools usually check model integrity and completeness), and supporting code generation from OCL expressions.

One of the most mature open source OCL 2.0 implementations is available in Dresden OCL2 Toolkit [4], [5]. The tool supports validation of OCL constraints, Java and SQL code generation from OCL expressions [6], [7]. University of Kent has also released OCL 2.0 interpreter called KFM [8]. Domain specific extensions and principles of OCL reusability for different domains were proposed in [9] so that it would be possible to adopt OCL language for specific domains clearly and smoothly. Also, some suggestions were made on OCL language as code transformation language in [10].

A well-known KeY tool supports OCL code transformation to predicate logic expressions [11]. This type of transformation is used for verifying model integrity by proving the generated expressions. OCLNL tool [32] is based on the KeY tool and is designed for transforming OCL to natural language. Reference [13] describes a method to transform OCL code to JML (Java Modelling Language) code. JML is similar to Z and VDM languages which allow specifying models using mathematical concepts like sets etc. Authors [14] provide a model repository implementation which allows model transformations based on graph rewriting rules that can be specified using XML and OCL.

For implementing principles of design by contract, a C# compiler extension that supports OCL was developed [12] at Ottawa-Carleton Institute for Computer Science.

This implementation supports OCL expressions embedded into C# code meaning that C# code could be executed in parallel with OCL code.

One of the most notable implementations of OCL 2.0 is the OCLE (Object Constraint Language Environment) tool. It provides Java code generation and reverse engineering. It also implements expression validation and evaluation subsystems.

Dresden OCL2 Toolkit was integrated into the Fujaba tool [15]. After adding capability to parse OCL code in Fujaba tool, it became possible to check if model transformation rules are valid before generating actual Java or C++ code. There are extensions to Dresden OCL2 Toolkit [25] supporting improvement of OCL constraints and incremental constraint checking during the runtime of implementation of UML models with OCL constraints.

The USE tool was developed at University of Bremen [16]. This tool allows specifying and tracing integrity constraints on the model. It also supports tracking of model states. There were proposals of turning OCL language to fully-featured transformation language [17]. The proposed ideas were implemented in the aforementioned tool.

Major commercial tool vendors also provide support for OCL in their tools. Borland Together supports OCL syntax highlighting, validating, code generation, OCL-based model metrics and audits. No Magic MagicDraw and IBM Rational Software Architect support only OCL-based validation rules.

Tools described above deal with various aspects of software modeling, however most of them do not generate code from OCL expression or at least use it for model transformations. In the following sections we will present a method to transform OCL expressions to expressions of a simple business rule language. We will also propose a method to do it efficiently, so that it would be possible to generate compact representations of OCL expressions and avoid situations when different business rules are generated for semantically equal OCL expressions. For this purpose we are proposing the use of attributes for context analysis when traversing OCL Abstract Syntax Trees (AST). AST trees are being built from OCL expressions and then traversed using Visitor patterns. There are many Visitor pattern implementations [10], [18], [19], [20]. However, when code is generated using the standard Visitor pattern, it generates chunks of code instantly for every AST tree node. This usually leads to inefficient, redundant and sometimes unexpected resulting code. We propose a way to analyze context before generating the code so that the resulting code would be of better quality.

3 Principles of code generation from OCL expressions

In this section we will present principles of OCL code transformation to other language code. We will explain how Visitor patterns are used to traverse AST trees, where and how templates are used in the transformation process and name the deficiencies the described method has.

Visitor patterns can be used for traversing various models. The traversal algorithm usually relies on metamodels and due to usage of visitor pattern it can be easily extended [20] when metamodels get augmented. When OCL code needs to be transformed to other language code, visitor patterns are usually used for this purpose.

However, this means that all known visitor pattern problems also persist when generating OCL code.

Parsing of OCL code is a two-step process: firstly a concrete syntax tree (CST), which is based on OCL grammar, is created; then CST tree is transformed into abstract syntax tree (AST), which is based on OCL metamodel, for expression evaluation or code generation purposes [21]. A generic algorithm for transforming OCL invariants specified for classes is shown in Fig. 2.

As shown in Fig. 2, code generation is performed recursively. In the first stage invariants specified for classes are gathered. Transforming of an invariant begins with detection of the expression type, i.e. OCL metamodel element, which corresponds to the analyzed expression. As stated above, visitor patterns designated for traversing models are based on metamodels. This means that for every metamodel element there is a method defined in visitor pattern implementation, which would be called when traversing the model an element of such type is detected.

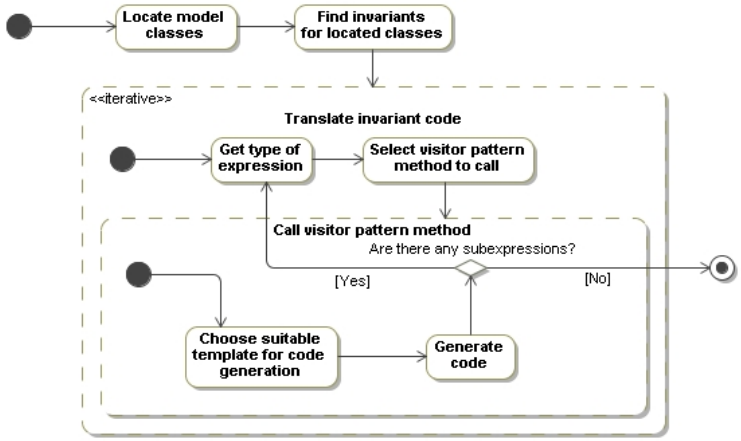

Fig. 2. Process of code generation using Visitor pattern

In many cases nodes of AST trees are quite abstract and often every single node represents several language constructs. Usually one more level of granularity is needed – some analysis must be done inside the visitor method. After calling visitor method, the right template for concrete code generation can be chosen. For example an object of OperationCallExp class may correspond to the "+", "-", and other operations, which need different templates for code to be generated. In other words, visitor pattern methods detect which templates should be used for code generation by using the concrete OCL syntax information. If some expression has subexpressions, then subexpressions are processed recursively until there are no more subexpressions left. Code for the analyzed expression and its subexpressions is generated by traversing the AST tree in the deep first, left-to-right order.

There exist many visitor pattern implementations like those presented in [18], [19], [20]. However most of them only allow instant code generation when each node gets traversed. Such implementations are simpler and easier to develop and maintain, however the resulting target language code for these implementations is usually re-

dundant and sometimes incorrect. Some alternative implementation might not generate code instantly – it could do some analysis of the context before generating code. Our target is to produce such a structured business rule code which would be easily readable by humans. As stated in Introduction, there are many cases when the same OCL code should be expressed differently in business rule code. In the next sections we will present a method for dealing with such situations. We will also present an example of generating different business rules for the same OCL operators depending on context the operator is used in.

4 Using attributes for context evaluation

In the previous section standard visitor pattern [20] was presented. Also, there was presented a standard way for traversing AST trees and generating code from them. We have stated that besides inefficiency and redundancy problems there are cases when the same OCL code should be transformed to different target code depending on context OCL code is used in. In this section we will present the conceptual idea of adding attributes to AST tree nodes to enable context analysis so that the generated code would be of better quality.

We will take the attribute concept from attributed-grammars [22], i.e. we will simply use them in the higher abstraction level. Adding attributes to AST tree nodes instead of productions would enable to perform context analysis thus improving OCL code transformation to other language code.

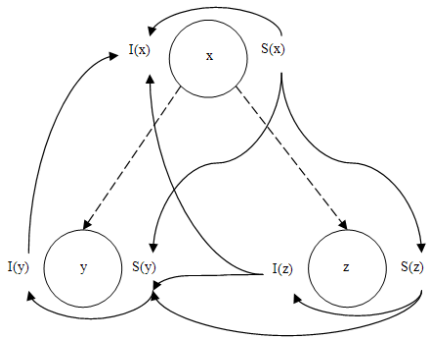

Fig. 2. Attribute inter-dependencies in AST tree

AST tree nodes (x, y and z), attributes and their relations are depicted in Fig. 2. Solid arrows reflect attribute inter-dependencies. Dashed arrows reflect parent-child relations between nodes of an AST tree. The attribute concept should preserve its semantics: it is a variable assigned to a node. There should also remain the concept of synthesized and inherited attributes (returned by functions I and S in Fig. 2). In general, principles defined in [23] can be adopted for AST trees. Inherited and synthesized attributes should be related as follows:

x, y, z ∈ N, where N – set of OCL metamodel elements;

Let A(m) denote all attributes for node m;

I(m) and S(m) – sets of inherited and synthesized attributes for node m;

$A(m) = I(m) \cup S(m)$.

Attribute evaluation rules (*f* and *g* are functions here):

$S(m) = f(I(m), S(m_1), S(m_2), ..., S(m_n))$, n = C(m), C – number of sibling AST tree elements;

$I(m_j) = g\ (I(m), S(m_1), S(m_2), ..., S(m_{j-1}))$, for j in 1..n.

If to apply these rules for the OCL AST tree depicted in Fig. 2, we would get the following:

$A(x) = I(x) \cup S(x)$

$A(y) = I(y) \cup S(y)$

$A(z) = I(z) \cup S(z)$

$S(x) = f_1(I(x), S(y), S(z))$

$S(y) = f_2(I(y))$

$S(z) = f_3(I(z), S(y))$

$I(y) = g_1(I(x))$

$I(z) = g_2(I(x), S(y))$

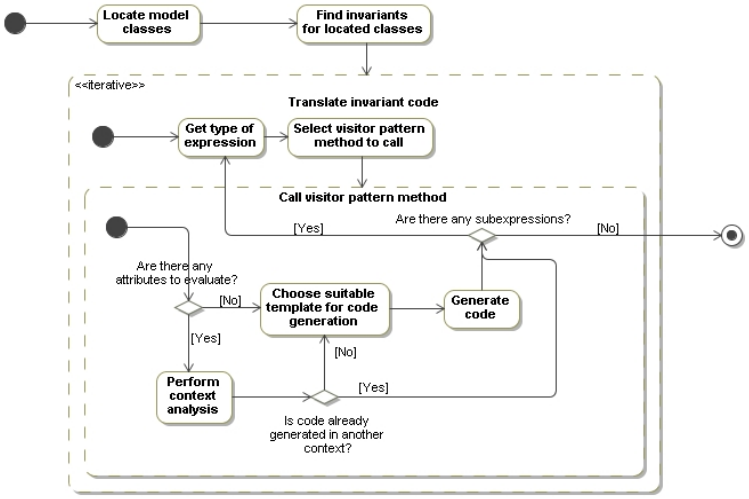

Fig. 3. Process of code generation using Visitor pattern with context analysis included

Visitor pattern should not only match the exact operation that represents the node, but it should also evaluate attributes. Attributes defined for AST nodes should convey information on the underlying subtree elements – that would lead to optimized code generation, i.e. in many cases code might be fine-tuned or not generated at all. Code transformation engines usually use templates to generate pieces of the target language code. If templates are used for code generation, they should access all attributes for the node that code is generated for. Templates may not only generate code for the traversed node, but they could generate code for the whole subtrees.

Modified code generation process with context analysis is depicted in Fig. 3. As seen in the figure, every visit method has routines that analyze context by acquiring attributes of the node currently traversed. Depending on analysis results different templates can be chosen for code generation. As mentioned above, it might be that no code will be generated. It is also possible that optimized code will be generated for several nodes at a time.

5 OCL transformation example

The aim of this example is to show how the same OCL code can be transformed to different target language code depending on the context it is used in. We will use attributes and their evaluation rules for context evaluation.

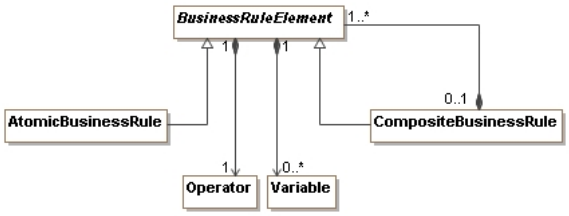

Fig. 4. A simple business rule metamodel

A simple business rule metamodel that will be used in this section is depicted in Fig. 4. It can be considered as some variant of structured English. The metamodel states that there are two types of business rules: atomic and composite. Composite business rules can be combined from other composite or atomic business rules using operators. Atomic rules are specified using operators and variables.

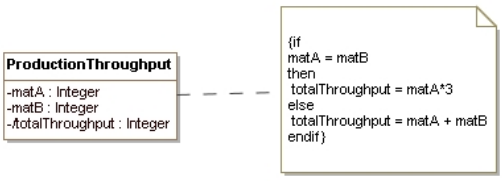

Fig. 5. A sample domain model

There is depicted a sample model which will be used as a PIM level model in Fig. 5.

A sample model depicted in Fig. 5 states, that system stores information on production throughput and material factors that comprise that throughput. Also, the following constraint is imposed on the ProductionThrouput class:

```
context ProductionThroughput inv calcThroughput:
if matA = matB
  then totalThroughput = matA * 3
  else totalThrouput = matA + matB
endif
```

The constraint calcThroughput is a business rule, specified for a software system. The same business rule, specified in structured business rule language we have defined above in this section, should look like:

```
if matA is equal to matB
then totalThrouput must equal to matA multiplied by 3
else totalThrouput must equal matA + matB
```

As may be seen from expressions above, the OCL operator "=" is transformed to a corresponding business rule expression "is equal to" if its context is condition of the control sentence, otherwise it is transformed to "must equal to" if its subexpression is a product which has multiplier being a constant. In other cases the operator is transformed to the "must equal" expression.

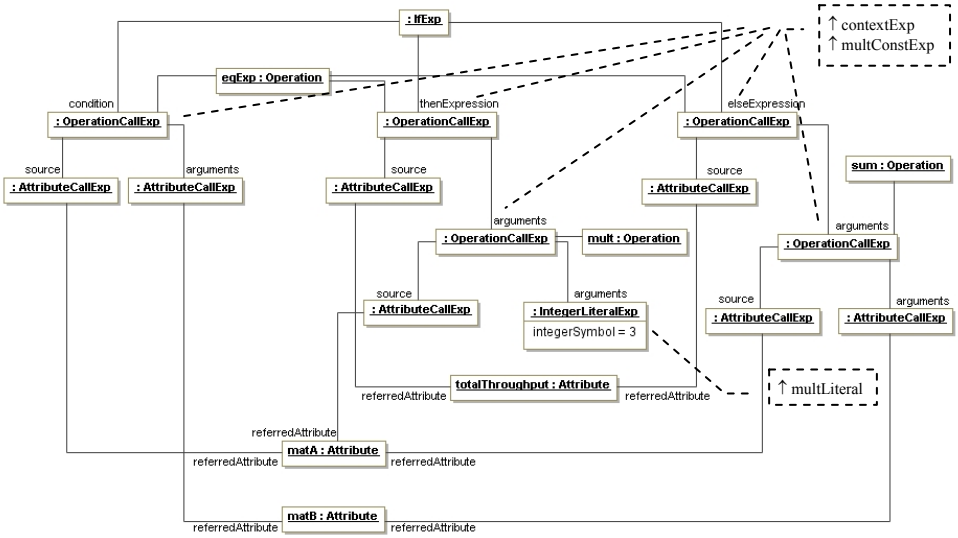

Fig. 6. AST tree for invariant calcThroughput with attribute definitions

The tree depicted in Fig. 6 reflects the "if" expression of calcThroughput invariant. Synthesized attributes are marked with arrows up. If there were inherited attributes, these were marked with arrows down. The "if" expression has three links to "condition", "then" and "else" expressions, which are instances of the OperationCallExp class. Condition tests if values stored in attributes matA ant matB are equal. If they are equal, then the "then" expression must be true, otherwise the "else" expression must be true. The OCL equality operator "=" in the aforementioned cases is referred to by instances of the same OCL metaclass OperationCallExp. Technically speaking, standard visitor pattern should generate the same code when traversing instances of the OperationCallExp metaclass. This is why we assigned attributes to this node. Code should be generated depending on subtrees of the OperationCallExp node by analyzing attributes that reflect context information. As seen in Fig. 6, the "then" expression has its own subexpression, which is multiplication by a constant equal to 3. The "else" expression also has its subexpression which sums values stored in attributes matA and matB.

This example will demonstrate how the OCL equality operator can be transformed to different business rule concepts depending on context information. Attributes will be used as formal mechanism for evaluating context.

Semantics of synthesized attributes for OperationCallExp class (Fig. 6) is detailed in Table 1.

Table 1. Synthesized attributes for OperationCallExp node

Attribute name	Type	Semantics
contextExp	String	denotes the type of OperationCallExp expression, i.e. "condition", "thenExpression", "elseExpression"
multConstExp	Bool	specifies whether the subexpression has production with a multiplier being a constant

Attribute evaluation rules for OperationCallExp node:
OperationCallExp.contextExp = <contextExp>
OperationCallExp.multConstExp = arguments.multConstExp
Condition 1: parent.contextExp is defined
[1] OperationCallExp.contextExp = parent.contextExp
Condition 2: OperationCallExp.contextExp = 'thenExpression' and
arguments.multLiteral = True
[2] OperationCallExp.multConstExp = True

Semantics of synthesized attributes for IntegerLiteralExp class is detailed in Table 2.

Table 2. Synthesized attributes for IntegerLiteralExp node

Attribute name	Type	Semantics
multLiteral	Bool	denotes if multiplier is a constant

Attribute evaluation rules for IntegerLiteralExp node:
IntegerLiteralExp.multLiteral ← True

In the example above we have defined attributes for nodes of OCL invariant calcThroughput. These attributes evaluate context information thus giving a chance to generate the desired business rule code, which has different code that corresponds to the same OCL equality operator:

```
if matA is equal to matB
then totalThrouput must equal to matA multiplied by 3
else totalThrouput must equal matA + matB
```

If the proposed method would not be used, the following example code would be generated:

```
if matA equal matB
then totalThrouput equal matA * 3
else totalThrouput equal matA + matB
```

The sample only illustrates capability of analyzing context using attributes in AST trees. The same principles can be used for analyzing complex situations, when semantically equal OCL expressions have to be transformed to the same target code, or some optimizations must be performed before generating target language code.

As stated in earlier sections, it is possible to generate any other language code from OCL expressions using the proposed method. For example, if to generate a SQL code for the same expression, we would get the following:

```
SELECT * FROM ProductionThroughput
WHERE
  IF matA = matB
    THEN totalThroughput = matA * 3
    ELSE totalThroughput = matA + matB
  END IF
```

Due to lack of space we will not be explaining in detail the process how SQL code was generated, but the generation process uses the same principles that were described in this section. Also, it is important to emphasize that it is enough to traverse AST trees once to evaluate attributes.

7 Conclusions and future work

Currently, need for automation of business rules is recognized in almost every non-trivial information system or application. However, there is a gap between methods and tools designed for business people and software developers. There is no traceability between business rules captured in Business Process Management tools and business rules, implemented in software systems.

OCL is considered as a Platform-independent language suitable for specification of business rules for implementation in software systems. As industry is starting to accept OCL, the language itself seems to be primarily used for validation purposes. One of the reasons is that other applications, like code generation, still are not supported by most of the tools, while existing implementations are rather inefficient and not mature enough.

The method proposed in this paper may improve the situation. OCL may be transformed to business-level languages for capturing business rules and platform-specific implementation languages in an efficient way with the usage of well-known attributed grammar principles for AST trees. We propose to use attributes in AST trees for context analysis so that it would be possible to determine places where and how optimized code can be generated during traversal of AST trees.

The implementation of the proposed solution is based on Dresden OCL2 Toolkit and the flavors of the visitor pattern that deal with attributes like Bivisit visitor pattern [23].

The future work foremost will be concerned on finding a balance between complexity caused by the extra analysis of an AST tree nodes, and effectiveness of OCL transformations. Also, we are planning an extensive implementation of the method for proving traceability between CIM level Business rules, OCL and implementation (PSM level) languages.

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Application of Ontology–Enriched Multi-Agent Techniques for Integration in the Health Care Domain

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Abstract. The article is concerned with an important issue of semantic integration in the broad context of medical settings when orchestration of interaction between multiple independent participants is needed. Authors propose to supplement multi-agent platforms with a user-centered hardware device called Ontology Mediator. It facilitates indirect message-oriented communication between agents and supports transformation of ontologies in the form of RDF-models. For quick implementation and reengineering of Ontology Mediators authors offer a specific model-driven design framework.

Keywords. Key words: multi-agent systems, healthcare applications, semantic interoperability

1. Introduction

"Is it in principle possible to use my electronic medical records in different hospitals, clinics and related business activities by a consistent and safe way with ability to control and prove eligible use of my private data by heterogeneous healthcare software systems?"

That and many other similar and important questions have the same conceptual core inside. It is a matter of integrating different software systems into a united intellectual network for processing different kinds of information. During many years rigorous formal methods for definition of semantics of computer data and algorithms were developed in parallel with empirical methods of software engineering. We believe that now, when complexity of data structures, software architectures became extremely complex, empirical methods should be inevitably fused with strong mathematical theories of data, information and knowledge modeling. That is only a single way to get meaning to all data and algorithms developed and used so far. Studies in principles of information modeling, knowledge representation and achieving semantic interoperability in complex distributed systems come to the first line, attracting attention of not only academicians but almost all parties involved in design, implementation and integration of modern software systems.

To have a detailed look on this complex subject from different points of view, in this work we give a broad observation of basic concepts, problems in the domain of healthcare, and major topics vitally needed for understanding what can a developer expect to find in modern knowledge representation theories to assign meaning to the data and algorithms, and which applied tools and methods are available. We also propose our own methods of integration, and give description of software architecture for the framework supporting our knowledge-intensive process of integration.

The structure of this work can be outlined as follows: in *Section 2* we analyze current integration achievements and challenges in medical applications. S*ection 3* presents proposed technological foundations and relevant theoretical topics in knowledge representation. *Section 4* describes our general methods, based on ontology transformation algorithms, for integration of complex distributed systems. *Section 5* contains description of integration principles specifically for healthcare. S*ection 6* concludes the work with results' discussion, and *section 7* contains the list of literature sources.

2. Integration Challenge in Medical Applications

Significant consequences of diversity in modern information technologies can be recognized in the domain of healthcare. Despite slow start of information technologies [24, 37] in this domain, sustainable efforts are spent to integrate disparate information sources and legacy software, developing and harmonizing healthcare standards, because proper medical diagnosis and decision-making involve interrelations between large numbers of medical knowledge resources [1, 2, 48, 55]. Publications, practical cases and vendor white papers illustrate this process mostly in the United States.

Since 1960s the US Government invests considerable amounts to the health information technology (HIT). Some sources predict that the level of HIT spending will grow to $39.5 billion by 2008. Among other expense items development of commonly accepted electronic healthcare records (EHR) plays a significant role. In [32] I. Iakovidis defines EHR as "*digitally stored health care information about an individual's lifetime with the purpose of supporting continuity of care, education and research, and ensuring confidentiality at all times*". In our terms EHR can be viewed as an example of complex information model shared between different HIT systems in a global healthcare environment. The systems exchange information in the form of EHR instances and mutual agreement on EHR structure and meaning can facilitate seamless integration and provide interoperability.

Founded in 1987, Health Level Seven (HL7) is one of several non-profit ANSI-accredited Standards Developing Organizations (SDOs). It works on development and promotion of interoperable EHR standards. In details the mission of HL7 is to provide standards for the exchange, management and integration of data that support clinical patient care, and the consistent management, delivery and evaluation of healthcare services [30]. In the course of its activity HL7 has developed a specific object-oriented modeling paradigm. Using that paradigm HL7 described most of clinical data formally and produced so-called Reference Information Model (RIM) [47]. RIM contains graphical representation of data and events sequences for most of healthcare business processes. HL7 proposals have been adopted as a standard and it plays a ba-

sic role in the enactment of HIPAA regulations in the US and in similar laws in other countries. Now HL7 develops a more general standard: HL7 Clinical Document Architecture (CDA). Except HL7 standards the Standard for Digital Imaging and Communications in Medicine (DICOM) also is very important because it specifies a non-proprietary digital imaging format, file structure and data interchange protocols for the transfer of biomedical images and non-image data related to such images [16]

In 2004 to support wide usage of HL7, DICOM and other healthcare standards the US Secretary of Health and Human Services announced start of the Nation-wide Health Information Network Architecture Project (NHIN) aimed to facilitate seamless exchange of patient medical records in an electronic form [41]. In correspondence with that project most of harmonization work is done in the framework of Health Information Technology Standards group (HITSP) [29]. HITSP brings together all relevant stakeholders to identify appropriate IT standards to exchange health data in USA. HITSP includes 155 different organizations and stakeholders. HITSP issued so called "Interoperability Specifications" for specification of unambiguous data exchange and interaction between independent systems. In accordance with these specifications a number of interoperability pilots started in 2006.

Other countries also work on development of interoperable healthcare standards. In Japan consortium of leading healthcare organizations have developed own healthcare information model for Japanese hospital information and Japanese healthcare domains - Enterprise Models (REM) [53]. In that case RM-ODP (Open Distributed Processing - Reference Model) and UML were chosen for modeling. In Europe the GEHR/openEHR initiative was started in 1992 as an EU research project, called Good European Health Record, in the Third Framework Program. The most noteworthy concept introduced by GEHR/openEHR is the archetype concept [4, 5].

Integrating the Healthcare Enterprise (IHE) [34] initiative gives an example of practical approval of multiple healthcare standards. IHE shows how integration of all types of medial IT systems (hospitals, pharmacy, diagnostics centers, etc.) and all types of information (including semi-structured data) can be achieved in order to provide healthcare professionals with all required information. The purpose of the IHE initiative is highlighted by its slogan – "Changing the way HealthCare Connects". IHE joins multiple practitioners and research centers in cardiology, radiology, eye care, oncology and IT infrastructure around the globe. In 2006 IHE included more than 100 vendors and test-bed implementations. IHE technical frameworks propose detailed implementation guides for independent vendors of medical tools and software systems.

The approach employed in the IHE initiative is to support the joint use of existing international standards, rather than to define new standards. The set of employed standards covers not only healthcare domain (e.g. HL7, ASTM, DICOM), but also electronic business (SOAP), and Internet (HTML, PDF, JPEG).

In order to achieve standards' harmonization IHE defines so called technical profiles. IHE profiles constrain process definitions and configuration choices where necessary in these standards to ensure that they can be used in their respective domains in an integrated manner between different actors. Integration profiles are formally defined in terms of IHE Actors and transactions. Actors are information systems or components of information systems that produce, manage, or act on information associated with clinical and operational activities in the enterprise. Transactions are inter-

actions between actors that communicate the required information through standards-based messages. In IHE profiles process flows are defined in form of UML diagrams and specific text description.

IHE pays great attention to development of a practical foundation for healthcare information interoperability and offers a concept of Cross-Enterprise documents Sharing (XDS) [33]. XDS enables a number of healthcare delivery organizations belonging to a clinical affinity domain (e.g. a community of care) to cooperate in the care of a patient by sharing clinical records in the form of documents as they proceed with their patients' care delivery activities. This profile is based upon ebXML Registry standards, SOAP, HTTP and SMTP. It describes the configuration of an ebXML Registry in sufficient detail to support Cross Enterprise Document Sharing. An XDS Document is a composition of clinical information that contains observations and services for the purpose of exchange. An XDS Document may be human and/or application readable. In either cases, it shall comply with a published standard defining its structure, content and encoding. A Document may contain references to other documents in its content which are not under the management of the XDS Document Registry.

Standardization of medical workflows and workflow support are also among interests of IHE. That fact reflects an important role of workflow in the healthcare domain, its ability to be an effective tool for capturing and disseminating best medical procedures. During the years multiple local medical workflow systems were developed. Among them diagnosis workflow management systems [3], treatment/therapy workflow management systems [15, 44] and hospital administration workflow management systems [13, 43] can be mentioned, and multiple IHE profiles for such systems should be developed in a short time.

Among commercial software products for integration of healthcare systems Quovadx solutions can be mentioned because they propose in combination clinical interoperability, financial interoperability as well as government interoperability [45].

Although all so far presented information inspires optimistic desires for nearest success in complete integration of healthcare information systems, critical researchers really concern about actual achieved results [20, 24, 31]. For example, difficulties in the HNIN project are well studied in [31]. The authors describe some inherent properties of healthcare information models, which destroy naive assumptions of IT specialists and complicate integration solutions. As a most serious problem the only partial availability of patient medical record is mentioned. According to [24] another source of danger is that healthcare providers may demand access to identified data even when someone has not given explicit consent. Heterogeneity in social structures can also be a serious obstacle for standards adoption and harmonization. For example, differences in the US state privacy laws, as well as regulations pertaining to medical records and practices, become significant obstacles for interoperability in medical applications. A lack of interoperability may create "islands of medical information systems" that exchange data with each other and preclude realizing the social benefits promised by the adoption of EHR. Mentioned impediments are mainly non-technological, but social, political and privacy related. So, deep integration requires application of social knowledge and communication with other domains.

It is important, that researchers and developers face with modeling pitfalls of existing healthcare standards. Comprehensive formal analysis shows [20] that widely used

standards HL7 and JAHIS have serious flaws on the conceptual level. Although they use the object-oriented paradigm for modeling, they are not fully confirmed with UML, and do not pay attention to software-oriented aspects during the modeling. Such a problem can cause necessity to apply complex transformations between different models during software integration.

We also need to mention a special issue with standardization in a presence of rapid changes in modern IT: under influence of emergent technologies new business models in healthcare arise so quickly, that standardization and centralized regulation become a serious obstacle on the way of the business. DocMorris.com enterprise shows a bright example how absolutely new forms of electronic commerce in healthcare can rapidly evolve [8].

3. Offered Technological Foundations for Integration

In authors' opinion profitable and successful single-vendor or standard-based approaches are not much probable. On this way one can not expect discovering a single "silver bullet" solution. Indeed, practical experience and personal opinions show that standards can be created only when semantics of some functionality is shared among all vendors, and there is one or several *de facto* ways of using this functionality. It is a matter of fact, that for proper functioning of heterogeneous HIT applications, when various stakeholders, complex autonomous software- hardware systems, information models, and standards are involved, the technological support should be provided for dynamically established cooperation of multiple autonomous components with some extra human efforts.

We believe that previously described social and security considerations of healthcare standardization would be better resolved in the context of the multi-agent paradigm. Now it is widely recognized that the paradigm and the concept of an intelligent agent can be applied both on design and development stages [12, 21]. According to Wooldridge [54], the intelligent agent is a software or hardware component that is (i) situated in some environment, (ii) capable of autonomous actions in order to meet its objectives and (iii) capable of communicating with other agents. From this definition we can say that an agent is an entity that can act and react in his environment and interact with other agents. When that concept is used, heterogeneous information systems can be naturally represented as a community of agents of different types. The agents act either cooperatively or compete with each other in attempts to govern some scarce resources. Usually such kind of the community has the name of multi-agent system (MAS).

If the multi-agent paradigm is applied both on design and implementation stages, different kinds of information modeling techniques (e.g. relational modeling, object-oriented modeling, semi-structured data models, workflows) can be utilized in parallel to cope with peculiarities in business processes, complex models of social behavior, and inherent vagueness of requirements.

In this situation empirical interoperability methods in software engineering and information modeling should be reinforced. In result of such reinforcement unavoidable

manual procedures will interweave with formal methods based on mathematical theories of automated inference, and knowledge representation.

In modern science we can expect multiple points of view on the definition of knowledge. Indeed, different authors propose different theories of knowledge. The epistemological philosophical view determines knowledge as justification of true believes [28]. Also in the area of Artificial Intelligence (AI) knowledge is generally seemed as a combination of domain representations "…needed by a human being (or a machine), organized in such a way that he or she or it can carry out a task considered as being complex."[21]. Knowledge in general can be separated onto declarative and procedural knowledge. The declarative knowledge can be embodied in a form of concepts, manifestations of these concepts (facts), and their interrelations. The procedural knowledge includes initial states and explicit definitions of procedures for dynamical processing and producing new knowledge. At first sight such definition brings together knowledge and the most abstract forms of information models (e.g. E-R models). But what can be used as the most important distinguishing feature of knowledge it is its active (teleological) manner. In own turn, that feature implies significance of such knowledge features as:

- interpretability;
- presence of broad classification and situational relationships;
- presence of some semantic metric defined on the set of data elements.

As far as we pay a great attention to practical application of knowledge in the context of MAS, we must select some formal mathematical structures for codification of knowledge constituents and the corresponding knowledge representation language. Among descendants of the conceptual graphs, the technique of ontology plays the leading role for knowledge representation now. According to [SOW00] ontology serves for strong support in detailed study of all potentially possible entities and their interrelations in some domain of discourse shared by multiple communities; ontology also enables conceptualization and forming categories of the entities committed by those communities. This direct connection of the ontology technique to integration is pointed out by Y. Kalfoglou: "ontology is an explicit representation of a shared understanding of the important concepts in some domain of interest. [35]." In the world of program systems only those concepts exist which can be submitted in the formal form. So, in general ontology declaratively defines a terminological dictionary and expresses some logic theory (assertions, axioms and inference rules); in its terms inquiries and statements which various agents exchange among them during interaction are expressed. In [18] we can see expression of this statement in the following form: "…to someone who wants to discuss topics in a domain D using a language L, ontology provides a catalog of the types of things assumed to exist in D; the types in the ontology are represented in terms of the concepts, relations, and predicates of L."

There is a plenty of various conceptual statements characterizing vital features of ontology and its meaning for knowledge representation, knowledge engineering, knowledge management, qualitative modeling, language engineering, database design, information retrieval and extraction [40]. It is became a good breeding to refer to the Gruber's pioneer definition of ontology as "a specification of a conceptualization" [26]. In [18] one can see a good collection of more recent cross-references, all of them underline ontology support for achieving interoperability: "*Ontology … can be seen as the study of the organization and the nature of the world independently of the form*

of our knowledge about it. [27]". Swartout and Tate offer an informal and metaphorical but extremely useful definition for understanding of the essentials of ontology:"*Ontology is the basic structure or armature around which a knowledge base can be built. [52]."* Finally authors of [18] conclude that "*…well-structured and well-developed ontologies enable various kinds of consistency checking from applications (e.g., type and value checking for ontologies that include class properties and restrictions). They also enable and/or enhance interoperability between different applications*".

One can see that modern pragmatic employment and definition of ontology went far from the original pure philosophical notion of ontology as a most general theory of being as such, that was originally developed by ancient Greek philosophers Socrates and Aristotle. Although modern philosophical works continue their speculative traditions (like [51]), practical applications of ontology require its embodiment into formal mathematical forms. In a result [18] states that "*…ontologies are growing fast into a distinct scientific field with its own theories, formalisms, and approaches*" and proposes studies of [50] for a more comprehensive coverage of the field. Following the proposals we need to find a well-formed mathematical description of ontology. One well-defined and elegant mathematical theory of ontology was developed at the Institute AIFB at the University of Karlsruhe [19]. That strict mathematical theory of ontology along with other similar approaches developed a solid foundation for *machine-readable* representation of ontologies in modern information systems and facilitated their practical application for solution of complex classification problems in such domains as Internet, bio-informatics, and enterprise management as well [14, 17, 46]. Over the years a broad group of specific machine languages for ontology representation were developed such as Loom [39], KIF [23], Ontolingua [25]. In resent years W3C XML became one of the obvious forms of ontology representation and interchange format between different components in the framework of distributed systems.

The FIPA standard (Foundation for Intellectual Physical Agents) [22] gives a bright example of XML-based ontologies supporting multi-agent communication in distributed systems. FIPA defines a special language (ACL) for communication between autonomous agents. Among other sections, the ACL message may contain a fragment of agent's world description. It is expressed in the form of XML-based ontology.

In order to apply ontology for semantic annotation of Web resources, RDF [11, 36] and RDF Schema (S) [9] were originally developed by the W3C as a refinement of XML. Now RDF and RDF(S) are widely used as an interoperable ontology representation language in the Semantic Web, which is "…designed to smoothly interconnect personal information management, enterprise application integration, and the global sharing of commercial, scientific, and cultural data." [7].

4. Our Basic Tools for Integration - "Ontology Mediator" Component and Semantra-2 Design Framework

In our approach to semantic integraton in multi-agent environments we propose to use a special architectural component. For most cases, that component is implemented

as the customized hardware device capable of mediation between different agents and heterogeneous data sources in accordance with information needs of certain single user or a small user group. We believe that differences in data formats and information needs reflect deep conceptual differences on the level of ontology. Thus, runtime mediation activities should be expressed explicitly as ontologies' transformation workflow process. In the course of that process, conceptual entities of the source ontology, together with corresponding data instances, are restructured and converted to the entities and instances of the destination ontology. To emphasize important role of ontology in the course of mediation we gave the name of Ontology Mediator to the described component.

In principle Ontology Mediator should provide for a wide range of different mediation scenarios, and, in our vision, its hardware should be principally able to support communication via any of the most popular protocols. Such requirements lead to broad variations in internal hardware and software architecture: depending on specific conditions and requirements, implementation of Ontology Mediator varies from specialized middleware components to reconfigurable hardware devices.

In order to reduce design efforts and enable reusability of designed subcomponents of Ontology Mediator we have applied the widely accepted model-driven design (MDA) methodology. Fitting the general MDA principles, the extensible hardware platform of Ontology Mediator comprises two specially designed hardware modules:

- Processing Unit – an unmodified part of Ontology Mediator, where the central processor and basic communication interfaces are installed.
- Extension Board – a customizable interface board that can be easily extended by different hardware and embedded software components (plug-ins) on demand of specific requirements.

Alone hardware components of Ontology Mediator would be not much useful for development and exploitation of complex integration solutions, because sustainable support has to be proved for developers during components' modeling, coding and design of ontology transformation algorithms. In order to provide such support we accompanied Ontology Mediator with a special design framework. We gave to the framework the name of SemanTra-2 (Semantics Transformation, version 2). The SemanTra-2 framework is based on our previous work of graph-based RDF ontology transformation. In the SemanTra-2 we will improve previous results and now automated methods of information modeling and design of ontologies' transformation workflow play a dominant role to assign unambiguous and strict semantics to the modeling concepts and algorithms. As a whole SemanTra-2 framework consists of four major components (fig.1). Some of the components are stable and accessable via standard service interfaces; others are generated in accordance with domain-specific models and transformation specifications.

The mapping design GUI facilitates group-oriented development of ontology transformation processes for selected target platforms. In this component we propose to represent ontologies as a hierarchy of UML meta-models and models, and apply our original graphical modeling paradigm – Semantics Transformation Lasso (SETRAL), which is extremely useful when modern Tablet PC and Visual Interactive Desks can be used during design. SETRAL is a kind of computer-aided design process of object-oriented information models. It is grounded in UML 2.0 and is practically implemented inside IBM Rational Software Architect tool. Main subject of interest in

SETRAL is the UML class diagram in the form of graphical representation. And the main purpose of SETRAL application is facilitating recurrent interactive activities of model-to-model transformations.

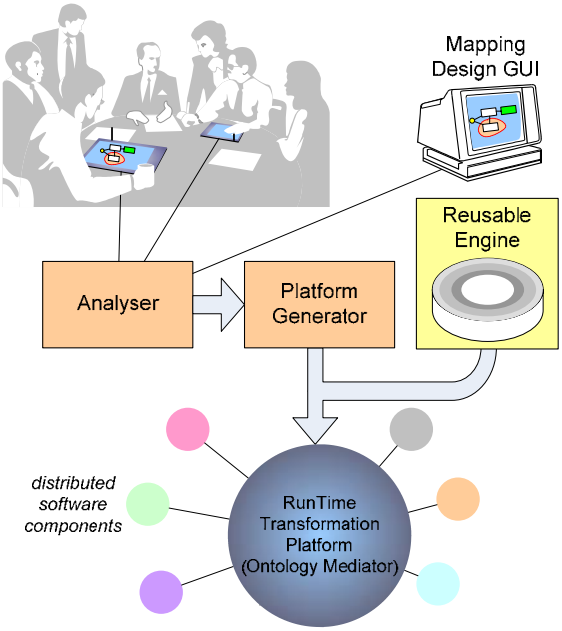

Fig. 1. Architecture of SemanTra-2.

For the user SETRAL offers a special smart graphical tool - Semantic Lasso (SL). That is a closed shape with arbitrary smooth boundaries. The user can draw a free hand fragment of the SL boundary (the path) on top of the source UML class model to select initial classes to be transformed. The special SETRAL algorithms (shaper) will automatically close the path which has been drawn and will make it smooth as necessary. Another part of SETRAL algorithms (conjugator) will perform logical inference on the source model and its meta-model to detect another entities (classes) that are semantically closely related to the entities inside the SL, but were not manually selected by user. Conjugator will propose to include related entities and will extend the shape of SL as needed. As soon as the source content of the SL was defined the third group of SETRAL (mapper) will perform semantic mapping of the source entities inside the SL to the correspondent entities of the destination model. The result will be displayed inside the SL as a fragment of the destination model.

On the basis of visual mappings between source and destination models the second component of SemanTra-2, Analyzer, produces internal specifications of ontology transformation workflow. Analyzer also plays a role of framework repository, providing interfaces for loading core meta-models, domain models, as well as specifications of target software and hardware platform for SemanTra-2 runtime services.

The SemanTra-2 Platform Generator adopts basic principles of Model-Driven Architecture and automatically generates software artifacts for the selected target trans-

formation platform. Each kind of supported target platform is based conceptually on the same SemanTra-2 Reusable Transformation Engine (T-Engine).

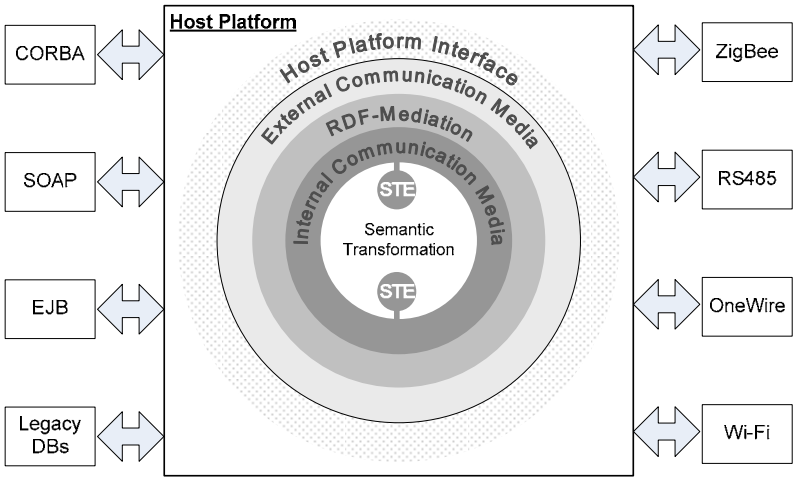

Fig. 2. T-Engine's Architecture.

T-Engine component plays a major role for runtime transformations and support of semantic interoperability of distributed software systems. T-Engine is designed on the basis of the layered approach and communication between layers is performed by the internal message passing mechanism. The data transmitted inside the message are represented in the form of a RDF model that depends on a particular ontology. The Semantic Transformation layer plays the central role in the successful fulfillment of Ontology Mediator's activities. In particular, on this layer the Semantic Transformation Management module collects instances of input messages and fuses them into the united RDF model. Relating message's instances with each other, the Semantic Transformation module exploits the message's meta-information and capabilities of RDF framework to link different resources via universal resource identifiers (URI). Once all needed instances have been collected and the source RDF model has been completely composed in accordance with the specification, the Semantic Transformation Management module places the model into the container for further processing by means of so-called Semantic Transformation Entities (STE).

The complete set of operations performed on the Semantic Transformation layer can be described by the following diagram (fig.3).

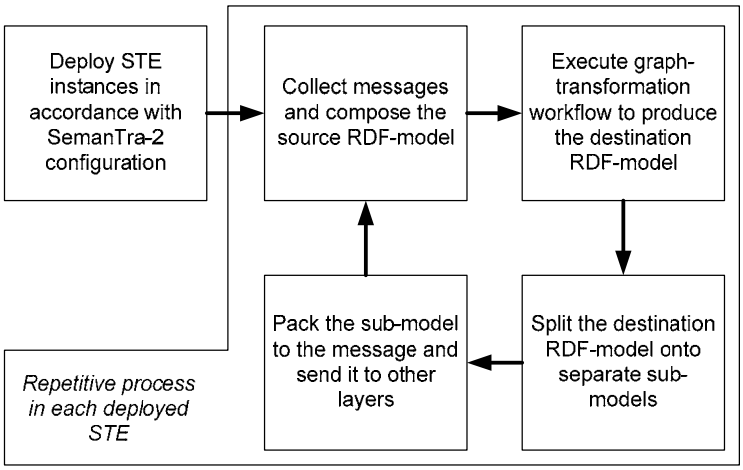

Fig. 3. Activities of the Semantic Transformation layer.

5. Ontology Mediator Settings in the Healthcare Domain

In the course of our healthcare project we focus on tight combination of a multi-agent platform and Ontology Mediator. Available third-party implementations of Java Agent Servers like JADE [6], and domain-oriented hardware implementation of Ontology mediator comprise a solid architectural component called Knowledge Hub, which facilitates secure integration of heterogeneous components and medical data sources in global environment (fig.4).

Knowledge Hub has two kinds of interfaces available for external components: (i) for submitting agents to the Agent Server, and (ii) for bi-direct communications with heterogeneous information resources needed for Ontology Mediator. Inside Knowledge Hub agents can use common MAS facilities for direct communications. But in most cases, due to differences in used ontologies and dynamically changed operation conditions, indirect message-oriented communication of agents is provided by Ontology Mediator. Each agent has abilities to submit definitions of ontology transformation workflow and STE specifications. Since the submission the agent is capable of transmitting and receiving messages to\from Ontology Mediator. It manages data processing and security control, performing real-time semantic verification of *ad hoc* queries and enactment of workflow processes.

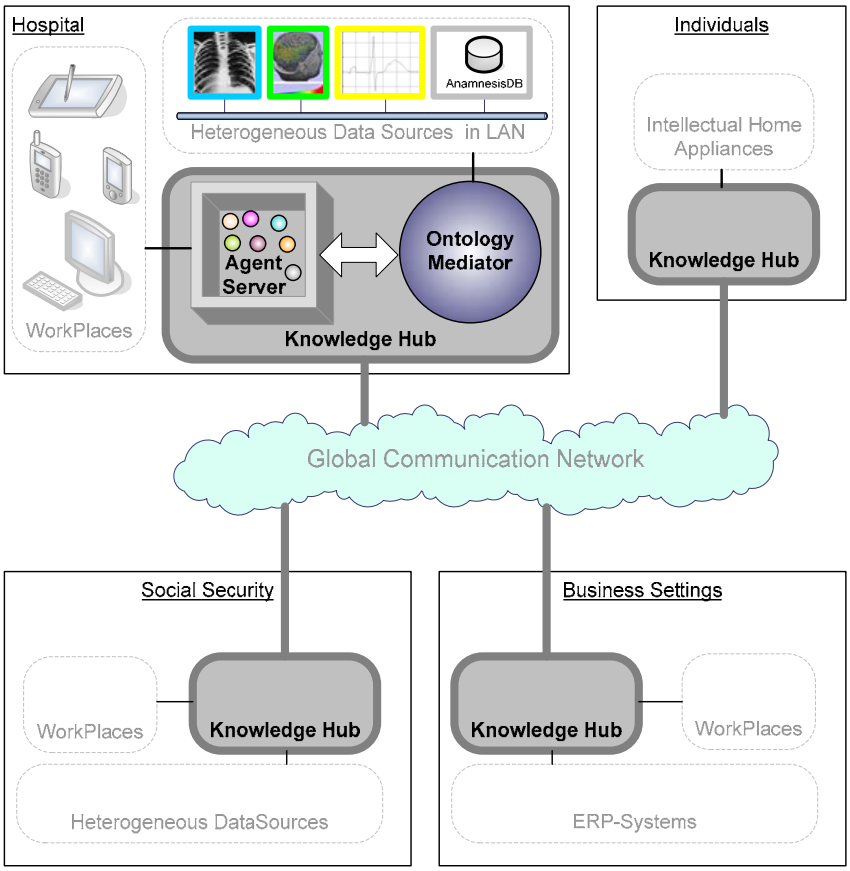

Fig. 4. T-Engine's Architecture.

In medical institutions access to Knowledge Hub is provided from different work places equipped with stationary or mobile computational devices. Specially designed devices use full power of the agent-based paradigm and implement own platforms for agent's mobility and communication. Legacy software systems and existing data bases are indirectly connected to agents' facilities of Knowledge Hub through the interfaces of Ontology Mediator. It translates requests and commands of such proprietary systems into MAS messages, which are expressed in terms of appropriate ontology, and passes the messages to the Agent Server. Once the response is produced inside the Agent Server, it is routed back to the external system. Knowledge Hub exposes secure interfaces of inter-agent communication to global communication network, so different interesting parties such as social security establishments, enterprises, and individuals can be connected to relevant information sources. Using our Sematra-2 design Framework developers can consistently design, implement, and deploy inter-connected Knowledge Hubs, forming the intellectual network of medical data and applications.

During software implementation of Knowledge Hub's components we exploited different distributed technologies, and the tuple space based communication paradigm [56] based on JavaSpaces technology [57] showed the best performance, and was the most attractive one from the architecture point of view.

6. Major Results and Discussion

In this work we have reviewed modern problems of information integration for the healthcare domain, and introduced a new approach to provide information interoperability among heterogeneous loosely coupled components. The basic outcome of our approach is the architectural concept of Knowledge Hub. It demonstrates benefits of joint application of multi-agent paradigm and an ontology transformation process. In practical cases Knowledge Hub is embodied in the form of MAS server and our own special hardware or software component called Ontology Mediator. Equipped with a wide set of input/output interfaces, Ontology Mediator becomes the appropriate platform for execution of message-oriented transformation workflow algorithms. Inside Knowledge Hub these algorithms, combined in the framework of the reusable engine, are parameterized by locally defined conditions for joining separate input messages into the united RDF model and explicitly defined rules of its transformation into the set of output RDF models. Application of RDF models reduces computational costs of ontology transformation, because inside the agent's message only URI links can be used, instead of original binary data. That feature is extremely useful for medical applications, where large number of sources is represented in the form of high-resolution images or even video streams.

The developed design framework SemanTra-2 gives abilities for design of domain-oriented Ontology Mediators and broad distribution of Knowledge Hubs in different settings. The model-oriented approach and layered architecture of the Transformation Engine allow easy adaptation of Ontology Mediator for different configurations of medical systems. Despite of modification of the structure and semantics of components in the course of their evolution, the SemanTra-2 allows for maintaining the permanent information consistence among multiple components. For example in a case of modification of the underlying database schema or the interface definition it is necessary only to modify the definition of semantic transformation for some STE without changing the implementation of external components.

Some solutions are known for us as closely related examples of application of message-oriented approach for integration of heterogeneous information sources. For example MARS-X [10] and XMIDDLE [38] use tuple-based coordination paradigm based on JavaSpaces software implementation. In MARS-X tuples are used for the XML document storing and different software agents can extract relevant information using complex search patterns defined programmatically. Our approach, implemented in Ontology Mediator, permits multiple autonomous agents to define declaratively the conditions for joining messages on the basis of its properties. As for semantic interoperability, the important restriction of MARS-X is necessity to use the same structure of XML document (share the same DTD) for all components of a distributed system. Modification of DTD will require redesign of software components that is not always

possible in the loosely coupled system. In our case several levels of abstraction exist. On the levels with lower abstraction middleware components solve pure technical tasks like collecting, unificating and joining messages. On the most abstract level general graph-oriented methods are used to achieve semantic interoperability.

In the nearest future authors are going to start wide practical investigation of the proposed design solutions in real medical settings. One of the attractive innovations would be integration of Knowledge Hub interfaces for multi-agent communication into existing desktop office applications used by physicians. It will reduce costs of training and will attract multiple participants with divergent information needs.

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Decision Making System for Quality Management in IT-Company

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Abstract. This article is devoted to the problems of IT companies in decision making process for quality management. Authors propose new principles for quality management in IT companies and describe the way how data warehouse technology can be used for supporting decision making process in quality management. As a result, authors tell about their own decision support system that is developed according proposed principles and models.

Keywords: Quality Management, Decision Support Systems, Data Warehouse Technology

I Introduction

Quality Management is an important part of managing a successful company. This process includes much more than controlling product quality and finding product items with defects. Really it involves all activities that are intended on planning, supporting, controlling, analyzing and improving quality level of the company. Today there are a lot of quality management models, concepts and standards. The most famous among them are Total Quality Management model, Six Sigma model and ISO (International Organization for Standardization) standards. All of them give companies common recommendations how to implement principles of quality management into their business.

Many articles and books are dedicated to the problems of implementing quality management models into reality [1, 2, 3], and not less describe success stories of companies who work according principles of quality management [4]. But really, despite the fact that all models use similar principles for quality management, quality management processes of various companies differ greatly. The cause of this problem is the fact that similar methods and techniques of quality assurance can not be used for different products and industries. That's why quality management processes must be designed for each company individually.

In this work we consider the quality management in small and medium-sized IT companies, which produce software products and services. The practice shows that quality management in such companies differs from quality management in manufacturing companies.

The first reason for this difference is the software development process. We can divide the types of software development process in two groups: traditional approach,

when all the parts of development process are precise, and so called quick methodology' which is often chosen by small and medium-sized IT companies. This approach is based on the fact that many phases of the process require imagination and non-standard attitude. It means that employees must not only recognize the situation and implement common method to solve the problem, but also develop new solutions. The customer takes part in the development process, the requirements are constantly changing and obviously there is no common solution. As Fauler says, constantly adapting according to user requirements software development process is unpredictable. Under these conditions it is very important to find corresponding people with necessary skills and continuously improve effectiveness of their work.

The second reason for the difference between quality management in IT and manufacturing companies is the product. Any software product is practically unique even if there are a lot of products with similar functionality. As a result, it's rather difficult to create a common metric to measure quality levels of software products. There are a number of standards, for instance,

ISO/IEC 9126-1:2001 Software engineering -- Product quality -- Part 1: Quality model

ISO/IEC 9126-2:2001 Software engineering -- Product quality -- Part 2: External metrics // Part 3: Internal metrics

ISO/IEC 9126-4:2001 Software engineering -- Product quality -- Part 4: Quality in use metrics

But they are not always suitable for every company and every product. So very often a company has to develop its own quality standards and quality measures. Besides, sometimes projects of IT companies don't refer to the particular product. Such Research and Development projects require even more attention to quality assurance because their results are relevant for strategic achievements of the company, but these results are difficult to measure.

The third reason is quality metrics. Mostly they are fuzzy and difficult to measure. Their estimations are based on experts' assessment and that's why they are always subjective. Besides, very often metrics that are suitable for one software product can't be used for another one. So, for example, telecommunication software and medical systems can't be measured by the same parameters. Telecommunication companies need to track the information about the following:

- Their network infrastructure including network components, assemblies, circuits.
- Service orders and repair orders. There is a need to be able to order telecommunication services and items, easily activate service, and track repair orders to fix problems.

And for health care enterprises it's important to know:

- Relationships between parties such as patient relationships with their practitioners, with which health care networks the provider is associated, and which practitioners are associated with which health care provider organizations
- The type of services and goods available from the health care providers.
- The types of different agreements.
- Records of health care services performed as they relate to various health care incidents, visits, and episodes [9].

So software products for different types of organizations should collect different types of information, as for telecommunication companies key information differs a lot from the most important information for health care organizations, and it's very hard to measure the effectiveness of the work in various companies by the same set of metrics. That's why even within one company it is very hard to compare quality level of different software products and to measure effectiveness of quality management procedures.

And the last but not least reason is the environment. Here we mean all external influencers that are relevant for the project. They can include customers, government, laws, technical progress, and so on. The fact is that for the company it is very hard to predict changes connected with them, but these changes are critical for achieving successful result.

All these features put a serious problem before IT companies - how to implement and make decisions according principles of quality management? In this article we give a possible solution to this problem and propose to use data warehouse technology to support decision making process in quality management of IT companies. This approach is not absolutely new for quality management and there are some articles devoted to this problem [5], but particularities of quality management in IT industry require other models and methodologies.

The goal of this work is to propose a solution focused on IT companies and to present our decision support system for quality management on the base of data warehouse technology. So, on the base of our aim, we divided our article into three parts: the first part is devoted to the problems of quality management principles in IT companies, the second part describes data models that we propose for building decision support system, and the third part gives an overview of our decision support system.

II. Quality Management Principles in IT Industry

The group of ISO standards is one of the most popular approaches for implementing quality management systems. It gives the common recommendations for developing quality management systems, grounding on eight basic principles: [6]

Principle 1: Customer-Focused Organization. Organizations depend on their customers and therefore should understand current and future customer needs, meet customer requirements and strive to exceed customer expectations.

Principle 2: Leadership. Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.

Principle 3: Involvement of People. People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.

Principle 4: Process Approach. A desired result is achieved more efficiently when related resources and activities are managed as a process.

Principle 5: System Approach to Management. Identifying, understanding and managing a system of interrelated processes for a given objective improves the organization's effectiveness and efficiency.

Principle 6: Continual Improvement. Continual improvement should be a permanent objective of the organization.

Principle 7: Factual Approach to Decision Making. Effective decisions are based on the analysis of data and information.

Principle 8: Mutually Beneficial Supplier Relationships. An organization and its suppliers are interdependent, and a mutually beneficial relationship enhances the ability of both to create value.

At a glance, all these principles are simple and can be common guidelines for all manufacturing companies, but particularities of software development companies "born" new difficulties here.

The first problem is System Approach to Management and Leadership. The fact is that IT companies usually use project-oriented scheme of management. It means that each employee has two managers – project manager and linear manager, who is the head of department. But if work of a department is intended on one project these two roles are performed by one person, who is mostly a project manager, and only then – a linear manager. Any of these situations is complex for management because all actions and decisions must be supported by all managers.

Next problem links to Mutually Beneficial Supplier Relationships. For many IT companies who focuses on software development it is very hard take this principle into reality because it is not clear who the supplier is. For such companies this principle is really unnecessary.

And the last but may be the most complex problem for IT companies is Factual Approach to Decision Making and Continual Improvement. The main its reason is that for IT companies it is much more difficult to define quality level of the company and to gather factual data about products, defects and customer satisfaction.

These problems do not mean that principles of ISO standards are not applicable for IT companies. In opposite, they show that it is not enough for IT companies to follow only these principles. We think that IT companies need to enlarge the sphere of quality management. We propose to use following ideas for quality management in IT companies:

- **Focus on Process quality instead of Product Quality**. This principle doesn't mean that product quality must not be measured, but company must pay as much attention as possible to the quality of the process. This attitude enables company to compare its projects and not to collect unimportant metrics for all products as it happens now. There through, this approach also helps company to collect factual data for decision making.
- **Measure Employees' Efficiency as a part of Quality Management**. This principle is intended to solve problems with System Approach to Management and Leadership. By using it we try to provide an objective system of measuring employees' efficiency that will be independent from manager and that will show people contribution to the development process. Besides, it also enables company to collect factual data and make decisions about forming workgroups for projects or hiring new employees.

- **Include Risk Management as a part of Quality Management**. This principle is intended to solve problems of the environment and to take into consideration different factors that can really influence the quality of products and development process.
- **Focus on Customer Support**. This idea is intended to elaborate the principle of customer orientation. It helps also to gather more data about product defects and to estimate the level of customer satisfaction.

III. Data Warehouse Models for Quality Management in IT companies

Proposed principles make the serious problem of decision making even more complex. To make this process easier we propose to use decision support system on the base of data warehouse technology [7]. The goal of a data warehouse is to bring data together from a variety of existing databases to support management and reporting needs. The most popular approach for designing data warehouse is “dimensional” one. In the "dimensional" approach, transaction data is partitioned into either a measured "facts" which are generally numeric data that captures specific values or "dimensions" which contain the reference information that gives each transaction its context. Such representation is known as multidimensional data model, and it is the foundation for any data warehouse. For our decision support system we propose to use following data models:

1. Defect Analysis Model (See Figure 1, Appendix)

The purpose of this model is to analyze number of defects that are made during project. By this model manager can understand what phases and spheres of the process must be improved. This model gives answers to such questions:

- How many defects in the project B were made on the design phase and found only on the testing phase?
- What is the degree of functional defects?
- On what phase most defects are made?
- What is the percentage of defects with ‘very high’ priority?

To answer these questions we propose to use following metrics:

- The number of defects
- The degree of defects (number of found defects divided by number of requirements)
- The percentage of defects (number of defects with given characteristics divided by total number of defects)

To conduct analysis we defined following dimensions:

- Project – It is intended to compare processes and to find if defects are repeated from project to project. Repeated defects are a signal of ineffective procedures that must be improved.
- Defect type – Defects refer to different spheres of software development: algorithms, user interface, functionality, documentation and so on. It is important

to understand what defects are made more often to improve the corresponding procedures of the process.

- Defect priority – Defect priority describes the importance of the defect and its impact on the project. In practice traditionally five priorities are used: very low, low, medium, high, and very high.
- Stage, when defect was made – This dimension is intended to analyze on what phases of the process most defects appear. These phases require more attention or even improvement.
- Stage, when defect was found – By using this dimension the quality control procedure is analyzed. The problem that must be solved is that defects can be found not on the stage, when they are made. The aim is to reduce number of defects which are found and made on different stages.
- Time – It is a common-used dimension for data-model. It enables to look at metrics dynamic during different time periods.

2. Process Actions Analysis (See Figure 2, Appendix)

The purpose of this model is to analyze actions in the process. It gives the answers to such questions:

- How many actions were cancelled in the project B but not cancelled in project A?
- What actions were performed with delay on the design stage in project A?
- What is the average deviation in budget for the actions that are performed with delay?

To perform this analysis we propose following metrics:

- Deviation in schedule (is calculated as real activity time minus planned activity time)
- Deviation in budget (is calculated as real activity costs minus planned activity costs)
- Frequency of canceling an activity (how many times an activity was cancelled)
- Number of activities

To conduct analysis we defined following dimensions:

- Project – This dimension is intended to compare processes and to find if same problems are repeated from project to project. Repeated time delays or budget overdrafts are a signal of ineffective procedures that must be improved.
- Phases – Traditionally, five phases are defined within software development process: gathering requirements, designing, coding, testing, and implementing. It is very important to understand if activities within each phase enable to get required results.
- Action priority – Action priority describes importance of the action within the process. The main question for analysis here is canceling actions with high priority because it is either a potential reason for defects or action is not so critical for the process.
- Action – By this dimension we mean the list of standardized actions within processes of the company. Statistic on each action will show the quality of the whole process.

3. Personnel skills Analysis (See Figure 3, Appendix)

The purpose of this model is to analyze personnel skills of employees. By support of this model a manager gets answers to the following questions:

- How do educational courses improve employees' skills?
- What skills, qualification and educational level are necessary for position A?
- What payment level is suitable for a new employee?

To answer these questions we propose to use following metrics:

- Employees (list of employees who have corresponding attributes)
- Number of employees

Main dimensions in this model are following:

- Education level – This dimension is intended to analyze what education is necessary for position. It helps manager to formulate requirements for position when new employee is hired.
- Educational courses – This dimension is necessary to assess courses' effectiveness. By using it manager will see what courses are useful to improve some skills or to acquire some qualification
- Skills and Qualification– These dimensions help manager to find employee for position or to form new workgroup.
- Payment Level – This dimension expresses payment categories that exist in the company.
- Employment duration – This dimension shows how many years employee woks in the company.
- Position – This dimension lists all positions of the company.

4. Task allocation Analysis (See Figure 4, Appendix)

The purpose of this model is to analyze tasks allocation within the company. By using it manager gets answers to the following questions:

- How many mandatory tasks are performed by employee A with delay?
- What skills are often required to perform tasks as developer?
- How often very important tasks are performed with delay?

The main metric here is number of tasks with corresponding characteristics.

To perform analysis we propose to use following dimensions:

- Time frames – This dimension includes two variants. First, it is a list of time periods (years, months, days), and secondly – it is a list of statuses that show if tasks were performed in time. Here we propose to use three statuses: before time, in time, with delay.
- Employee responsible – By this dimension we mean a catalogue of all employees who perform tasks. This dimension can help to analyze effectiveness of particular employees.
- Assignment Type – Here we mean that each task can be assigned to the employee as a common responsibility, or employee can volunteer to perform the task. This difference is important to estimate employee's performance.
- Importance rate – This dimension shows how critical the task is for the process or for the company. Manager must always take this fact into consideration when he assigns the task to the employee.
- Employee position – This dimension lists all positions within the company. By using it manager analyses what tasks are usually performed by employees on particular position.

- Required skills – This dimension is intended to analyze what skills are necessary to perform tasks. Using this dimension manager can understand what skills are most required in his department.

5. Organizational Structure Analysis (See Figure 5, Appendix)

The purpose of this model is to analyze structure of personnel. By using it manager gets answers to the following questions:

- How many employees work in department A on position B?
- How many employees from department A are involved in project B?

The main metrics here are number and list of employees with corresponding characteristics. Main dimensions here are following:

- Project
- Manager
- Time
- Age
- Position
- Department

All these dimensions represent the lists of corresponding entities within the company.

6. Customer Requests Analysis (See Figure 6, Appendix)

The purpose of this model is to analyze requests that are got from customers. This model can give answers to the following questions:

- How many requests on product A have high priority and are preceded more that one week?
- How many urgent requests are preceded now?
- What is the average price of work for requests from customer A?

For this model we propose to use following metrics:

- Number of requests
- Average price

As dimensions we propose here following items:

- Customer – This dimension is intended to analyze the level of customer service for each particular client.
- Customer Product – This dimension is intended to analyze common requests and defects for each particular product.
- Priority – It shows how critical the request is. Traditionally there are five priority categories: very low, low, medium, high, and very high.
- Work duration – This dimension includes two variants. First, it is a list of time periods (years, months, days), and secondly – it is a list of statuses that show if work on requests was performed in time. Here we propose to use three statuses: before time, in time, with delay.
- Type – This dimension lists all types of requests that can be in the company: requests for support, requests for modification and so on.
- Status – This characteristic shows the stage of work on requests. The main problem for analysis here is time frames of each phase.

7. Defects Analysis (See Figure 7, Appendix)

The purpose of this model is to analyze defects that are found during work on customer requests. By using this model manager gets answers to the following questions:

- What reason type is distinguished for defect category A?
- What quality metrics are suitable for defects from category B?
- What actions are more effective to work on defect with reason type C?

To perform this analysis we propose to use number of defects as a main metric. Besides, we propose to use following dimensions:

- Category – This dimension reflects possible risks types: organizational, structural, technical, knowledge, and so on.
- Product – This dimension is intended to analyze common requests and defects for each particular product.
- Action Category – This dimension shows different actions that are used to close defects. The purpose of analysis here is to find most effective actions for defects with different characteristics.
- Quality Metrics – This dimension lists all possible metrics that can be used for measuring quality level of work on defects. The purpose of analysis is to find most suitable metrics for different defect categories and reason types.
- Reason Type – This dimension is intended to analyze what reason types are distinguished for different defect types.
- Complexity – It is important characteristic of defect because it is base for estimating time frames and price of work on defect.

8. Risk Analysis (See Figure 8, Appendix)

The purpose of this model is to analyze different types of risks. By using this model it is possible to get answers to the following questions:

- How many risks are identified with priority A and category B?
- What is average probability of risks from category A?
- How many risks occur after using mitigation A?

To perform this analysis we propose to use following metrics:

- Number of risks
- Average probability

To analyze these metrics we propose to use following dimensions:

- Risk Category – This dimension reflects possible risks types: organizational, structural, technical, knowledge, and so on.
- Risk Importance – This dimension describes the categories of risk importance. Traditionally five categories are used: very low, low, medium, high, and very high.
- Mitigation Type – By mitigation type we mean different ways of reacting on risks. For example, risks can be ignored, risks can be only monitored, risks can be prevented or actions can be taken only when risk situation becomes a reality. All these types can be used but it is important to understand what type is better in a particular situation
- Risk Output – This dimension shows if a particular risk occurs or not. It is one of the most important facts because it reflects effectiveness of risk management.
- Risk Probability – Each risk may occur with different probability. And it is important to predict this probability as exact as possible.

- Risk Priority – This characteristic shows if the risk is critical or not. Traditionally work begins for risks with high priority, and risks with medium or low priority may be ignored.

9. Impact Analysis (See Figure 9, Appendix)

The purpose of this model is to analyze impacts of different risks and quality of impact prediction. By using this model it is possible to get answers to the following questions:

- What impacts are distinguished for a particular risk category?
- How many impacts are registered for a particular impact type with impact probability more that 50%?
- What is the mean probability for impact type A?
- What mitigation type is used more often for impact type B?

Main metrics here are following:

- Number of predicted impacts
- Number of registered impacts

To analyze these metrics we propose to use following dimensions:

- Risk Category – This dimension reflects possible risks types: organizational, structural, technical, knowledge, and so on. Its purpose is to find what impacts occurs more often for different risk categories so that simplify defining impacts for new risks.
- Impact Type – This dimension is intended to analyze what impacts occur more often. It lists all possible impact types for risks: budget overdraft, time delay, project stop and so on.
- Mitigation Type – By mitigation type we mean different ways of reacting on risks. For example, risks can be ignored, risks can be only monitored, risks can be prevented or actions can be taken only when risk situation becomes a reality. All these types can be used but it is important to understand what type is better in a particular situation
- Impact Probability – Each impact may occur with different probability. And it is important to predict this probability as exact as possible.

10. Mitigation Analysis (See Figure 10, Appendix)

The purpose of this model is to analyze mitigations and to find most successful among them, so that use only successful mitigations in future. By using this model manager gets answers to the following questions:

- What mitigations are successful against organizational risks that can cause delay of the project?
- What is mean probability reduce of mitigations against knowledge-lack risks?
- What cost category is suitable for mitigations against budget overdraft?
- What mitigation type is most effective in short-term period?

To perform this analysis we propose to use following metrics:

- Number of successful mitigations
- Number of failed mitigations

Within this model we also propose to use following dimensions:

- Risk Category – This dimension reflects possible risks types: organizational, structural, technical, knowledge, and so on. Its purpose is to find the most

effective mitigations for different risk categories so that simplify choosing mitigations for new risks.

- Impact Type – This dimension is intended to analyze what mitigations are more effective for different impacts. It lists all possible impact types for risks: budget overdraft, time delay, project stop and so on.
- Mitigation Type – By mitigation type we mean different ways of reacting on risks. For example, risks can be ignored, risks can be only monitored, risks can be prevented or actions can be taken only when risk situation becomes a reality. All these types can be used but it is important to understand what type is better in a particular situation
- Probability Reduce – It is an important characteristic of the mitigation because it shows its effectiveness and allows comparing different mitigations against same risks.
- Cost Category – Each mitigation requires additional resources and for manager it is important not only to find mitigation with the biggest probability reduce but also with the lowest cost category
- Time - It is a common-used dimension for data-model. It enables to look at metrics dynamic during different time periods.

IV. Decision Support System Software Product

Our principles and data warehouse models made up the foundations for the practical development of decision support system for quality management of the IT Company. As a platform for our system we used open sourced system Ofbiz [8]. Open For Business (Ofbiz) is a suite of enterprise applications built on a common architecture using common data, logic and process components. The loosely coupled nature of the applications makes these components easy to understand, extend and customize. For our task we exploited three major Ofbiz components:

- Workflow engine – It is used to automate processes described in XPDL (XML Process Definition Language) notation. Within this component the user can import processes into repository; execute processes; assign time frames, executers and additional attributes to activities; monitor process execution and gather statistics on process.
- Entity engine – This component represents a special interface for working with database. Its using simplifies defining database schemes because it enables engineer to work only with info-model and don't pay attention on technical realization of a particular database. It means that engineer needs only to define entities in XML (eXtensible Markup Language) file, and all work with database is performed by engine.
- Data Warehouse engine – This component is responsible for collecting data, generation special reports and executing requests on the base of data warehouse models. It represents a special tool for analysis and decision support.

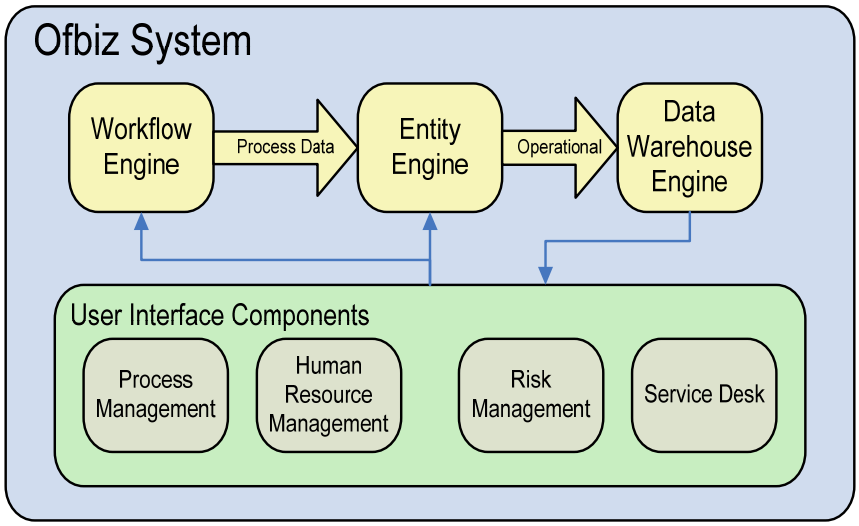

Fig. 1. System Architecture

Data Warehouse engine plays a central part in our system, but before performing analysis and generating reports with it we need to collect operational information. This activity includes two tasks: first of all – design database scheme, and secondly – develop user interface to input information. For designing database we decided to divide our system into four components: Process Management, Human Resource Management, Risk Management, and Service Desk. For each of them we developed data models, which enable us to collect data for data warehouse models. (See Figures 11-15, Appendix)

Next, we developed user interface. So, for Process Management component we developed interface that enables user to do such operations as: start processes, monitor process execution, assign attributes to activities, create additional task for users, join tasks into groups, join tasks into sequence, etc.

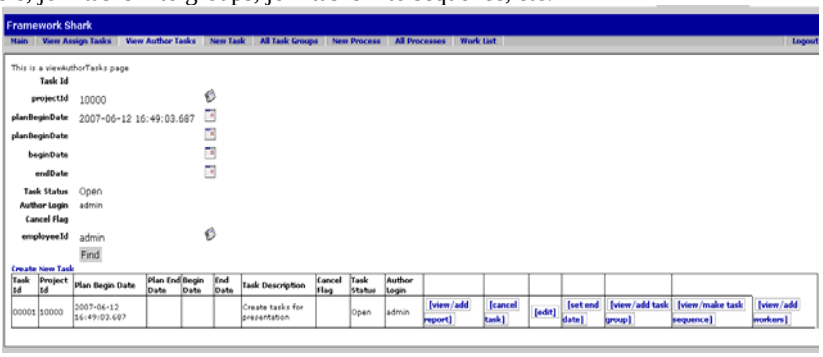

Figure 2. Process Management User Interface

For Human Resource Management component we developed interface that enables user to do such operations as create organizational structure of a company, create position structure of a company, create employees, create workgroups for the project, define employee skills, qualification and so on.

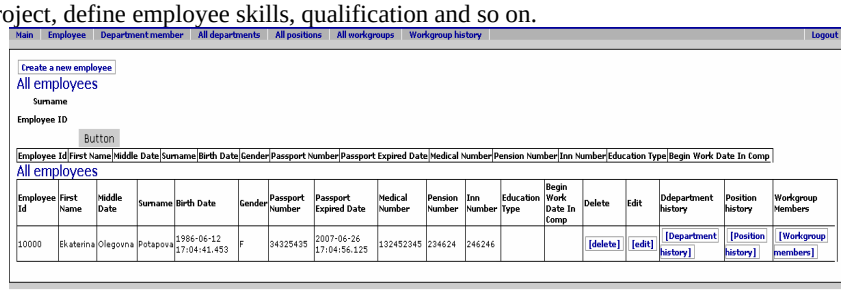

Figure 3. Human Resource Management User Interface

For Risk Management component we developed interface that enables user to do such operations as: create risk list for the project, define risks impacts, define risks mitigations, create risk monitor plan, create risk monitor reports, etc

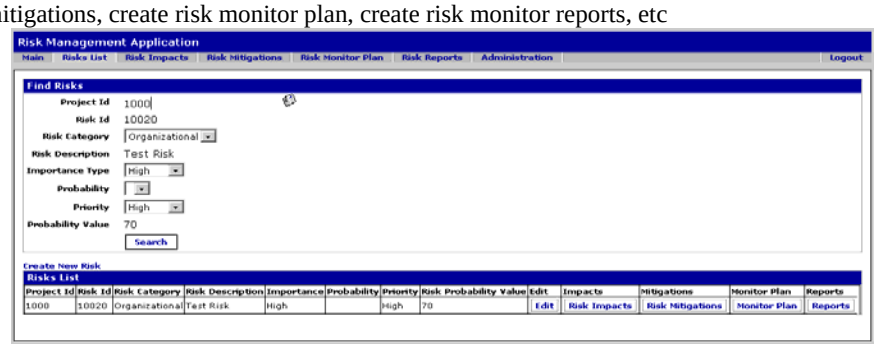

Figure 4. Risk Management User Interface

For Service Desk component we developed interface that enables user to do such operations as: create customer requests, define requests defects, define defect reasons, create actions to work on defect, define quality parameters for defect, etc

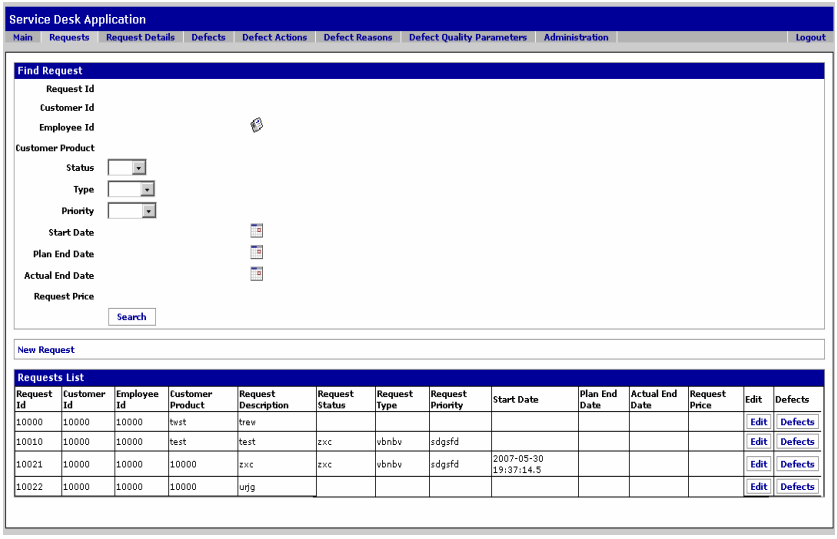

Figure 5. Service Desk User Interface

Now we work on transporting our models into data warehouse engine and configuring processes of data transition from operational to warehouse databases.

V. Conclusion

So, during our research we studied the particularities of developing decision support system for quality management in IT companies. We consider that for IT companies it is not enough to follow common principles of quality management. Quality management in this industry must cover more spheres and all this information must be taken into consideration in decision making process. To improve quality management in IT companies we propose four new principles:

- Focus on Process quality instead of Product Quality.
- Measure Employees' Efficiency as a part of Quality Management.
- Include Risk Management as a part of Quality Management.
- Focus on Customer Support.

Also we propose to use decision support system on the base of data warehouse technology. Such a system can simplify gathering factual information for making decisions that will have a significant impact on quality management.

The limitations of our approach are that we consider quality management only in small and medium –sized IT companies that differs from quality management process in big IT companies. Besides, we focus on principles of ISO standards that are wide-spread but vary a little bit from requirements of Total Quality Management

model and others. In future we are planning to investigate other quality management models and approaches.

The results of our research are quite actual and original. There are similar researches devoted to the problems of implementing quality management systems, but for the best of our knowledge there are no attempts to expand quality management principles for IT companies and to develop a decision support system for quality management.

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Appendix

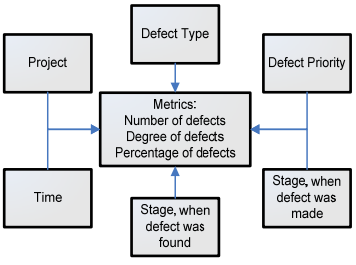

Figure 6. Defect Analysis Model

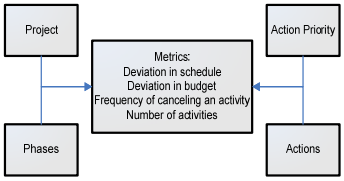

Figure 7. Process Actions Analysis

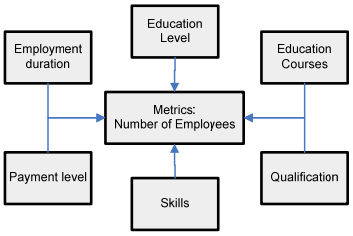

Figure 8. Personnel skills analysis

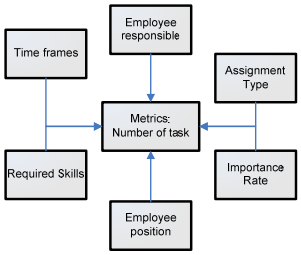

Figure 9. Task Allocation Analysis

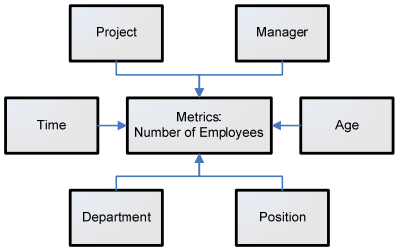

Figure 10. Organizational structure analysis

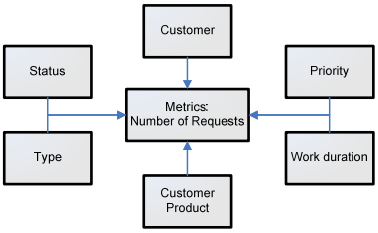

Figure 11. Customer Requests Analysis

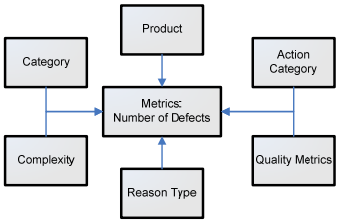

Figure 12. Defects Analysis

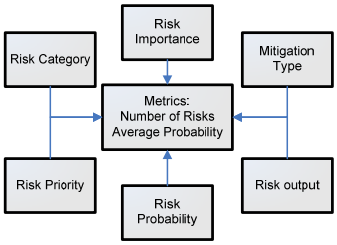

Figure 13. Risks Analysis

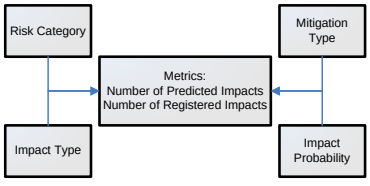

Figure 14. Risks Impacts Analysis

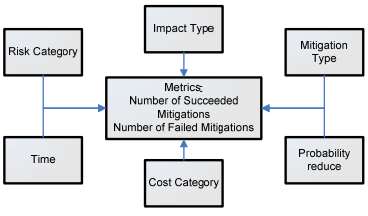

Figure 15. Mitigations Analysis

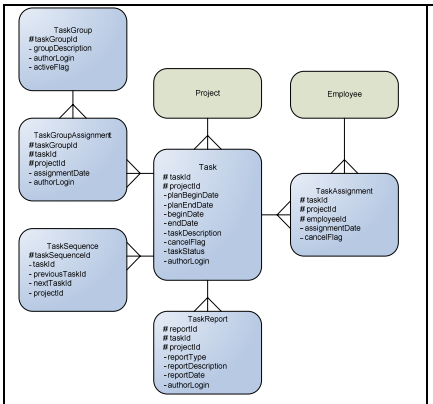

Figure 16. Entity model for task management

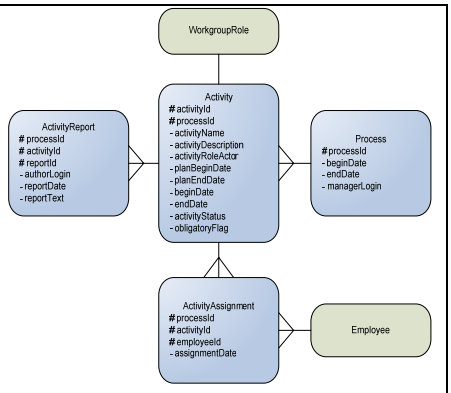

Figure 17. Entity model for process management

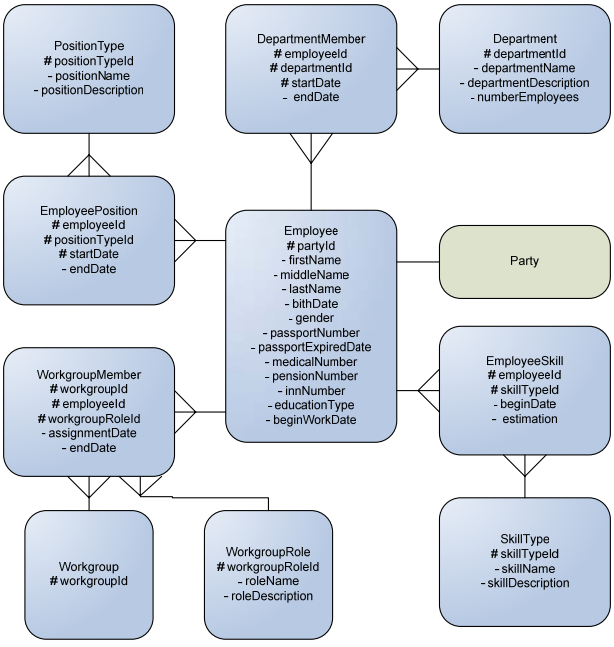

Figure 18. Entity model for human resource management

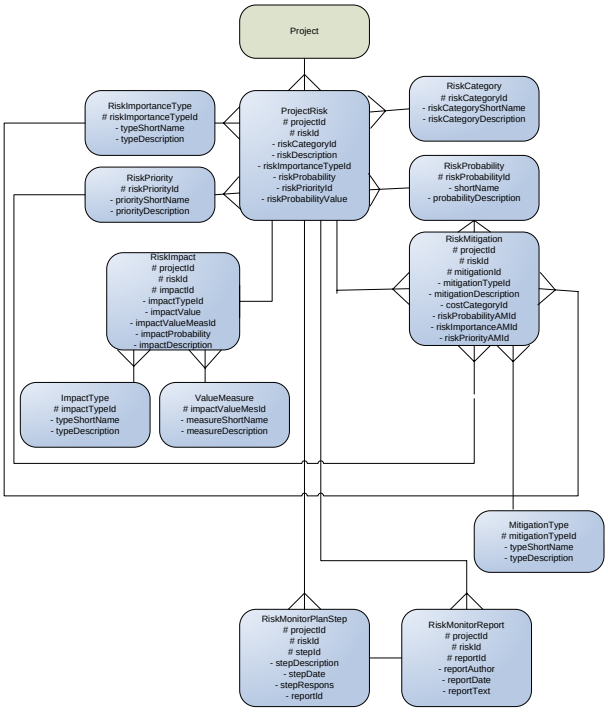

Figure 19. Entity model for risk management

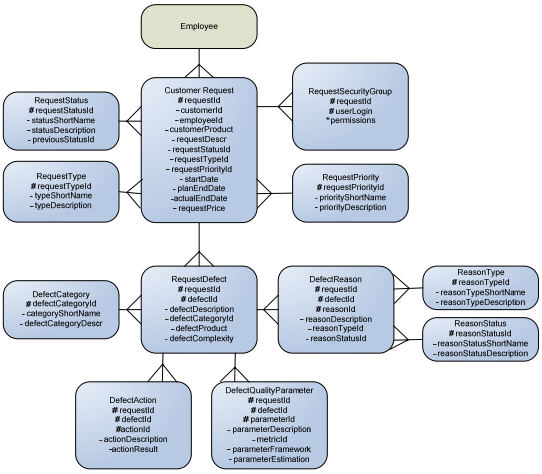

Figure 20. Entity model for service desk

My country or yours? The promise and unknowns of Community Source

David Ferro

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Keynote address, extended abstract

Information Technology officers, presidents, and provosts frequently hold out that the organizations within which they must make technology decisions are inherently different than those of corporate entities. At the same time, driven from the top down, American universities are increasingly ascribing to a corporate model for administrative functions, including Information and Communication Technology (ICT). I propose that, in terms of the technological decision to build, buy, or borrow software, Universities are even less unique than their corporate cousins than they suppose.

The open/free/libre source options still have institutions scrambling to create good business practices. Universities face the same issues of economic necessity and resource management, competition, and cultural resistance to a paradigm shift. They have difficulties in balancing between dependability and flexibility, managing (centralized or) distributed engineering, addressing licensing issues, addressing user needs, and, ultimately, creating evaluation criteria for rational decisions; including evaluating new communities of technological collaborators.

I argue that in their attempt to distinguish themselves from corporate entities, however, Universities have begun creating one model of openware/freeware that warrants watching by the corporate sector as potentially useful. A few projects created in what has been termed community/directed source development may benefit small and mid-sized companies. Community/directed source development begins with a concept, and tries to realize economies of scale by building the cross-institutional management to create a common application from the ground up. On the flip side, universities can learn from the corporate sector the distributed engineering practices used in directed development.

The discussion will range through some of the difficulties presented by community/directed source development. The discussion benefits from recent literature and the many personal experiences of the author to examine how, given these difficulties - civic (or user) considerations can be problematized in technological decisions. The discussion inquires into the importance of these civic considerations and explores attempts to create pragmatic guidelines and resources for these decisions by putting the debate in historical context and referencing the use and power of language and metaphor in creating technological perspectives.

The author spent 15 years developing software in the IT industry, was the senior

manager of Iomega ebusiness operations, and is currently an Assistant Professor of Computer Science at Weber State University and is the chief technologists for the faculty senate there. He is residing in Tampere, Finland, for 2007, engaging in research in usability and creating "The History and Social Implications of Computing" course with the TAUCHI unit of the University of Tampere Department of Computer Science.

The Resource Knowledge and Knowledge Transfer Processes in Business Process Models – An approach based on UML and EPE

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Abstract In a world of complex products and complex business processes, the resources information and knowledge become more and more important. Following the paradigm of managing businesses by managing processes, knowledge and knowledge transfer have to be considered in business process management. Modeling approaches for both – processes and knowledge (transfer) – can only express selected aspects. The authors propose an addition to the Eriksson Penker Extensions (EPE) for UML. This opens a new way to express knowledge descriptions and knowledge transfer processes in EPE-based UML business Process Models.

1 Introduction

Due to the increasing complexity of the external environment in a global market and the increasing internal complexity of organizations, their processes and products, organizations are forced to increase their flexibility [1]. This reflects the high variability of complex systems. A higher variability results in so called knowledge intensive business processes because involved employees have to make more decisions [2, p. 29] and have a higher communication effort [3] in order to fulfil the goal of the respective process. Generally, the level of necessary abilities and capabilities is higher [4]. Knowledge needs special attention by modeling these processes. Since knowledge is necessary to ensure flexibility, it becomes a critical success factor. Business Processes use, implement and generate the know how of organizations, therefore a joint view on both processes and knowledge is required [5].

There exist several approaches that combine Business Process Models (BPM) and aspects of Knowledge Modeling. A selection of them is discussed in section 3. None of them combines Knowledge Modeling (KM) with UML process diagrams. A look into section 3 will show that each of the approaches emphasizes on a certain aspect of knowledge modeling. Since a new approach can only focus on a subset of KM as well, different views on knowledge are presented and discussed in section 2. Our approach bases on UML BPMs applying the Eriksson Penker Extensions (EPE) for UML. Several authors ([6][7] for example) showed the advantages of UML based Business Process Modeling (BPMing) and the necessity of BPM specific extensions to UML. A main

advantage is the broad availability of case tools that process UML diagrams. The use of UML for BPM is discussed in greater detail in section 4.

Our approach combines selected aspects of KM and UML-EPE. Section 5 discusses the aspects of KM that are going to be shown in BPMs based on our UML extension. Furthermore, it is shown how our extension fits into the UML-EPE metamodel.

2 Knowledge and Knowledge Management

The importance of the resource knowledge for organizations has already been shown. Knowledge management is a management discipline that focuses on this important resource. Raub and Romhardt define in [8] eight interconnected functional building blocks of knowledge management. See figure 1. On the strategic level the existing knowledge has to be evaluated and knowledge goals have to be set. Based on the strategic framework, existing knowledge has to be identified (*Knowledge Identification*). Missing knowledge has to be obtained from external (*Knowledge Acquisition*) or internal (*Knowledge Development*) sources. All knowledge be it existing, acquired or developed knowledge has to be made available in an appropriate way to those who need it in order perform their tasks or even to improve their performance (*Knowledge Distribution*). Those who have access to the required knowledge have to be enabled to use this knowledge (*Knowledge Application*).

Finally, it must be ensured that already obtained knowledge is kept available for the organization (*KnowledgeConservation*). These building blocks lead to different views on knowledge as shown below. One might argue that knowledge management can easily be mapped to information management and that there is no real difference between knowledge management and information management. The resource information is already represented in Process Modeling Languages. In EPE knowledge and information are treated synonymously [6, p. 78]. However, there are some characteristics of knowledge that justify special attention. Here, it does not matter whether knowledge is seen just as a special kind of information.

2.1 Knowledge and kinds of knowledge

In the domain of business administration a distinction of knowledge and information based on the three main layers of semiotics – syntactic, semantic, and pragmatic layer – is common. Information represents the semantic layer while knowledge represents the pragmatic layer. Knowledge is required for using information in order to reach a certain goal [9, p.28]. Schwarzer and Krcmar define knowledge as a meaningful, goal-oriented combination of information. It consists of an information set and the context of its elements to each other [10, p.9] .

Different kinds of knowledge require different representations in Knowledge Modeling (KMing). A basic differentiation is to divide between declarative knowledge and procedural knowledge. Declarative knowledge consists of terms and objects and their relationships. It is basically the so called “knowledge-that” while procedural knowledge forms the so called “knowledge-how”. The latter consists of methods and activities and

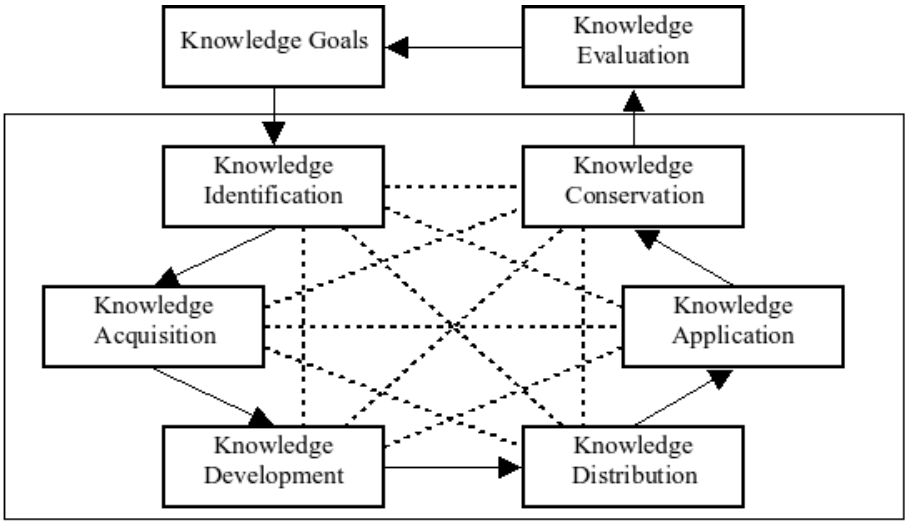


Figure 1. Building blocks of Knowledge Management, adapted from [8, p. 58]

their relationships. It is necessary to apply declarative knowledge in order to perform a certain task [11]. Therefore, representations that combine both aspects are of interest.

Dittmann proposes in [11] another differentiation, based on the intended use and the processing of knowledge in an organization. See table 1. Although Dittmann does not justify this selection of knowledge types and representations, it helps to derive appropriate ways of knowledge representation seen from the perspective of knowledge management.

There is a base of more or less structured factual knowledge, which comes close to information. In order to use and maintain this knowledge it needs to be identifyable respectively. Therefore, structural knowledge and its representation is necessary for *Knowledge Identification*. Furthermore, knowledge needs to be addressable in order to use and maintain it. While some knowledge is administrated and addressable by information systems, personal knowledge is bound to persons and is not accessible via information systems. Here, the notion of tacit and explicit knowledge is common. Tacit knowledge is bound to persons and it is subjective. It is not formalizable and not communicatable [9, p.31]. Explicit knowledge in contrast can be communicated and formalized. Therefore, it is fully administrable by information systems. However, it is not necessarily administrated by information systems. For reasons of simplicity, we use the term tacit knowledge for knowledge that is bound to a person and the term explicit knowledge for knowledge that is administrated by information systems.

As shown before, procedural knowledge describes the *Knowledge Application*.Here, it is represented by Project and by Process Knowledge. The knowledge to apply has to be identifyable, addressable and accessible. Therefore in the view of knowledge management, models like Event-driven Process Chains (EPC) or UML process diagrams

must at least identify necessary knowledge. They should provide information how to address and how to access this knowledge because it may affect process execution significantly. Since *Knowledge Development* is done by the recombination of knowledge, a process may develop new knowledge. The application of knowledge in knowledge intensive processes is based on the combination of different knowledge. Therefore, process models should also identify developed knowledge in order to make it accessible for knowledge management.

Mainly the identification of the knowledge that is necessary in order to perform a certain task but also the knowledge that may be developed during task execution is the base for *Knowledge Distribution* or the management of knowledge access respectively. Here knowledge transfer processes which are discussed later in brief play an important role. They influence the performance of *Knowledge Distribution*. The knowledge transfer processes differ depending on the kind of knowledge that is subject to the transfer process – tacit and/or explicit knowledge.

The other building blocks of knowledge management are not discussed further. The interface between process management (or more precisely process execution) and knowledge management is sketched: Knowledge that is required and developed has to be identified in order to allow knowledge management to perform its task. Additionally, knowledge addressing, access, and transfer processes are of interest in process models because they influence process behaviour at execution time.

Kind of Knowledge	Representation Examples
Factual Knowledge	Texts, Tables, Diagrams, Charts
Structural Knowledge	Knowledge Asset and Structure Charts, Knowledge Maps, Ontologies
Personal Knowledge	Yellow Pages
Project Knowledge	Project Models
Process Knowlege	Petrinets, EPC, Interaction Charts, Reference Processes

Table 1. Kinds of Knowledge and their representation adapted from [11, p. 4]

2.2 Knowledge Transfer processes and Knowledge Objects

The knowledge units of a knowledge structure model (e.g. a knowledge map) are knowledge objects [12, p. 89]. In consequence, referencing to a knowledge object identifies knowledge. A knowledge object is bound to a knowledge carrier which may be an information system, a hard copy, or a person. Tacit knowledge can only be bound to a person. Literature (beginning with [13]) speaks of knowledge transfer and knowledge transformation processes when knowledge changes its carrier. The possible transformation processes are shown in figure 2. Socialization describes the exchange of tacit knowledge between individuals. This can be done by observation and cooperation for example. Externalization transforms tacit knowledge into explicit knowledge. Internalization is the transformation of explicit knowledge into new tacit knowledge of an individual. The Combination does not fit completely into the given systematics. The

transfer of explicit knowledge from one carrier to another carrier is not the main focus here, but the combination of existing knowledge objects to an altered or possibly new knowledge object. These commonly time consuming knowledge transfer processes have an influence on process execution if a process is new or has been changed, or if the process environment is characterized by a high variability, or if a knowledge carrier changes. In these situations, a knowledge transfer is necessary because new knowledge is required and/or it is generated.

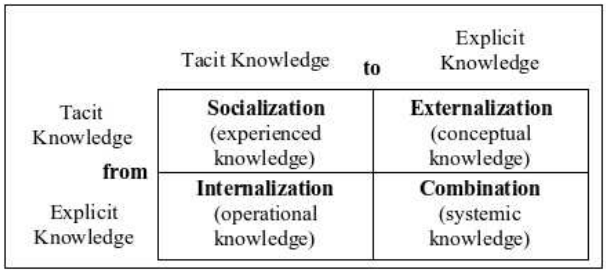


Figure 2. Knowledge transfer processes, adapted from [14, p. 483]

3 Modeling Business Processes with respect to knowledge management

The last section showed what elements of KMing should be considered by modeling Business Processes:

- knowledge objects
- knowledge carriers
- knowledge structure (relationships between knowledge objects and/or their distribution among knowledge carriers)
- knowledge transfer processes

In the following we discuss selected approaches of combining KMing with BPMling. All together, they cover all of the elements of KMing that are named above. However, each approach has some drawback or it focuses just on some of the relevant aspects.We assume that the BPM is in a graphical notation. This supports the use of such models as a means for communication between different stakeholders.

3.1 Modeling of Technical Terms

Business Processes cross several functional units of organizations. Experts of different knowledge domains are involved in the modeling process. Therefore and for other reasons, synonyms, homonyms, ambiguities are likely to occur [15, p.75]. The modeling

of technical terms describes the structure of a part of the organizational knowledge – the knowledge about the semantics of communication . It defines technical terms and their relationships. It helps to identify and to avoid the mentioned problems. A basic way to implement this is a glossary. However, a textual glossary does not fit well within a graphical BPM. Exemplary, we show a different notation by Rosemann [15]. It defines icons for technical terms and their relationships. Additionally, the name, the definition, examples and abbreviations of a term are part of the model. The following stereotypes for relationships are defined:

- "is a" – directed subset-to-superset relationship
- "belongs to" – directed organizational set-to-set relationship
- "part of" – directed set-to-subset-to-whole relationship
- "synonym of" – undirected set-to-set relationship

Additionally, specializations of these relationships are defined. In an BPM only the graphical icons may be shown. See figure 3 for an example. A navigation to explore the structure of technical terms may be implemented.

3.2 Knowledge Objects in extended EPC

In addition to existing objects in extended EPC, knowledge objects are introduced. They are depicted by thought balloons. See figure 4. Knowledge objects are divided in two categories – explicit (rectangular balloon) and tacit knowledge (oval balloon). Directed edges are used to show whether knowledge is required or knowledge is developed by performing a certain activity within the process.EPC with knowledge objects may be accompanied with knowledge structure models like knowledge maps and knowledge structure charts. Both make knowledge objects addressable [16, p. 30].

Communication is the base for *Knowledge Distribution*. Therefore, communication structure may be of interest for BPMing. The ARIS toolset for example defines an additional view that depicts the communication structure of the organizational units that are involved in a Business Process [17, p. 104]. See figure 5.

3.3 Process Modells in KMDL

The KMing and Description Language (KMDL) has been developed in order to model knowledge intensive processes, knowledge transfer processes, and the knowledge that is bound to individuals [18, p. 32].There are two views defined in KMDL. In the process view, the control flow of a processes is depicted. A KMDL process model is restricted to the connectors `and`, `xor`, and `or` and activities. Required Roles and Information Systems may be associated with activities. In consequence, the underlying process model lacks the expressive power of events or conditions respectively.

The second view is the activity view. Knowledge carriers (Persons), knowledge transfer processes (Conversation) and knowledge objects (information/knowledge objects) are modeled here. In contrast to the terminology introduced in section 1, KMDL uses the term information objects for objects of explicit knowledge and the term knowledge objects for objects of tacit knowledge. In the following we keep using the term

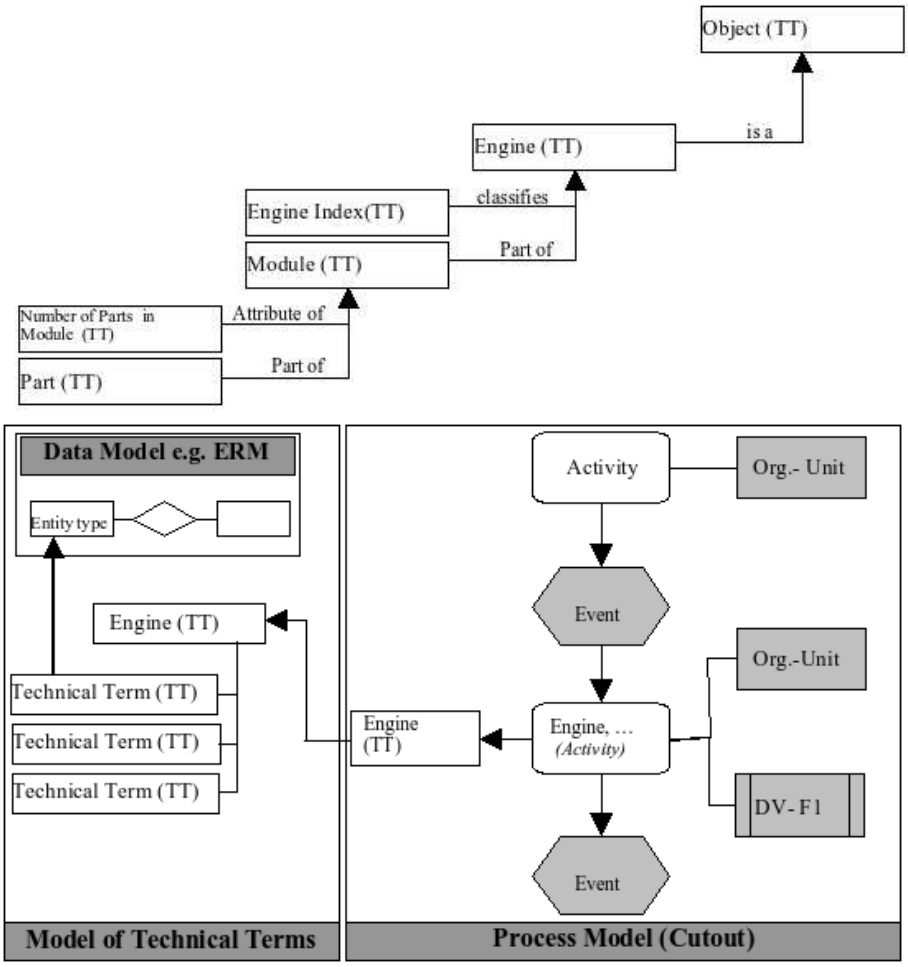


Figure 3. Modeling of technical terms, adapted from [15, p. 80 – 82]

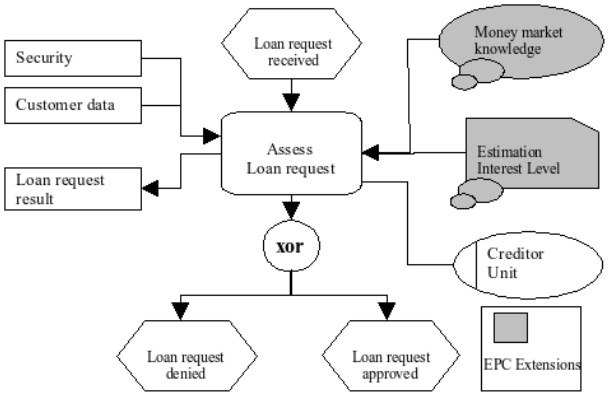


Figure 4. EPC with knowledge objects

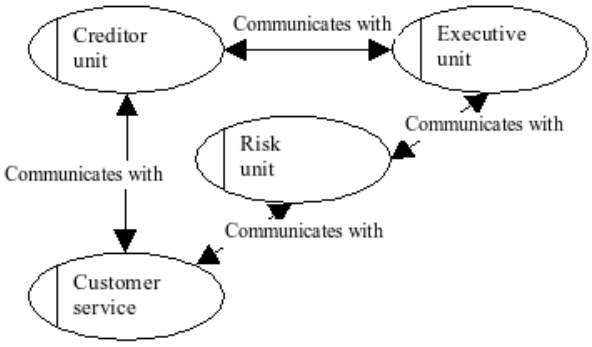


Figure 5. Communication chart, adapted from [17, p. 105]

knowledge object for both explicit and tacit knowledge. In the activity view, an activity (or a task respectively) of a process is broken down to one or more conversion steps and the involved persons and knowledge objects. Furthermore, a person can be associated to roles that are defined in the process view. KMDL covers all relevant aspects of KMing in BPMs. The knowledge objects contain attributes that allow mapping them to knowledge structure charts [19].

However, KMDL lacks some features of process modeling (e.g. events) and the great detail of KMing requires an additional model view. Furthermore, the process view does not show relevant aspects of KMing. There is no differentiation of the amount of knowledge transfer processes within the activities. It is not shown, whether knowledge is required or developed. In the process view, roles and information systems are the only information about possibly relevant knowledge which may be too coarse grained for some applications. Some elements of the KMDL notation are shown in figure 6. Section 5 contains an example KMDL diagram for comparison with the approach given in this paper.

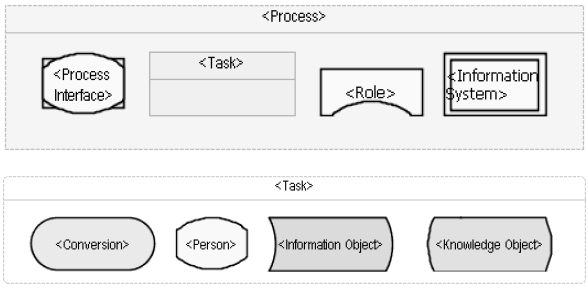


Figure 6. Selected basic KMDL Elements

3.4 Conclusion

Selected approaches to combine Knowledge and BPMing have been shown. There are more, for example the action workflow model by Terry Winograd et al.. It lays the main focus on socialization processes. For details see [20]. However, the chosen selection suffices in showing requirements and problems of the combination of both Knowledge and BPMing.

The discussion showed,that the level of abstraction of KMing should be congruent with the level of abstraction of the overall process model. There is already a variety of additional information to the control flow and the activities within process models. Therefore, only selected aspects of KMing should be shown within a process model. However, the explication of the shown aspects can be done in additional views. The KMing aspects that are part of the process view should be compatible with KMs of the respective other views. It should be shown to what degree knowledge availability

and knowledge transfer processes influence the Business Process or its activities. An integrated toolset for BPMing and KMing facilitates the work with such models.

So far no integration of UML BPMing and KMing that covers the sketched requirements is available.

4 Eriksson Penker Extensions for UML

There are several reasons for the desire to model Business Processes in UML [7]:

- Generally, the elements of UML are applicable to business modeling.
- The communication between Business Engineer and Software Engineer improves because both use the same modeling language.
- Generally, the orthogonality of the methods within a modeling language is guaranteed. The different views complement each other and do not overlap. However, this aspect has to be seen critically considering UML.
- The quality of software specifications improves because transformations between modeling languages are avoided. Thus, possible sources of errors are avoided.
- The documentation of process and application development and implementation improves due to the different views of modeling.

However, a look into the different UML models reveals that only activity diagrams are applicable for modeling Business Processes or the control flow of a Business Process to be more precisely. Starting with UML 2.0 these state diagrams are not a special kind of state chart anymore but a separate diagram type. Thus composite activities which are a common means to structure process models are compatible with the UML semantics. As already shown, the description of a Business Process contains more than activities and the control flow between them. Therefore some aspects are missing in standard UML activity diagrams. A process is characterized by (adapted from [7]):

- a certain level of abstraction (composite processes as a means of aggregation)
- necessary resources (Workplaces, Information Systems, Knowledge Carrier)
- specific input objects (material, information, knowledge)
- specific output objects (material, information, knowledge)
- involved organizational units
- one ore more goals
- added value
- implemented business rules
- business events that trigger activities or that are triggered by activities

These new concepts and the relationships to and between them have to be introduced in order to model Business Processes in UML.

Generally there are two ways of adding new concepts to UML depending on the chosen Meta Modeling Level. Additions based on the M2-Level concepts would allow completely new semantics and models aside to the ones known from UML. Basically, it would be the introduction of a new language that may be combined with the UML. Existing UML-toolsets would hardly allow such additions. In contrast, additions based on the M1-Level concepts define specializations of existing UML concepts. Therefore, a new meta model level between M1 (UML Concepts) and M0 (Model of the real system) is created. Already UML 1.1 profiles allowed to define such M1' metamodels by [21]:

– Stereotypes
– Tagged Values

Additional semantic information can be applied by the definition of constraints. With UML 2.0 constraints are defined in Object Constraint Language (OCL) which is an addition based on M2-Level concepts. Nowadays, the concept of profiles has been extended and is more powerful. It also allows meta modeling in general. With the XML Metadata Interchange (XMI) specification there exists a standard for the definition and exchange of meta models [22].

The Eriksson Penker Extensions (EPE) are based on the M1-Level metamodel. They use the extension mechanisms that are known from UML 1.1. Table 2 shows how the aforementioned process characteristics are modeled by EPE.

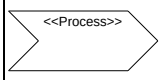
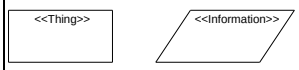
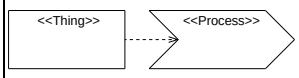
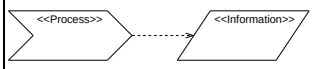
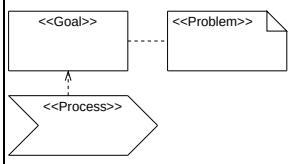
Concept	Addition to UML	Icon
Composite Process	Stereotyped Activity	
Resource	Stereotyped Object	
Input	Association	
Output	Association	
Organizational Unit	Swim Lane	–
Process goal	Stereotyped Object with tagged value	
Added Value	Goal Attribute	–
Business Rule	Constraint	–
Business Event	Stereotyped Event	

Table 2. EPE for UML, adapted from [6]

In EPE, goal structures are expressed by associations that are bound to the { complete} constraint. There are class hierarchies defined for business events and resources in order to allow a more differentiated view on these model elements. The interface between processes is built via shared resources that the processes are associated to.

Eriksson and Penker define a set of patterns in addition to their UML extension that describe common business situations on a lower level of abstraction.

Though being built on UML 1.x mechanisms, the work of Eriksson and Penker can still contribute to Business Process Modeling in UML. Some but not all of the concepts are adapted by UML 2.x. With the patterns by Eriksson and Penker, their work goes far behind a simple profile definition. Compatibility with existing CASE tools can be assumed. Furthermore, the EPE are officially supported by the Object Management Group (OMG) that maintains the UML standard.

5 Addition of Knowledge Objects and Knowledge Transfer Processes to EPE

In the EPE the stereotype is used with priority as an extension mechanism. A substantial starting point, to integrate knowledge into the models is the explicit consideration of resources in the processes by using the EPE. Resource types are inserted as new stereotypes and are represented in classes. Instances of resources are objects, which are required and produced in the processes [7, p. 10]. In the Eriksson Penker Extensions a class model for different resources is defined. Into this hierarchy, as new type of resource, the stereotype ≪Knowledge≫, is inserted (see figure 7). While Eriksson and Penker use the resource information for information and knowledge synonymously, now there is an explicit distinction between both. In order to emphasize this distinction graphically, knowledge objects are shaded. The two categories explicit and tacit knowledge are implemented by specializations of knowledge. Tacit knowledge is associated to objects of the class people which depicts the "personal" character of that knowledge. The semantics of the class people is not well defined by Eriksson and Penker. However, based on the given examples in [6] it seems to be a role definition similar to the roles in KMDL. Therefore, associating knowledge objects with people objects allows role definitions. Knowledge structure modeling is not defined in the additions to EPE. It can be done by attributes of the class resource or by tagged values.

To illustrate the knowledge transformation in UML, which is also represented in the KMDL models, further stereotypes are taken into the profile. As a subclass of ≪Process≫ , the ≪Knowledge Intensive Process≫ (KIP) is a process whose behaviour is highly influenced by knowledge transfer processes. Thus, emphasizing important knowledge related aspects is already possible at a high level of abstraction. Specializations of the UML activity class describe externalization, internalization, socialization, and combination. If a knowledge-intensive process was identified during the modelling of the business processes, the knowledge transfer activities within the process may be described in detail. In contrast to KMDL the kind of knowledge transfer is not an attribute of the links between knowledge objects and transfer activities. This is, because no additional semantic has been expressed by this concept in KMDL [19]. It is redundant and may be confusing.

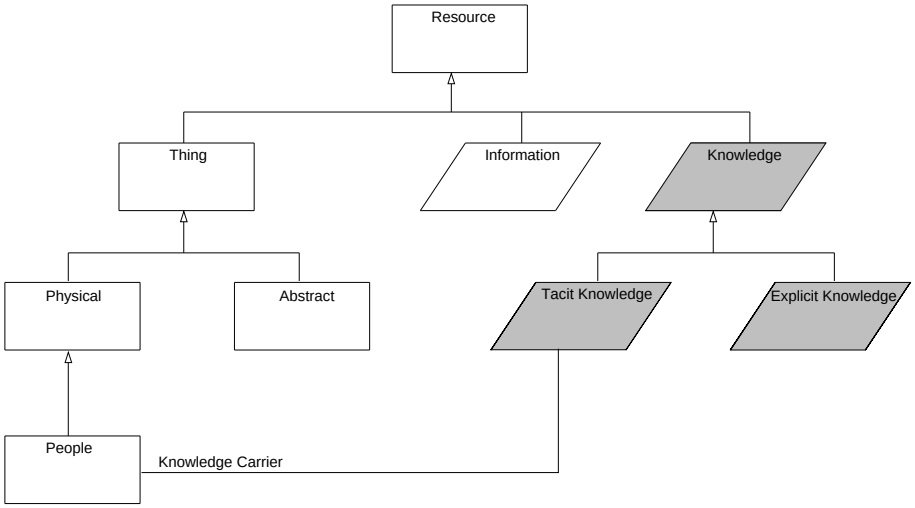


Figure 7. Knowledge Resource Additions to EPE, based on [6, p. 77]

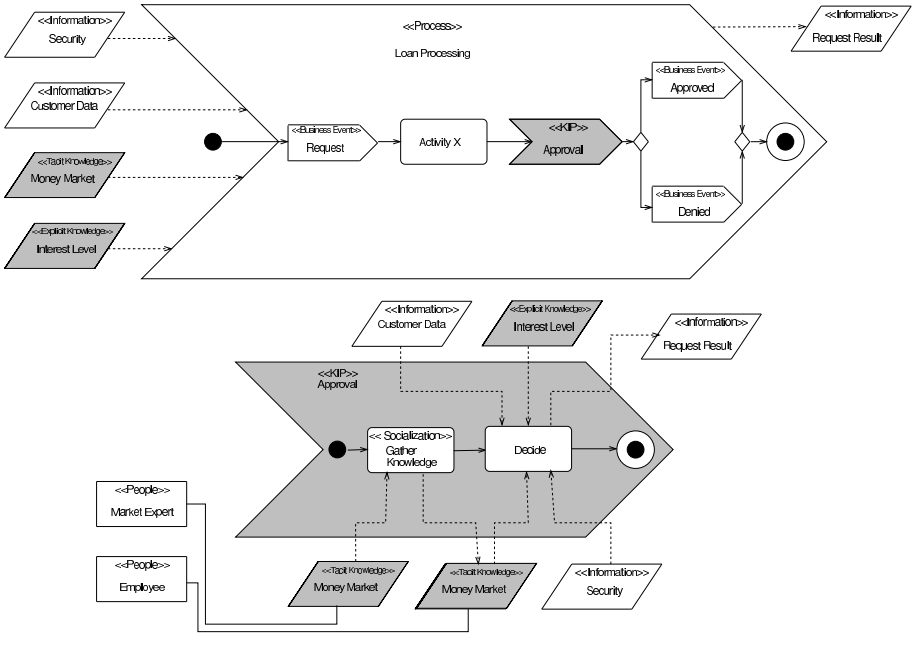


Figure 8. Loan Processing with Knowledge Intensive SubProcess based on extended EPE

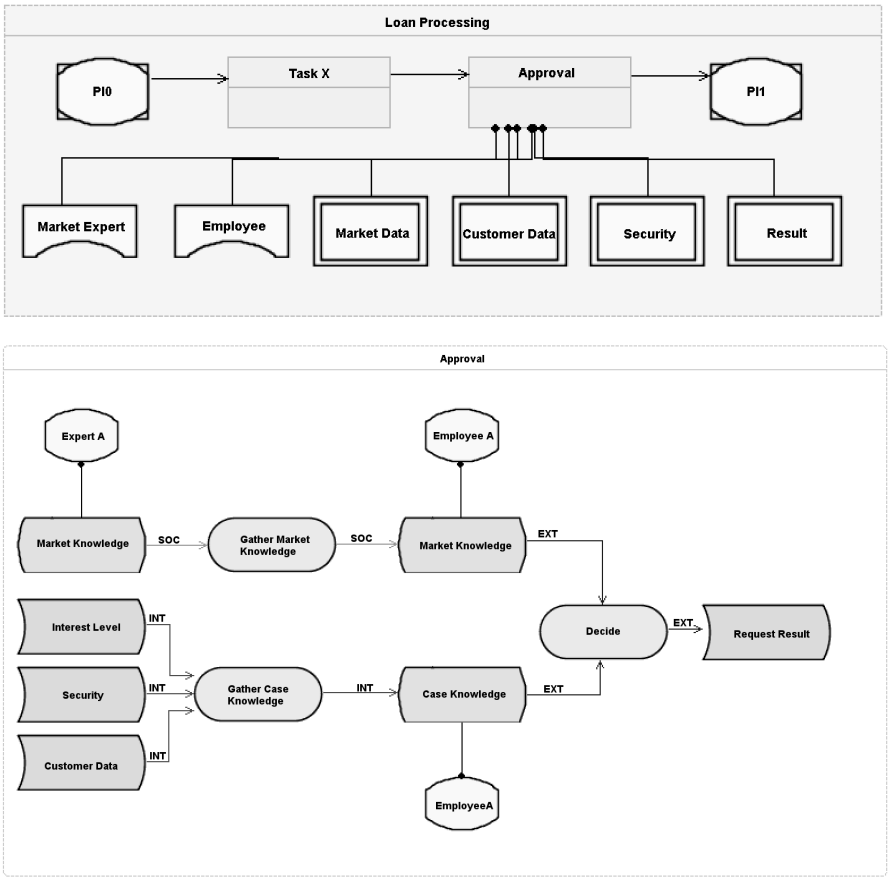


Figure 9. Loan Processing Diagram based on KMDL: Process and Activity View

In figure 8, a Knowledge Intensive Process (KIP) is identified as a subprocess of "Loan Processing" . In this subprocess the transfer of tacit knowledge takes place. Assuming that loan processing is not one of the main processes of an organization, the responsible employee needs to contact a money market expert prior to the decision about the loan request in order to gain the necessary knowledge about the current market situation.

The level of detail based on these additions to EPE is comparable to KMDL. However, views of different granularity and abstraction are possible with this new approach. Furthermore, it allows a coherent modeling of Business Processes and Knowledge in UML. Figure 9 shows the given loan processing example in KMDL notation. This illustrates the discussed differences of the two approaches and the limitations of KMDL as discussed in section 3.3.

6 Conclusion and Further Research

We have shown that KMing within BPMs is desirable. Furthermore, the benefits of Business Process Modling in UML have been shown. Based on existing approaches for both we developed a new approach that joins UML based BPMing with KMing. This new approach meets the requirements that have been formulated. It allows defining knowledge objects and knowledge transfer processes. The connection to knowledge structure models is only sketched but generally possible. With knowledge carriers for tacit knowledge some structure aspects can be modeled. The approach also allows different levels of abstraction which is an advantage for its use within BPMs. Most of the concepts of KMDL can be expressed without the limitations of KMDL.

The next steps would be a further harmonization with UML 2.x and a view into possibly existing UML KMing profiles. Since the EPE stem from UML 1.x some adaption might be necessary. In order to allow the use of the new approach on a broad base, an XMI profile should be developed. The discussion of this paper started from BPMing languages. Therefore, new impulses might be given by a view from KMing languages and UML profiles for KMing. Generally some aspects still have to be described more explicit. A deeper look into the patterns defined by Eriksson and Penker seems also to be necessary. The changes in the resource class hierarchy may not be compatible with all of them since the semantics of the class resource is not described completely. The resource use pattern of Eriksson and Penker might be another way to describe knowledge transfer processes. This needs to be evaluated in future.

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The Model Morphing Approach - Horizontal Transformations between Business Process Models *

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Abstract. Due to company mergers, acquisition and business to business interoperability, there is a need for model transformations in the area of business process modeling to facilitate scenarios like model translation, integration and synchronization. Thus this paper concentrates on transformations of models between different business process modeling languages. As current transformation languages provide general solutions and do not support the special properties of business process models, it is still a challenge defining such transformations. To tackle this problem we introduce the model morphing approach. Our main idea is to create an integrated metamodel containing all concepts of the languages of a given domain. Based on this integration the model transformation can be defined in terms of morphing steps. Our approach is demonstrated by model transformation in the area of business process modeling but is generally suitable for domains in which a variety of languages is used that express similar concepts.

1 Introduction

Since companies discovered the value of modeling their business processes, many languages for this purpose have been developed. Some are theoretically funded specifications, for example UML 2.1 Activity Diagrams [20], Event-driven Process Chains [13] or the Business Process Modeling Notation [19], but the bulk of the existing languages evolved from consulting projects in industry, for example ADONIS® Standard Modeling Language [5]. Consequentially nowadays we are faced with a proliferation of business process modeling languages that are used to model real world processes.

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Changes concerning business process modeling languages due to company mergers, acquisitions or software changes often require transforming models complying to one modeling language into models complying to another modeling language. Thus this work concentrates on providing and supporting solutions for the problems occurring during the definition of business process model transformation. After analyzing the issues arising at transforming process models [17], the first step was to inspect state-of-the-art transformation languages for solving these problems.

Inspired by the vision of MDA [16] current techniques or specifications used for defining model transformations, such as ATL [4] or QVT [18], operate nearly exclusively at the level of metamodel elements. From this it follows that direct 1:1 mappings between metamodels are supported very well. But for the transformation requirements in a specific domain, in our case BPM, these techniques are not sufficient [17]. On the other hand, using pure Java for defining model transformation makes it possible to define everything needed, but it does not support the infrastructure that model transformation languages provide.

This motivated us to provide the Generic Model Morphing Framework that supports a software architecture which combines the use of an existing model transformation language, and a programming language. ATL is used for the definition of "simple" 1:1 correspondences between the different metamodels. Java is used to implement the special transformation issues of a specific domain, in our case the the BPM domain.

Accordingly, the contribution of this work is threefold:

1. The transformation mappings between four selected business process languages.
2. The model morphing approach and also the architecture is defined domain-independently and thus can be specialized for any distinct domain.
3. The architecture of the model morphing approach supports reuse. On the one hand concerning existing technologies used (in our case ATL and Java) and on the other hand concerning the morphing methods which are encapsulated solutions for non-trivial transformation requirements that can be applied to different transformation scenarios within a given area.

The reminder of this work is structured as follows. The next section introduces the model morphing approach. In Section 3 the framework for business process model transformations is presented. Section 4 demonstrates the approach in the business process modeling domain. Furthermore it outlines the reuse potential of the morphing methods in in this domain. Section 5 puts our work into context of related work. The conclusion in section 6 summarizes this work and gives an insight into ongoing work.

2 Model Morphing

Model morphing is a new approach to tackle model transformations in a specific domain. This approach represents a software architecture for model transfor-

mation, that enables the reuse of model transformation definitions and allows the embedding of different technologies. Model morphing operates mainly on the differences between the languages dedicated to a specific application domain, whereas the similarities of the languages can be treated by using simple declarative 1:1 transformations.

The main assumption is, that the languages of a specific domain are all used to express similar concepts characterizing this domain. This makes it possible to create a common *integrated metamodel* which covers all concepts found in the participating languages. Conceptually this integrated metamodel represents a union of all concepts found in the languages belonging to a given area.

Through this integration it is possible to map models complying to specific metamodels directly to the integrated metamodel. The corresponding transformations can be easily developed using an existing model transformation approach, for example ATL.

The core transformation is performed by using so-called *model morphing methods*. These methods are derived from the differences between the specific languages and are defined based on the integrated language (IntL). They are applied step by step on the source model which has already been translated to the IntL until it fits to the structure of the target language. In the last step the model is translated from the IntL into the target language.

This approach responds to the non-trivial transformation issues occurring when defining transformations between models in a distinct area. The incremental nature of the model morphing approach makes it possible developing the transformation step-by-step. This supports a transformation definition where the result could be inspected after every step.

As this approach strongly singles out the particularities of a specific area in form of the morphing methods it makes it possible for the domain specialists to define model transformations by only the use of their expert knowledge and also without programming skills.

2.1 The Generic Model Morphing Framework

To realize the model morphing approach a so called Generic Model Morphing (GeMM) framework has been developed. This framework consists of four main components, the *Integrated Metamodel* connected by the *Adapter Layer* with the *Specific Metamodel Layer* and the *Method Repository* which makes use of the graph and the patterns operating on the graph (see Fig. 1).

To develop the GeMM framework we have used the Eclipse Modeling Framework (EMF) [8], [6] because it provides an environment to develop metamodels very fast and easily. Furthermore EMF has implemented an automatic (java) code generation mechanism for such metamodels. Moreover this java code provides the basis for the morphing methods. As we wanted to use a metamodel-oriented transformation language for the adapter layer we found that ATL is a good solution because it offers a declarative way to define metamodel correspondences and moreover it operates on EMF metamodels.

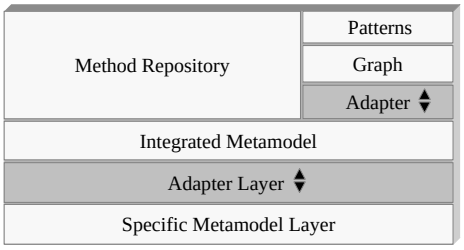

Fig. 1. The Generic Model Morphing Framework

The *integrated metamodel* has been defined under the consideration that every graphical model when reduced to the minimum is a graph consisting of nodes and edges. Consequentially the core of the integrated metamodel could be defined as a model having nodes and edges. Therefore the fix parts of the integrated metamodel are the class `Integrated Model` and the abstract classes `Node` and `Edge` each containing two attributes, `name` and `description` (see Fig. 2, the three classes in the dashed rectangle). The core of the integrated metamodel is the starting point for connecting further classes needed for the integrated metamodel of a distinct domain. Note that during the use of a specialization of this framework, for example when attaching another language to the framework, further classes or attributes can be added easily.

The *method repository* consists of templates for methods and mechanisms which are needed to construct the concrete methods for a distinct area. These methods make use of the generated code from the integrated metamodel implemented in EMF. The graph component is realized according to the theory of well-known graph algorithms as for example characterized in [21], [14]. At the moment the basic patterns which are defined in this graph are structural patterns on directed graphs. As the core of the integrated metamodel always stays the same the graph and the pattern implementation can be reused in different domains without changes.

The *specific language layer* has to be defined newly for every domain. For the metamodels of the specific languages, we also used EMF to be able to use ATL for the adapter layer.

The *adapter layer* between the specific metamodel layer and the integrated metamodel is designed to achieve a 1-to-1 mapping from the metamodel of a specific language to the integrated metamodel. In our case this means that each element of a languages metamodel is mapped to one element of the integrated metamodel. In case this is not possible, the integrated metamodel has to be extended with adequate concepts (classes or attributes) until the adapters can be written by using only 1-to-1 mappings.

The next section demonstrates for the business process modeling domain, how the GeMM framework can be specialized for a distinct area.

3 The Model Morphing Framework for Business Process Model Transformation

Having the ability to design an integrated metamodel (IMM) for the domain of business process modeling it is necessary to understand the concepts [23] and aspects [24], [11], [3] used in this domain. Furthermore it is required to get familiar with the syntactical and semantical expressions of the concepts and aspects in each of the participating business process modeling languages (BPMLs).

Due to the lack of space we have decided to present the GeMM framework by means of the control flow aspect [3] which is the main aspect of business process modeling. This should be sufficient to understand how the construction of such a framework has to be done.

Four BPMLs, ADONIS® Standard Modeling Language (ADONIS®) [5], Business Process Modeling Notation (BPMN) [19], Event-driven Process Chains (EPC) [13] and UML 2.0 Activity Diagrams (AD) [20] have been selected to participate in our example.

In the following the concepts which characterize the control flow aspect of the business process modeling domain are described.

3.1 The Business Process Modeling Domain

Process modeling languages for describing the behavioral aspect in the domain of Business Processes are used to model the flow of work which has to be done to reach a certain aim. Illustrating such processes in form of a directed graph on a two-dimensional drawing area it is necessary to create syntactic elements which are representatives of the concepts used in reality. The connection between an element and its corresponding concept clarify the semantics of the element. In the following the concepts and the modeling elements are described.

The main concept of a business process is a working step, represented by the task element. Such a working step lasts a distinct period of time, is done by somebody using some resources and converts some input into some output. This integral concept could be found in each of the participating BPMLs, for example a task in BPMN or an activity in ADONIS® . To support the clear arrangement of a process model a concept for structuring processes into main and sub processes is provided, represented as Sub-Process element. Every participating BPML provides an element for this concept. Some languages provide an explicit element - event - to model the actual state of a process whereas others do not model states explicitly.

Beside these integral concepts like working step, sub process and event some concepts in form of logical operators to model the behavioral aspect of a process are needed. They are used to depict the begin and the end(s) and different kinds of pathes a process could run. Some kind of start element is used to depict the begin and some kind of end element is used to illustrate the end of a process. In the course of a business process decisions lead to different continuations of a

process. This is realized in the form of elements expressing alternative paths. In most cases a finer differentiation is given by exclusive and inclusive alternatives. As some working steps could be done concurrently there are elements like parallel forks for modeling such circumstances.

As glue between and within the integral and the behavioral elements the flow of control itself is depicted by using arrows with some kind of arrowhead.

The concepts which are used to describe the integral and behavioral aspect of a business process model could be found more or less in every participating language (see Table 1).

3.2 Analyzing the Languages

Table 1 provides the result of an analysis regarding the similarities and differences between the BPMLs we use. Note that the terminology of the integrated language (IntL) has been chosen freely.

Table 1. Comparison of the elements in the participating BPMLs

IntL	ADONIS®	BPMN	EPC	AD
Task	Activity	Task	Basic Function	Opaque Action
Sub-Process	Subprocess	Sub-Process	Complex Function	Call Behavior Action
Event	n/a	n/a	Event	n/a
Start	Start	Start Event	Event	Initial Node
Multiple Starts	n/a	yes XOR	yes XOR	yes AND
End (local)	End (local)	End Event	Event	Flow Final Node
End (global)	End (global)	n/a	n/a	Activity Final Node
AND (split)	Parallel Split	Parallel Fork	AND	Fork Node
AND (join)	Parallel Join	Parallel Join	AND	Join Node
OR (split)	Decision	Inclusive (OR)	OR	Fork Node + Conditions
OR (join)	implicit	Inclusive (OR)	OR	n/a
XOR (split)	Decision + Conditions	Exclusive (XOR)	XOR	Decision Node
XOR (join)	implicit	Exclusive (XOR)	XOR	Merge Node
Control Flow	Successor	Sequence Flow	Control Flow	Control Flow

After analyzing the participating BPMLs four types of differences can be observed:

(1) Context-dependent semantics of elements.
   (a) Local context is needed - adjacent elements. This type of difference can be observed in the case of the concept XOR-Split in ADONIS® where the same element Decision is used for the OR and the XOR-Split. The distinction can only be made by inspecting the conditions of the outgoing Successors. Similarly the OR-Split in AD is realized by using a Fork Node and entering or-conditions into the attribute condition on the outgoing Control Flows. Furthermore AD provides the possibility to model the AND-split and the AND-join implicitly instead of using the fork and join node.
   (b) Global context is needed - structure of a part of the process. The *OR-join* and the *XOR-join* can only be modeled explicitly in BPMN and EPC. In ADONIS® this element can only be depicted implicitly by two or more Successors leading into the following element (this is also the case for the *XOR-join* in ADONIS®).

(2) Missing possibility to represent a concept - *no element provided*.
   In row 3 in table 1 it can be seen, that the concept *Event*, which is a process state in a distinct point of time, is only provided in the EPC language. In BPMN and EPC there is no possibility to depict a *global end*. And in case of AD there has not been found any valid solution for the OR-join in the UML 2.1 language specification [20].

(3) Elements are provided for a distinct concept (same syntax), but they have *different semantics*.
   There is a concept for modeling the *start* of a process in every language. But one language (ADONIS®) only allows one start element for each process model, whereas the other three allow more than one. Furthermore there is a difference between the semantics of the BPMLs which allow more than one start elements. In BPMN and EPC it is enough if one of multiple start elements is activated to trigger the process, whereas in AD it is required that all of the used start elements are activated to run the process.

3.3 An Integrated Metamodel

As a result of this analysis we have built the integrated business process metamodel (IBPMM) depicted in Figure 2. The IBPMM is built upon the core of the integrated metamodel as described in Section 2.1.

The `Task`, the `Subprocess` and the `Event` are implemented as simple classes. As a subprocess has to be linked to a another process the association `refProcess` has been established between the class Subprocess and the class `Integrated Model`.

The grouping of the Logical Operators has been made to provide a general access to these structuring elements of a model. To keep the number of classes small there is only one class for each of the logical operators `AND`, `XOR` and `OR`. The differentiation between a split and a join/merge operator is indicated by the attribute `kind` which is of type `LogicalOperationKind`. This design decision was made to make changes to a model during incremental transformation easy, only attributes must be changed instead of replacing whole elements.

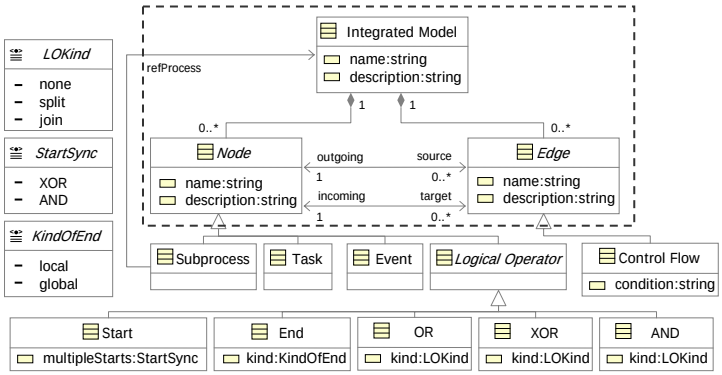

Fig. 2. The integrated business process metamodel

As most of the BPMLs provide an element for explicitly marking the start and the end of a process the class `Start` and `End` has been implemented.

In case of the class `Start` the attribute `multipleStarts` has been introduced to differ between the different semantics of multiple start elements. The type of this attribute is the enumeration `StartSynchronisation` which could have the value XOR for exclusive alternative or AND for synchronisation semantics.

In case of the class `End` a distinction has to be made between a global or a local kind of end. This is also realized by an attribute namely `kind` of the enumeration type `KindOfEnd`.

The `ControlFlow` summarizes the concept of a flow of control which connects all other elements and thus is the linking element within a model. The attribute `condition` contained by the class `ControlFlow` is needed to indicate conditions after decisions. The generalization of the Control Flow to Edge seems a bit unnecessary at the moment but as the IBPMM is dedicated to grow this was a preparation for further extensions of edges.

3.4 The Adapters

To be able to specify the necessary adapters all metamodels of the participating BPMLs have to be realized as EMF metamodels. Based on these metamodels the adapters have to be implemented between all of the participating BPMLs

and the IntL in both directions. As the IntL contains all concepts found in each of the participating BPML the relations between each element of each BPML to the elements of the IntL are 1:1. For implementing these correspondences we used ATL.

3.5 Model Morphing by Example

The morphing methods implemented in the Method Repository (MR) reflect the differences between the participating BPMLs (see Table 1). That means that they are derived from these differences. Furthermore the methods provide the possibility to overcome these differences at transformation time and thus make the main contribution to the transformation. In the following the methods and their mode of operation within the GeMM framework are described by means of an example business process model transformation.

Problem Description

The ADONIS® source model (see Fig. 3) should be transformed into the semantically equivalent target model (see Fig. 4) conforming to the EPC language.

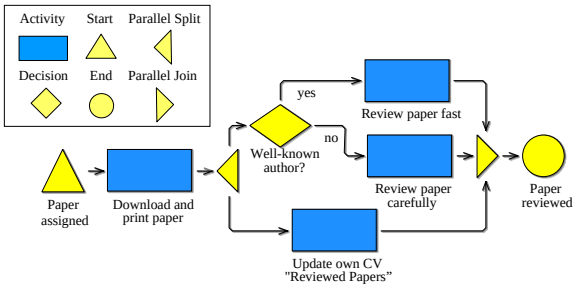

Fig. 3. "Review Paper" Process Model in ADONIS®

According to the model transformation issues described in [17] this model transformation poses the following difficulties:

- *Decision (Un)Ambiguity.* In ADONIS® the decision element is used to express inclusive and exclusive alternatives. Whereas EPCs provide one distinct element for each of the two concepts, namely OR and XOR.
- *Invisible Merger.* In ADONIS® the merge of a decision is implicitly modeled by two or more successors leading into an object. In EPCs there are explicit elements for illustrating such mergers, namely XOR and OR.
- *Mandatory Events.* In EPCs events are mandatory. Furthermore it is mandatory that event and function elements are alternating during the flow of the process model. There is no corresponding element in ADONIS® .

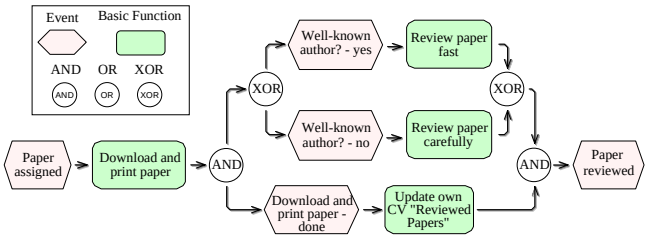

Fig. 4. "Review Paper" Process Model in EPC

Furthermore the Start and End elements of the ADONIS® model have to be transformed into Event elements in EPC.

Solution Description

The first step is to transform the ADONIS® model via the *ADONIS® to IntL* adapter to a model conforming the integrated metamodel, the resulting model is illustrated in Fig. 5. Note that this is an 1:1 translation so only the abstract and concrete syntax has changed. The further transformation definition is realized

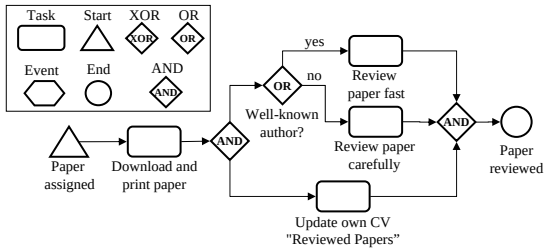

Fig. 5. "Review Paper" Process Model in the IntL

by using the following methods:

1. The `convertStartToEvent()` method substitutes the start with an event element.
2. The `convertEndToEvent()` method changes the end to an event element.
3. The `makeLOsUnambig()` method operates on a heuristic making use of antonyms. It checks if the values of condition attributes of the outgoing control flows of the OR element are antonyms and converts them to XOR elements if necessary.
4. The `makeJoinsExplict()` method uses the graph and the pattern component to find out, if there is an implicit merge. If so an explicit merge element

(OR or XOR depending on the branch element) and necessary control flows are created and integrated into the model.

After applying the methods 1-4 the model looks as shown in Fig. 6.

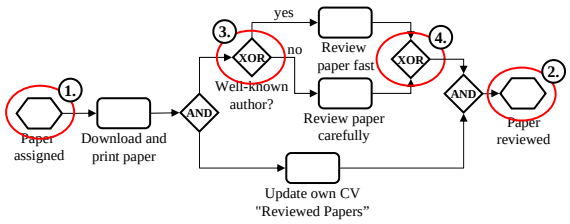

Fig. 6. "Review Paper" Model after four morphing steps

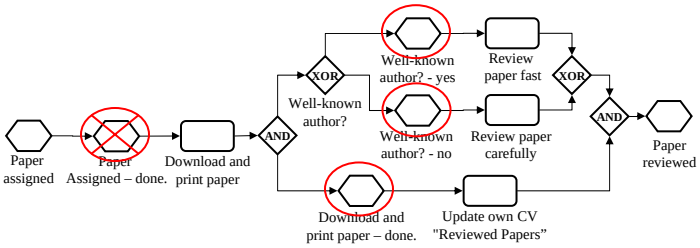

Fig. 7. "Review Paper" Model after applying the insertEvents() method

5. Finally the events which are mandatory in EPCs have to be inserted. The method `insertEvents()` inserts an event in front of each function. This could lead (as in this case) to an unnecessary event if there is no preceding event (see Fig. 7 Event "Paper Assigned - done"). This event is redundant and makes the model invalid concerning the syntax of EPCs where events and functions must alter during the process model. Therefore the method `insertEvents()` calls a helper method which searches for such interfering events and deletes them. The name of a newly inserted event is generated depending on the preceding node and edge. In case the preceding edge has a name value it will be added to the name of the preceding node, like "Well-known author - yes", if not, then the fix term "- done" is added to the preceding node name.

After applying these methods the "Review Paper" process model is ready to be transformed into the target BPML, in this case EPCs. This is done by using the *IntL to EPC* adapter.

3.6 Morphing Methods Overview

The table 2 shows the methods needed in the possible transformation scenarios using the four BPMLs, ADONIS®, EPC, AD, BPMN. It provides a good overview and makes the reuse of each method visible.

Table 2. The use of methods in the different model transformation scenarios. In this table the abbreviations are as follows: EP = EPC, AD = AD, BP = BPMN, AO = ADONIS®.

Method / Source Language	ADONIS®			EPC			AD			BPMN		
Target Language	EP	AD	BP	AO	AD	BP	AO	EP	BP	AO	EP	AD
convertStartToEvent()	x							x			x	
convertEndToEvent()	x							x			x	
makeLOsUnambig()	x	x	x				x	x	x			
insertEvents()	x							x			x	
makeSplitsExplict()							x	x	x			
makeJoinsExplict()	x	x	x				x	x	x			
removeEvents()				x	x	x						
makeLOKindExplicit()				x	x	x						
makeLOsImplicit()		x		x	x		x			x		x
annotateGlobalEnds()	x		x					x	x			
convertEventToStart()				x	x	x						
convertEventToEnd()				x	x	x						
mergeMultipleStarts()				x	x		x	x	x	x		x

The first four of the eleven methods implemented in the GeMM framework for the participating BPMLs have directly been introduced during the example. So let us have a look at the remaining seven.

The method `makeSplitsExplicit()` works similar to `makeJoinsExplicit()`. Also the graph and pattern component is used to detect the implicit split element and then a new explicit split element is created and integrated. To remove events from a model the method `removeEvents()` can be used. The method `makeLOKindExplicit()` is used to be able to differ between an splitting and a merging logical operator. To make logical operators

implicit, in case of transforming in the direction of ADONIS® the method `makeLOsImplicit()` has to be used. This method can be seen as reverse method to `makeJoinsExplict()`. The method `annotateGlobalEnds()` is used to avoid loss of information regarding the different kinds of ends. As some BPMLs do not support the concept of global end, this method annotates the string "+ global" to the description attribute of an end. In case of transforming from EPCs it is necessary to convert the start and end events to start and end elements, this is reflected in the methods `convertEventToStart()` and `convertEventToEnd()`. The method `mergeMultipleStarts()` is used for different purposes. In the case of transforming models of BPMLs which have an AND semantics for multiple starts to a BPML which allows only one start element or has an XOR semantics for multiple start elements, the multiple start elements must be reduced to one start element and an AND-Split must be added after this element to connect it with the remaining process paths. A similar situation where the start elements in the source models have an XOR semantics can also be handled with this method. In this case the multiple start elements must be reduced to one start element and an XOR-Split must be added after this element to connect it with the remaining process paths. Note that nothing has to be done in case of transforming models from a BPML which allows only one start element.

The overview in Table 2 makes obvious, that the reuse of the most morphing methods depends on the BPML used as source or target language. The methods `removeEvents()`, `makeLOKindExplicit()`, `convertEventToStart()` and `convertEventToEnd()` for example are only used if EPCs is the source language. Whereas the methods `convertStartToEvent()`, `convertEndToEvent()` and `insertEvents()` are used when transforming to EPCs.

The degree of dissimilarity of the participating BPMLs regarding their support of the concepts of the domain is another observation that can be derived when looking at the numbers of methods needed for a transformation definition between two languages. The more different methods have to be applied, the higher are the differences.

4 Related Work

To the best of our knowledge there is no directly comparable approach to model morphing, which specifically supports horizontal model transformations in a distinct domain. Therefore we have decided to relate model morphing to existing general purpose model transformation approaches based on the work of Czarnecki and Helsen [7]. According to the feature model introduced in [7] the main characteristics of the model morphing approach are as follows.

- The integrated metamodel, the morphing methods and the adapters form the *transformation definition* part.
- Two kinds of *transformation rules* are used. Relational rules within the adapters implement exogenous transformation and the morphing methods implement endogenous transformations based on the integrated metamodel.

- In the transformation approaches considered in [7] intermediate *data structures* are playing a secondary role compared to the transformation rules. In contrast, the integrated metamodel plays the central role in the model morphing approach, whereas the morphing methods are defined based on the integrated metamodel.
- *Traceability* is not required in case of the model morphing approach. But it is implicitly covered in the morphing methods and could be extracted if necessary for a distinct application scenario.
- *Hybrid approaches* as characterized in [7] combine different transformation techniques within one transformation language. Whereas model morphing is a technology spanning and at the same time technology independent approach. That means the advantages of different transformation techniques can be combined. In our realization we used the relational approach and direct manipulation.

In the following we discuss related work regarding the integrated metamodel and the reuse of the methods.

The definition of an integrated metamodel is not a particular new approach, much work has been done in the 90s in the area of integrated metamodels. However the focus of this work is different. COMan [12] for example integrates an object-oriented application and a relational database, providing persistence for complex objects and object-oriented manipulation of relational data. This approach is dedicated to support business reengineering. In [9] an integrated environment for method engineering has been introduced. The aim of this work was to integrate different design notations to support metamodeling. Another relation can be observed to the area of schema integration. In case of schema integration, local data source are integrated to one global view as for example in [10] or [22]. This global view can then be used as a unified representation of the local data sources. This makes it possible sending one query to the global view instead of sending many queries to each local schema. In contrary to the different works stated above, our integrated metamodel specially focuses on the support of the transformation process, thus is an important component of our framework rather than a stand-alone product.

In the INTEROP [1] project the Unified Enterprise Modelling Language (UEML) has been developed [2]. The UEML provides core modeling methodology elements and is intended for exchanging information between enterprise modeling tools. UEML provides common semantic definitions - an intersection - of modeling constructs defined in an abstract UEML meta-metamodel. This is in contrast to our integrated metamodel that forms an aggregation of all concrete metamodel elements of all participating BPMLs.

Regarding modularization and reuse, the work in [15] analyzes rule based transformation languages for the support of creating modular transformation definitions. Assuming that transformations are built on the base of source and target metamodels, modularization of the transformation is derived from the modularization of these metamodels. The authors conclude that existing rule

based languages provide support for modularization and integration mechanisms, i.e., rule inheritance and rule calls. However, this does not meet the requirements for reusability and adaptability of transformation definitions. Modularization in the our approach is achieved by decomposing the transformation into adapters and morphing methods. The modularization of the morphing methods does not depend on any modularization of the metamodels, rather morphing methods encapsulate the solution algorithms for non-trivial model transformation problems. Due to fact that there are many similar transformation scenarios between the languages belonging to a specific domain, this kind of modularization facilitates exploiting the reuse potential.

5 Conclusion and Outlook

In this paper we presented model morphing - a new approach to tackle model transformation issues which we found to be difficult using existing model transformation techniques. We used this approach for defining transformations between different BPM languages. It should be noted, that model morphing is generally intended to define horizontal model transformations in a given domain where many different modeling languages are used to capture the same or similar concepts.

Inverse to the presentation in this paper the development of the approach started with the implementation of the transformation in the area of business process modeling domain. From that it has been generalized to the generic model morphing framework and further abstracted to the model morphing approach.

Thus, future work includes the application of the approach and the framework to a different domain to validate our hypothesis regarding the applicability of the model morphing approach to different domains. The framework will be further elaborated regarding the treatment of attributes, bi-directionality in form of inverse morphing methods and test mechanisms for validation. Furthermore an evaluation regarding the use of other transformation languages than ATL for the adapter layer has to be done.

As the construction of the framework requires a lot of expert knowledge and implementation skills it is not efficient to use the framework with only a small number of languages (2-3 languages). Therefore we have to evaluate the minimum number of participating languages where the construction of such a framework pays off.

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Talking Security to Managers: How to Do it

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Abstract. Seven security specialists working close to managers were interviewed about what managers wanted to know about security, as well as other security issues and asked to perform a scenario. This information was analyzed, and the major conclusion of the study is that managers are interested in knowing about security mainly regarding financial and strategic matters, formulated in managerial terms rather than technical and grouped in sets of cross-information rather than individual detailed data. A trend of giving the users themselves more responsibility for security was also noticed which is potentially worrisome due to the increased insider threat.

Keywords: Communication, Information Security, Management Information Systems, User Centered Security.

Introduction

During the last couple of years information security has become a business problem that concerns not only system operators but also company managers. Thanks to the media coverage on recent worms, viruses and DOS-attacks (denial of service attacks) the threats against companies and both public and governmental information security has been made visible for the public. Business partners and stakeholders demand good information security if they are going to conduct business with a company whilst company management is being held responsible to a higher degree for information security than before [1].

It has also been shown that technical solutions are not enough to provide adequate information security in an organization; good security requires an organization with employees who understand how to act to attain adequate information security [1], [2], [3]. Hence there is a need to present information about the organization's information security targeted to management so that they can become more aware of how their employees act, and have a broader understanding of the situation in the organization today. If they know more, they can more efficiently work towards attaining adequate information security, both by managerial decisions, and by acting as a role model.

Leadership and management is a key factor in developing a good security culture. The senior management of the company must be seen to take security seriously and demonstrate exemplary security behavior [4].

While there are a number of software products tending to the supposed needs of managers in many respects, such as business information systems, there is a lack of studies focusing on what managers would like to know about their organizations information security.

Security has traditionally been a technical field, centered on the development of technical tools to protect against mostly technical vulnerabilities. Making the users understand the programs and making the same people understand the importance of a safe behavior when using computers and computer networks has to some extent been neglected [5], [6], and [7].

Since the mid nineties there has been a growing amount of researchers in the security-area who have called for a more user-centered approach to security. The term "user-centered security" was introduced by Simons & Zurko in 1996 [8] and it can be seen as a key component of the movement for user centered development of security applications. The term refers to:

"*Security models, mechanisms, systems and software that have usability as a primarily motivation or goal*" [8, p. 27].

This study is the first part of a user centered security project funded in part by The LogicPlanet AB, trying to develop a prototype for an interface to an information security software to be used by managers. The second part of the project involves creating an interface based on the information gathered in this first study. This second part has been presented at the HAISA conference [9]. One of the authors has done a case study on the more technical aspects of information security in the health care domain [10], but that study focused on technical aspects and common problems with security, and not on how to communicate security to managers.

This paper is structured with a short introduction on the problem area, followed by a description on the study performed. The results are presented in part in a section called what managers know, then a section on what they would like to know and conclusions.

The Study

The research question was: "How can information security related issues best be communicated to managers with a limited knowledge of information security".

Method

Seven interviews were conducted. Four of these were face-to-face while three of them were done over the phone due to external constraints. The interviews were semi-structured including a fixed set of questions. Depending on the answers the questions were either followed up with new questions (non-fixed) to clarify and develop the interviewees answer or the interviewee was asked the next pre determined question.

The questions were developed to be relevant and broad enough to cover most areas of information security. They were discussed with and informally tested by the supporting organization. Several questions were asked regarding the current status of the organizations information security in order to get a broader understanding of how the subjects worked, as well as to find potential information not mentioned in the direct questions. The interview also included a scenario where the subjects were asked to rank different kinds of security information depending on its relevance for managers.

The questions were developed in cooperation with information security experts previous to the interviews. During the interviews the guidelines for interviewing by Breakwell [11] were used. The interviews were systematically analyzed through a scheme, resulting in a summarization of the answers.

The Subjects

While it would seem logical to directly ask top level management what they would like to know about security, the problem with this approach became obvious in informal tests. Top level managers often knows little about security, even less about what areas of security that are important, and a lot of the information they normally receive has been filtered through a security specialist. As this specialist acts as a facilitator between the manager and the information relating to security, the authors found it logical to interview persons in such specialist roles in order to get to know what they had experienced that managers wanted to know.

Three of the interviewees worked for medium sized governmental organizations while the other four worked for small to medium sized commercial companies. All have security responsibilities to some extent, and some are in charge of security for their respective organizations. The subjects were from a group of available and interested managers, contacted through a national, Swedish, security network, as well as two subjects that the researchers had contacts with before.

The Questions

The questions were in eight question areas, prepared with follow-up questions. The questions are presented below. In some cases not all of the follow-up questions were asked due to individual variations in the interviews and how the subjects answered.

1. Which routines does your organization have for information-security today? How is the work concerning information-security organized? Who is responsible for this work today (in practice/official)? Do you consider your organization to have any lacks in the work with information-security? How can these be solved?
2. What kind of threats do you consider to be the most dangerous for your organization? Internal or external? Technical or human? On what threat is most of the budget spent? Why?
3. Which are the most severe security incidents that you have experienced? Why did they happen? Could they have been avoided?
4. Does your organization have a security policy? If yes, how is it used? Does your organization have any kind of follow up of the security policy to see if it is com-

plied with? What kind of problems are there with today's security applications (i.e., firewalls, anti-virus software, IDS, patches/upgrades) from your point of view? In general?
5. What kind of information is most important to show to get a grip of the status of the security for an organization? (i.e., level of education, if the security policy is complied with, status of the firewalls etc.) For you? For company management? In general? Which aspects are not covered by today's systems?
6. In what way do you think company management would like to have information concerning levels of security presented? Do you think that this group would like to have the information presented in another way that for example system administrators would like?
7. What sort of information is important for the users to know when they are using the company network? (The need for updates, potential security threats etc.)
8. How much does your organization spend on information security today? How are these money spent? How much is spent on education? Could this money be spent better to attain a higher quality on the information security? What improvements should be made if you more funding?

Scenario

Each interview was concluded with a short scenario exercise. The scenario consisted of the subjects ranking nine different kinds of information regarding information security after what they believe would be the most important for managers. The aim with the scenario was to find what kind of security information that was most usable for the managers through quantification of the answers, thus providing a view complementary to the one given through the previous questions. The information pieces to be ordered by the subjects were:
1. How many employees that has passed a certain education.
2. The education level at the company.
3. How the education level at the company has evolved over time.
4. How well the security routines at the company are complied to (i.e. if there are backups made on the database each day).
5. Which employees that are "weak links" (not following the security policy, has not undergone education etc)
6. How different computers/services complies with the company's security policy.
7. What kind of equipment that the company possesses (computers/Operating systems etc.).
8. What kind of risks there are against different computers/systems.
9. How/if the company is attacked.

Validity

The potential validity is influenced the fact that the subjects where not homogenous in their professional background, or in what kind of organization they worked for. Their most common trait was the fact that they worked for small to medium sized organiza-

tions. It is therefore possible that another sample of managers would have resulted in another outcome of the study. The aim of this study, however, was to get a broad view on the problem area, rather than a too narrow view, and since the results and the opinions that were used in this study were relatively equal among the individuals in the group, this result should be valid.

What Managers Knows

In this chapter the results from the interviews are presented in regards to the problems and situation at present that the subjects have informed their managers about. These are the problems and challenges the subjects are facing regarding information security. These are real life problems that managers should, and perhaps will, be informed about. This section also gives some general background on the subjects' organizations.

Six out of seven subjects told that their organizations did have specific employees who were responsible for the security, both formally and in practice. It is notable, however, that while most of the organizations might have someone formally responsible, in case of an incident, the responsibility would fall on the employee that has made the error however "informal" the responsibility is claimed to be. Human actions are also specifically mentioned as risks; both that users are talking too much and thus potentially giving away information and more organizational problems relating to humans, such as how to get awareness on the need to act secure. This tendency to put the responsibility, however informal, on the users does of course put higher demands on the awareness training as well as the education of the users.

At the same time that the employees have a large part of the responsibility, all subjects except one, claim that internal threats and human threats are the biggest threats for their business. This is highlights an interesting inconsistent reasoning, because the organizations actually make their biggest threats quite responsible for the security in the organization.

Most of the subjects generally felt that there was a lack of training and education of the users. This is probably in response to the problems with the human actions mentioned above. Two of the subjects had specific demands on education, such as that the user had to know rules and security policies when they were using the company's network. Two of the interview subjects mentioned that the users had to know how vulnerable the information was that they were using. A general view was that the users should know which information is the most important to protect. Getting the users to understand, and to properly value, the importance of information is a big problem noted by many subjects.

The other major security problem mentioned was hacking, according to the subjects. Three mentioned it specifically as something they had been victims of. There is one subject that specifically mentions physical security, in that case the theft of computers and it is indirectly mentioned when one subject comments on the risk of having infected computers connected to the LAN. It does seem, however, that physical security is not one of the major problems, although this could reflect the fact that most of

the subjects work with information security and might have organizational counterparts working with physical security.

All the interview subjects had some kind of security policy. Verification of the policy differed greatly, however. The policy was:

- Followed up by education in one of the cases.
- Followed up by formal control and tips in one of the cases.
- Followed up by surveillance of the network in one of the cases.
- Followed up by formal control and education in one of the cases.
- Followed up by surveillance of the network and education in one of the cases.

It is hard to judge the efficiency of the verification, but a strict technical approach such as network monitoring is probably not efficient if the problem lies with the users, and network monitoring, for instance, probably only verifies a small part of the policy, at least if the policy consists of more than network rules.

The security systems the subjects are using suffer from some problems. Three subjects mentioned that the systems were either too time consuming, hard to get an overview of or appeared "immense". One of the interview subjects did also mention that it was hard to backtrack changes that were made in the systems, and the fact that the attackers were always one step ahead was also mentioned. This inability to backtrack changes was apparent in a previous study, where the subjects complained about an inability to check old logs for changes [10].

When it comes to resources three of the interviewees said that most resources were spent on technical solutions. One said that most resources were spent on human (organizational) aspects, but might have included salaries in that context. The rest could not tell or thought that the resources were spent quite equal.

What Managers Want to Know

A general view from the subjects was that information and language must be adapted to suit managers. The language used in the current products was too complicated and should instead be made easier to understand and it should present an overview of strategic and economic concerns rather than unnecessary technical details. Through this overview, strategic decisions could be easier to make. Managers are more interested in strategic and risk concerns than the technical problems many products are focused on today.

One of the subjects said this about overview and security: "*They need to get an overview of security, but they do also need some technical details in another way. They need to know if our security team has some kind of problems, so that the security team gets more resources to update or buy new things. So of course they will need to know the technical things as well. But the technical stuff must be wrapped in a way that a person that might not know so much about technology understands that language… [The manager] can't start to scan ports and find vulnerabilities in Cisco-routers etc. but [the manager] can decide how the money should be spent, on the softer sides, or on the technical sides.*"

On the problem of interpreting technical information for management one subjects said: *"[…] then some technically skilled person must be close to management and be*

able to answer technical questions, so that strategic decisions are made without to much concern about the technical aspects but with information security in mind."

While there is a need to make the information more understandable for non-technical users such as managers, there is a need for some detailed information to, according to the subjects. Specifically mentioned was if the technical team is having problems with resources, but the more minute technical details are unfeasible for most managers to understand and use.

Apart from technical and managerial issues, there are several requests for better ways to see the educational level of the users, as individuals and as groups.

It is also of interest for the managers to know whether or not the organization is being attacked right now, current inside and outside attacks and the current level of security. This information is very difficult for managers to get currently, as most of the solutions today require a lot of technical information, as well as experience in the field to properly estimate the risks.

A good overview of the security seems to be missing in most of the subjects organizations. In case it is believed to exist at all, it exists informally "in someone's head". Without any proper description of the current security mechanisms, it is almost impossible for managers to make good decisions unless they blindly trust the person with this informal information.

Scenario

The interviewees found it hard to rank the alternatives in the scenario. Instead, some of them ranked a sort of overlying categories where they put some information together (like the three top alternatives that are seen simply as education) and gave them a common grade. Those who did not do this followed the same pattern where they ranked (for example) the upper three alternatives as the most important. The category issue was not just only shown through how the interviewees filled in their scenario, but it was also mentioned by most of them when they were doing the scenarios.

It is hard to quantify the individual alternatives but the scenario shows that the interviewee's mental model of security consists of categories rather than single fragments of information.

The options of the scenario could be seen as categories by this classification:

- Alternative 1, 2, 3 is grouped as educational aspects on security.
- Alternative 4, 5, 6 is grouped as routines for security.
- Alternative 7, 8, 9 is grouped as the situation today.

The overall attitude during the scenario was that it is first and foremost important to know how the organization is attacked currently, second most important is to know about routines for security and third most important is to know how educated the employees are in security. Alternative 8 and 9 covers the hardware situation of the organization and this was perceived as the least (fourth) important to know but it was important to connect this to the situation today. If that connection was made then the information became more interesting

Conclusion

It is clear that managers primarily are interested in an overview of the information security rather than the details. This distinguishes managers from more technical persons involved in information security, so managers must be presented with different, adopted, information. The scenario used during the interviews also implied that the mental model of security in managers consists of categories rather than single fragments of information. Managers consider information security in a grander context; they do not want to isolate single areas from each other. They would rather like to group many small areas (i.e. the cost for education and the percentage of educated employees during a specific time) that affect information security into bigger chunks of information to get an overview of the development of this area rather than a more precise overview of smaller areas.

Managers also see a strong connection between security and finances; showing the importance of talking about security from a financial perspective when talking to managers. It is necessary for managers to know where an investment in information security will take the company in the future, one year, three years etc.

While managers do consider security on a more strategic level than the technical specialist, they also view security as a competitive advantage against other companies, where it is a business benefit to be able to showcase a high information security.

The information given to managers should inform about why an incident did happen, what can be learnt from it and the costs, as well as the long time influence. The subjects also pointed that it was important to know how the company was doing today in different areas to be able to put resources on critical areas. This can be seen in contrast to the often weak verifications of policies that the subjects have. Information given to management should also include any strains on resources that could influence security decisions.

The language must also be adapted to suit managers. Since managers does not have the knowledge of, or the interest for, technical terms these should be avoided or offered with explanations. The language should be straightforward, concise and explaining.

Managers do not solely aim on creating a more secure company. It is also interesting for managers to see how investments in security can make the company more efficient by for example avoiding downtime of administrative systems.

A security monitoring program for managers should concentrate on the strategic and financial concerns of information security and present these in a language that is easy to understand for the management. This could also make it possible to not have the employee as the one with the final responsibility for security; instead more sound structures of responsibility can be created.

Concise tips on how to present security information to managers and to improve the current situation

These tips are aimed towards the security professional, finding herself in a position to cooperate with or to present to general managers. Begin by trying to see what information is interesting for the target audience, not information that is necessarily inter-

esting for the technical persons. Focus on information that allows managers to make financial and strategic decisions. Do not focus on technical implications and terms, instead focus on how it influences the company right now, and how what effect it can have in the long run. Never be shy about pointing out potential resource problems that could affect security, but do it from an effect perspective, rather than a cause perspective.

For instance, it is better to say that the organization may be given a bad reputation and have problems sending e-mail in the future, if unsolicited e-mail might be sent through an outdated firewall, than to begin by stating that external resources are needed to update a firewall. Try to facilitate the decision making by giving fair and relevant alternatives, avoiding doomsday scenarios, while still being honest about problems. The model in Fig. 1 below describes a suggested flow of information, together with detailed areas that the subjects expressed interest in. This simple model can be used as an easy to remember mental model of which areas that are important to focus the information on. Note the difference between the specific reports, as given on regular meetings, and the information that is available from when the management wants them, preferably through the use of an IS system.

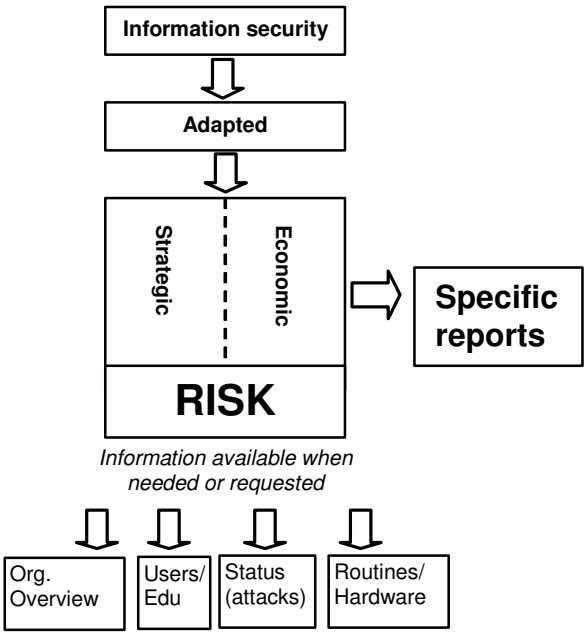

Fig. 1. The information model. This is an example of how information can be given to management.

In other words: Managers want information they understand and can use in their information process. They are interested in security, but not the minute details, rather their interest are from a strategic and financial perspective.

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Using Contextual Design to Understand Mobile Work and Design Mobile Services: A Longitudinal Case Study

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Abstract. This paper addresses the use of Contextual Design (CD) to understand mobile work and design mobile services. We adapted CD for designing and exploring mobile services that aimed to support building workers on building sites. The paper presents an assessment of using CD in this domain in three studies accomplished in 2003-2006. The studies covered different phases in a life cycle of designing mobile services, i.e. understanding the field, prototyping in the field and deploying in the field. This research presents both benefits and limitations for using CD when designing mobile services for mobile workers.

Keywords: Mobile work, mobile services, Contextual Design, user-centered system design, ethnography, creating ideas, exploring, building industry.

1 Introduction

Studies with an ethnographical approach are common in human-computer interaction (HCI) research. Some of the characteristics are "in situ", "qualitative and open-ended" and "studying technology in the wild". Important principles are natural settings, taking a holistic point of view, providing a descriptive understanding of people's everyday activities and interest in their view of the situation being studied [5]. Often, ethnography is seen as an approach that enables us to understand the context of use [29,22,3,5] and hence, to generate requirements for system design [22,38,5,14].

CD is a method building on an ethnographical approach and deals with the issues of gathering data, driving design, and managing the team and organisation. The purpose of CD is to support the process of creating software that addresses users' needs [3]. The book "Contextual Design - Defining Customer-Centered Systems" includes many examples and illustration of the method in use in office domains like a flow model for secretarial work, a sequence model for handling mail, a culture model for a product development organisation, a physical model of an office, etc. Furthermore, related to system design, the examples include mail systems, Microsoft Powerpoint, shipping commercial product, configuration management, which all relate to windows applications for PCs. Hence, as a particular interest, we aim to investigate the usefulness of CD when designing mobile services.

The building industry has a large potential as users of mobile services. According to [27] mobile computing is the missing link to effectively use IT in an integrated and

holistic way in construction – especially in the construction and operation phases of built artefacts [27]. The building industry is slow to adopt information technology on the sites and there is not much research on IT adoption and use that focuses on blue collar workers [2,9,1]. We have found some new studies that document successful adoption of mobile technology at building sites [6]. Most of them focus on the workers that work both at the site office (site hut) and on the sites, i.e. managers and foremen [13,37,21]. We have not found any studies using CD for designing mobile services to support the building workers.

The purpose of this research is to present and discuss the experiences when adapting CD in mobile settings. The experiences originate from three field studies accomplished in 2003-2006 within the building industry. This setting contrasts with the "normal" environment in offices in many ways. Some of the characteristics that we find on the building sites that might challenge the use of CD are: 1) the building workers do manual and hard physical work, 2) they have a high degree of tacit knowledge, 3) they have a high degree of mobility, 4) they very seldom read and write during a working day, i.e. they mainly discuss and observe other workers, 5) they seldom attend meetings, and if so, the meetings are short and they are "only" listeners, 6) the physical work environment at the sites is characterised by variation in temperature, humidity, light, noise, dust and dirt. And it is risky, i.e. climbing in staff holdings and working on roofs, 7) and they have little or no use of mobile technology to support their work.

Next, section 2 reviews related work. Section 3 presents the research design i.e. an overview of the field work and how we used CD. Section 4 presents the results. Discussion and conclusion are given in section 5 and 6.

2 Related Work

At an earlier stage in HCI, ethnographical techniques were used in Computer-Supported Cooperative Work and Participatory Design [29,14]. But now they are common in other areas like User-Centered System Design and CD [3]. The emergence of ethnographic studies in mobile HCI is well under way. Often the use of ethnographical studies is motivated by the intention to achieve an understanding of the complexity of technology in everyday settings [19,35].

CD has gained mainstream acceptance among designers for understanding and designing technology supporting workers for the traditional environment, i.e. stationary PCs and fixed networks. Among many, we find examples of using CD to develop models of information management, resource integration, and collaborative processes of medical students in problem-based learning groups [4] and using CD to model the context of use of an enterprise resource planning (ERP) system [36].

In mobile settings, we are starting to see studies using parts of CD, Rapid CD [20] or CD in combination with other methods. One study uses Contextual Interviews, affinity diagrams and consolidated artefact models of CD to investigate mobile workers when they are mobile and what they do to achieve their communication goals. The mobile workers included a variety of occupations from white-collar managers to blue-collar plumbers [7]. While one study uses Contextual Inquiry (CI)

to gather users' requirements in order to design a mobile exhibition system [15], another study uses CI to identify user requirements for mobile construction professionals. Their spatial, temporal and contextual mobility is described based on fieldwork conducted in the UK [23]. Furthermore, we find a study describing experiences in applying an adaptation of Rapid CD called Rapid Contextual Evaluation in a small scale field evaluation of a course administration system in the field [25]. In addition, we find an example using CD and Social Structural Theory in order to understand human interaction in a social context in order to design for mobile work [8]. Moreover, another example allows contextual and seamless design and prototyping based on user and task knowledge, i.e. Contextual Prototyping together with usage-relevant representation and execution mechanisms [34]. However, further research is required related to the design of mobile services supporting mobile workers.

3 Research Design

This research revolves around the use and adaption of CD in mobile settings. Before presenting the field studies and how we used CD, we give a short introduction to CD's six steps.

3.1 Contextual Design

In six steps, CD deals with the issues of gathering data, driving design, and managing the team and organization [3,18]: **1) Contextual Inquiry (CI)**: Collect data using ethnographic techniques by observing and questioning workers while they work. **2) Work Modelling:** Capture the key issues of one individual's work practice and model their work using the five work models capturing different dimensions of work practice. **3) Consolidation:** Consolidate individual work models and issues to reveal the structure of the work across a population without losing individual variation. **4) Visioning/work redesign:** Invent how new technology will address the user work practice by creating a high-level story (visioning and storyboarding) of how work will be changed. **5) User Environment Design:** Design a floor plan (diagrams) that shows how the parts of the new system will interrelate. Represent the structure and the function clustering of the system independently of consideration of user interface and implementation. **6) Prototyping:** Test and modify the new system design in partnership using paper mock-ups of the user interface. Have people to do real work tasks with the prototype [3,18].

3.2 The field studies

In order to develop and explore mobile services that support mobile workers on building sites, this study has tried to understand the work practice on the sites. Three ethnographical studies that cover different phases, i.e. understanding the field, prototyping in the field and deploying in the field have been accomplished. In all

these studies, we used and adapted CD in order to explore and design the mobile services. This research aims to take a holistic point of view regarding these studies. Table 1 outlines some of the characteristics of the field studies, i.e. research goals, procedure, settings, duration, participants, data collection and materials.

Table 1. Characteristics of the field studies.

	Field study 1: Understand
Research goals	- To understand the field in order to create ideas of where and how mobile services could support building workers.
Procedure	- Contextual Inquiry
Settings	- 3 different building sites that build apartments in blocks in a city.
Duration	- 3 weeks during spring (May 2003)
Participants	- One researcher
Data collection	- Mixture of qualitative techniques: Mainly observations, but also interviews, paper reviews (work process documents, checklists, and similar), pictures, note taking. - Observation of work including occupations like carpenters, concrete workers, electricians, plumbers, bricklayers, painters, digger drivers, crane drivers, etc. Time spent with workers varied from a few hours to several days. - 6 interviews of workers on site and at site hut.
Materials	-none for the users
	Field study 2: Prototype
Research goals	- To create ideas for mobile services supporting knowledge processes, to explore some of the emerging ideas and to prototype.
Procedure	- All steps in CD. - Creating and performing scenarios in an iterative process based on workshops, shadowboxing/bodystorming/experience prototyping.
Settings	- 1 building site that builds apartments in blocks in a city.
Duration	- 6 months during summer and autumn (May- October 2004)
Participants	- Three workers. - One researcher.
Data collection	- Mixture of qualitative techniques as in study 1, but in addition video and audio recording. - Observation of work as in study 1. - 12 interviews of workers on site. - 8 workers at site hut and head quarters (ganger, project leaders, working managers, and architects). Informal discussions with workers.
Materials	- 3 types of dictaphones. - An advanced mobile phone.

	Field study 3: Use
Research goals	- To test and explore usability problems in order to initiate improvements and to explore experience of use.
Procedure	- All steps in CD. - Training and deployment of the services to identify usability problems in an iterative usability evaluation process. - Using two action research projects.
Settings	- 2 building sites in two different companies. One builds apartments in blocks in a city and one builds a little village with 44 luxury properties at the coast.
Duration	- 5 months during winter (December- April 2005-2006)
Participants	- 11 workers. - Two developers. - One researcher.
Data collection	- Mixture of qualitative techniques and observation as in study 2. -22 interviews of workers on site. - Database with 36 usability issues. -Database with 128 real work issues registered by using mobile services.
Materials	- An advanced mobile phone. - Deployment of 19 mobile services and a web application.

3.3 How we used Contextual Design

We have used CD in all the field studies and one of the main steps in all the studies was CI. We used ethnographical techniques like observation, interview and video [29]. In many cases we shadowed [38] the workers and frequently we “dived into" the situations when they arose, i.e. being in action. Other techniques used are audio recording, informal talks, picture taking, diary logging and paper reviews (work documents, checklists, drawings, etc). The research has emphasized the master/apprentice model and has made an effort to create a partnership with the workers in their work context.

Through all the studies we have focused heavily on work issues. A work issue is characterised as an issue that requires some kind of action in order to proceed or to be solved. It can be an experience, a quality problem, a question, a suggestion for improvement, a request, an order, etc. Possible work issues could be related to normal working procedures or routines, related to complex activities or complex problems, related to lack of information, poor quality of work, etc.

In the first field study we mainly carried out CI and started with work models and created our first version of the vision. In this study we revealed important characteristics of the building workers, i.e. they do manual hard physical work, have a high degree of tacit knowledge and mobility, they discuss and observe other workers, they seldom attend meetings, they work in an exposed and risky physical environment, and they have little or no support of mobile services during their work. These characteristics we had to take into account when we prepared for the second and third field study, i.e. we tried to find techniques which tried to allow for these characteristics.

Modelling has mainly been by the researcher as a part of the analysis of field study 1 and as a part of the preparation of field study 2. We composed flow models, sequence models and cultural models.

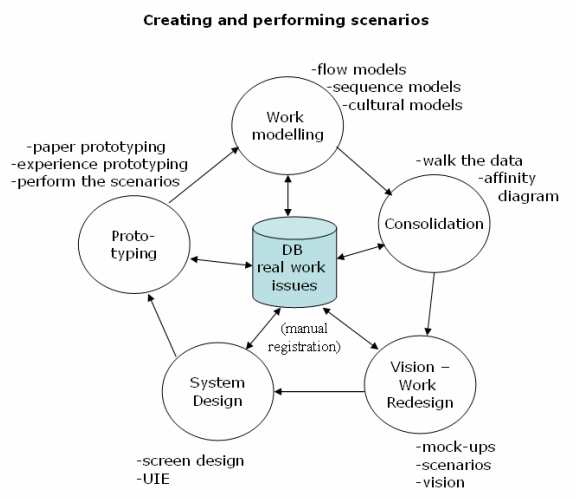

Fig. 1. Illustration of the CD steps and how we used them in field study 2.

In the second field study, we worked intensely with work issues in all steps of CD (see Fig. 1 for an overview). Each time a work issue arose on the sites, the participants had to register it with the "mobile" application, that is, make an audio-recording. The building workers used dictaphones as props during work. They had to pretend that the dictaphone was a real mobile application. This exercise we called "Shadowboxing", i.e. experience prototyping [10] or bodystorming [25], where they explore by doing/reflection-in-actions [28]. After 6-7 weeks the workers started to use mobile phones (SonyEricsson P900) as props. With these mobile phones the workers took pictures, made audio-recordings, and videos of the work issue (see Fig. 2). All the work issues were manually registered in a database.

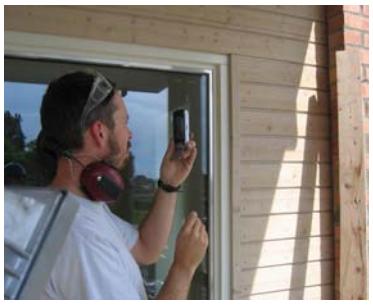

Fig. 2. Tom uses a mobile phone to record a work issue.

We had short weekly workshops (1-2 hours) at the construction hut. During the workshops we tried to envisage how mobile technology can address the building workers practice by creating a high-level story (vision). We used mock-ups when we

discussed work issues and created related scenarios (see [31] for further details about creating and performing scenarios).

In order to consolidate the data, we discussed and explored each work issue that was collected on the site together with the workers. The variation across the building workers was used to categorise the work issues, i.e. likewise the Affinity Diagram.

According to CD we used User Environment Design and paper prototyping [3]. To do the paper prototyping for the mobile services we made a template sized as an A4 paper using a mobile phone as a "frame" (see Fig.7A). We could then illustrate and discuss details by drawing directly on these papers. Furthermore, when we had drawn and discussed possible screen for the mobile services, we made a prototype for handling the work issues, e.g. registering, updating, follow-up and reporting (see Fig.7B). According to our vision the prototype covered mobile services for handhelds and an application for stationary PCs. This prototype was done in three iterations.

Further modelling was done by the researcher as a part of the analysis of field study 2 and as a part of the preparation of field study 3. This time the models were used in discussion and design specification of the mobile services with the developers.

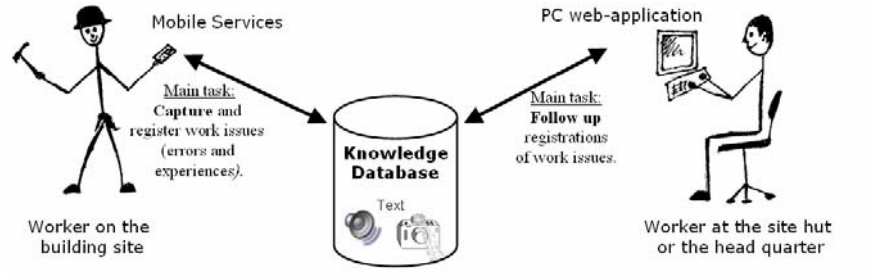

Fig. 3. The worker on the site captures and registers a work issue using the mobile services. The work issues are stored in a database (knowledge repository). The worker at the site hut or the head quarters of the company can see and follow up the work issues using the web application.

Based on study 2 we developed a mobile system and a web application (see Fig.3). The mobile services aimed to support workers on sites and 19 services were developed. Examples are: suggestions for improvements, report of errors (materials/tools/processes), health and safety, notes, various checklists for quality assurance (insulation, soundproofing, grade of drain, wind proofing, degree of moisture, diaphragm, tile work, parquet, kitchen, wardrobe and doors), and inspection lists of regular safety audits. All the functions had the possibility of taking pictures, recording audio and registering textual information. The services runs on a Qtek 9100 built with MS.Net 2.0 for Windows Mobile 5.0 using web services for storing and retrieving information with wireless technology (GPRS).

The web application supported the process of reading, updating and following up work issues registered on the sites with the mobile services. The users could see the pictures, listen to the audio records and register other information like costs, progress, history, etc.

In the third field study, we also used all steps in CD. However, now we deployed the mobile services in order to evaluate and improve them (see Fig. 4 for illustration of study 3). The workers registered real work issues on the sites using the mobile services. The work issues were registered automatically in the database. This study used training and deployment of a mobile system in the field to identify usability problems. An iterative usability evaluation process was conducted, refined and validated using two action research projects. Further details are found in [31].

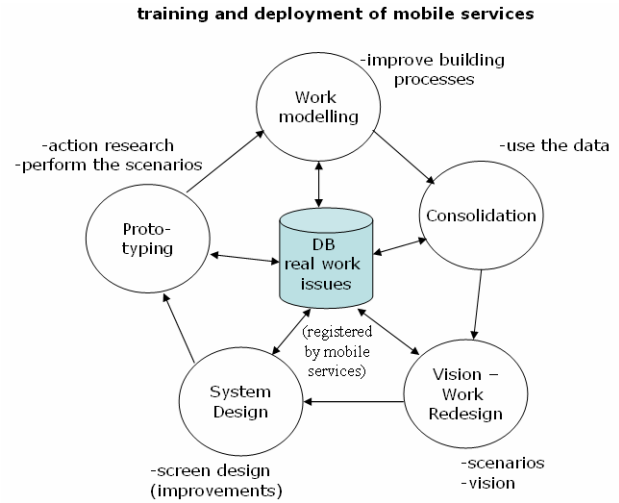

Fig. 4. Illustration of the CD steps and how we used them in field study 3.

A limitation of this research is that we have been a small team when developing the mobile services and doing the data collection in the field. Mainly this was done by one research and two developers. However, we have tried to compensate for this by carrying out long-term studies and involving and observing many building workers. In addition this research was a part of a larger development and research project.

4 Results

Together with building workers we managed to design and deploy mobile services to support their work. The whole process is based on CD with the adaptions as described above. This section presents the results from using CD.

4.1 General aspects

Focus on work issues. Undoubtedly, the heavy focus on and work with work issues has been of vital importance in order to succeed in designing the mobile services. This way the workers became involved and participated actively in the process. This was

very obvious when their efforts led to improvements in their work processes on their building site, or even better, in the whole company. Furthermore, frequently we used scenarios based on work issues to discuss and elaborate mobile services [30].

Storing text, pictures and audio recordings of the work issues in the database was a great advantage. Hence, it then was very easy to retrieve the information and gradually the database grew both in detail and in breadth. Especially the use of pictures of the work issues was fruitful since it made them easy to remember and discuss.

CD and other techniques and methods. In the studies we have used techniques and methods that are not a part of CD. For instance we used experience prototyping [10] in study 2 and action research in study 3.

Our experience related to this is that these techniques and methods seem to fit very well as an integrated part of CD or as a method in combination with CD. We believe that the main reasons for this are that the integrated parts focus on work and improvements in real settings and are user-centered. These also are essential principles in CD. During experience prototyping [10] which we called shadowboxing, or bodystorming [25] where the workers explored by doing, the workers gained first-hand experience and understanding of existing and future scenarios based on the work issues, i.e. reflection-in-actions [28].

Action research can be defined by three characteristics [12,16,26]. First, it is research in action, rather than research about action. The process is based on repeating the steps as they are distinguished by: planning, taking action and evaluation, which leads to further planning, for instance by an iterative cycle of gathering data, feeding them back to those concerned, analysing the data, planning action, taking action and evaluation. Second, it is participative which means that members of the system that is being studied participate actively, i.e. the members are not objects of the study. There is a belief that total participation leads to increasing productivity and more acceptance of the changes. Third, it is action where the goal is to make the action more effective while simultaneously building up a body of scientific knowledge. The outcomes are solutions, important learning (both intended and unintended) and a contribution to scientific knowledge and theory.

We found that the CD principles had strong similarities with the characteristic of action research. Both stress the importance of having an iterative and incremental process focusing on evaluations and planning of further improvements. In addition, both are user-centered and stress active and strong involvement from participants in real settings, and furthermore, both stress actions where the outcomes are solutions and important learning [32].

4.2 The steps involved in CD

Contextual Inquiry (CI). Through CI we obtained a thorough understanding of the work on sites. The observations and shadowing revealed comprehensive empirical data. Observations also had the effect of generating questions immediately and in later interviews. This empirical data contributed to the suggestion of 23 ideas that cover a

wide range of mobile services like building work, logistics, health and safety, quality assurance, communication and access to information [33].

The master/apprentice model suites sites very well since apprentices are common on the sites. This model supported the process of making a partnership with the workers.

One disadvantages of CI is that it is time consuming. Not only does it take a long time to do the fieldwork, but it also takes a long time to analyse the empirical data and write it up. However, the cost of this must be weighed against the usefulness of the data collected. On the building sites the use of mobile services is very limited and in many cases absent. Hence the needs of the users were quite unknown and complex. However we have found it necessary and worthwhile to spend time on sites due to the following aspects:

The participants must have time to mature especially when introducing mobile services in a new domain. In some cases the participants were very sceptical and it took time to change their attitudes [32]

We have experienced that it takes time to build trust among the building workers. Not all the workers willingly volunteered their opinions and experiences early in the project. For instance, in one of the studies, one of the participants did not speak openly to the researcher during the first three months.

Observing mobile workers that do manual work and have a lot of tacit knowledge takes time. It takes time to understand and ask questions while they are working.

Work Modelling. This was mainly carried out by the researcher as a technique to understand and structure the empirical data.

Consolidation. In order to consolidate the data, we explored, discussed and visualised each work issue and placed them in an affinity diagram (see Fig. 5). The variation among the building workers was used to categorise the work issues. This was done bottom-up and by discussing detailed properties of each work issue. Frequently, we also discussed them "over" the picture taken. Based on these discussions we established a common understanding of existing work practice. Since the building workers were the experts on work issues, they wanted to contribute with their experiences. When prototyping we used the real work issues that were registered in the database, and we used the affinity diagram to design the categories and properties of the issues in the prototype.

The work issues we worked with were also consolidated by the workers when they worked alone on the sites.

In the beginning we tried to distribute documentation of the work issues and other aspects. However, the workers did not take time to read it. Hence, we found the discussion of the work issues at the workshops as a remedy for this situation.

The consolidation of work flow was not discussed over flow and sequence models together with the workers.

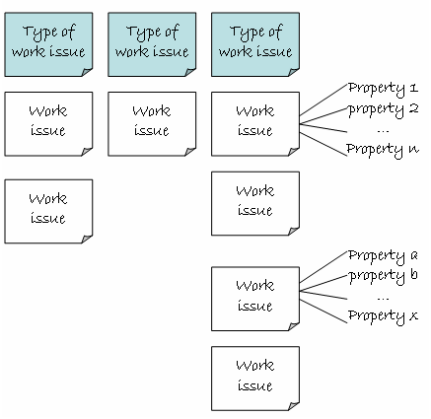

Fig. 5. Illustration of an affinity diagram.

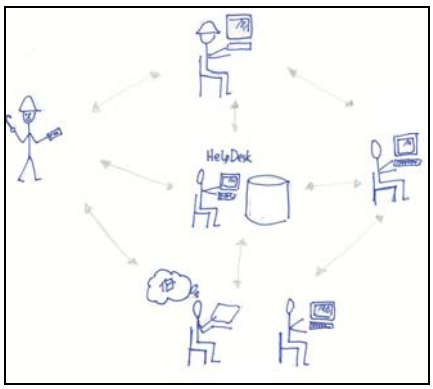

Fig. 6. The illustration of the vision.

Visioning/Work Redesign. During the workshops when we worked with the work issues and tried to "place" them into our vision, the workers participated actively. Now they were the experts and were full of with ideas and suggestions. During this process the users invented and told stories. Furthermore, as we started to use mock-ups with simple illustrations, i.e. in this case stick figures (see Fig.6.), they became engaged in the process. The workshops revealed open-ended [11] and wide-ranging scenarios on a conceptual level. However, as the process proceeded, the scenarios became more and more detailed. It appears that this was connected with the use of the work issues. The further we went into detail in order to solve the work issues, the more detailed the scenarios became [30]. As with [11], this research found it important to create trial use situations as part of the design process, in order to stage users' hands-on experiences with the future.

Prototyping. When prototyping the screens and their contents the workers found it very useful to use the A4 papers with a frame that looked like the mobile phone (see Fig. 7A). On these papers they drew and discussed the contents using the real work issues. Furthermore, when starting to prototype using a development tool (in this case Microsoft Access, see Fig. 7B) and using the work issues directly on the screens the workers immediately gave feedback on the design and the contents. We have found this to be a useful way to explore work practice that does not yet exist and to reveal future possibilities from the mobile services.

In study 3 when we deployed the mobile services, the workers pointed at and discussed the screens during the work on the sites, i.e. when situations arose. The workers evaluated the mobile services when using them during work. Since we had an iterative evaluation process and implemented many of their suggestions for improvements, the workers continued to suggest improvements throughout the project. This relates to "design-in-use", and we have experienced that using CD is very useful for capturing experience in designing while using the mobile services. We

have used real work to push design. This is the opposite of what others claim, i.e. that CD never gets to grip with the real-life reality of being a user of the new system [17].

Furthermore, during "design-in-use", i.e. watching the work and simultaneous inquiry the use resulted in high awareness among the workers of their own use and need, and the way the mobile system could support their work. In addition, by letting the workers explore and use the mobile services in their own way, new use patterns arose [32].

(A) (B) (C)

Fig. 7. 7A: An example of an A4-paper framed as a mobile phone with drawings from the prototyping. 7B: A prototype of a mobile service using real work issues in a database. 7C: Example from one of the deployed mobile services.

5 Discussion and future work

One of the important experiences from the studies that we want to discuss is the creation of mobile services by letting the workers be in action, i.e. participating in their context of work. By watching the work and simultaneous inquiry the workers achieved high awareness of their own uses and needs. We experienced that the workers who had never before used mobile services during work created other ideas for mobile services as soon as they experienced the potential of the deployed mobile services. Furthermore, by letting the workers explore and use the mobile services in their own way in their context of work, new use patterns arose and suggestions for new use patterns emerged. We believe it would be of interest to create and explore new design techniques in the workers' real working environment. Observations on sites revealed that the workers frequently draw on the walls in the buildings or on materials when they have an issue they want to discuss and solve. Hence it might be an idea to explore how it will work to draw on the walls and discuss design issues of mobile services when they arise. Or it might be useful to carry out a workshop on

sites, especially when we know that the workers do not like to sit in a workshop in the construction hut. They soon become restless.

6 Conclusion

Bases on our fieldwork and using CD we would like to emphasise that we have collected rich and comprehensive empirical data that provides a meaningful input on how to build mobile services to support building workers. Together with the workers we have designed and deployed mobile services. By focusing and working with work issues the workers participated actively. We found it very useful to register work issues including related pictures, audio recording and text. This real work data, made the discussion very fruitful and straight to the point. Furthermore, the apprentice/master model suits building sites very well. We also find CD easy to integrate with other techniques, i.e. shadowboxing/experience prototyping, and use in combination with other methods, i.e. action research. This we find very interesting for development for mobile settings, since this domain might require new techniques in order to design mobile services. The CI step was time consuming. But we found it necessary in order to build trust among the participants, to give time for maturation in this "green field" of technology, and to observe manual physical work. We have found the consolidation and creation of an affinity diagram together with the users very useful. Also mapping the work issues into our vision engaged the workers. Furthermore, paper prototyping and prototyping mobile screens with a development tool using the real data of work issues seems to be of vital importance.

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Enterprise Model-based Generation of the Class Model*

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Abstract. The article presents principles of the Enterprise model-based generation of the Class model of the system (on the Platform independent level). Enterprise model being an integral part of the Repository of a CASE system becomes a core structure (Knowledge base) for the accumulation of business domain knowledge. The purpose of this article is to show that the knowledge stored in the Knowledge base is enough to generate one of the main models of the object-oriented Information systems development approaches, namely, Class model on the Platform independent level. In order to show the basic principles of the Class model generation algorithm, Enterprise and Class metamodels as well as mappings between the corresponding elements of these metamodels are presented and briefly discussed in this paper. The algorithm of the Class model generation and a brief overview of its realization are also presented in this paper.

1 Introduction

Recently, one can observe much effort coming from the developers of CASE (Computer-Aided System Engineering) tools to improve processes of the Information systems (IS) development life cycle using various techniques. One of the techniques is the automation of Information system development (ISD). Indeed, in theory all stages of ISD life cycle are closely linked and it should be possible to find stage-to-stage mappings to perform an automated transition from one stage of ISD to another. But the practice shows that most of the CASE tools still face serious problems while trying to reach some satisfactory results in this area. Usually a model that was developed on the early stages of the ISD (e.g. Business modeling, User requirements specification) is not used for the generation of models on the later stages. System designer develops models of the system by analyzing earlier created models and relying on his own experience and knowledge about the problem domain. In other words, the transition from stage to stage is done empirically. P. Coad identified such logical gaps and called them “twilight zones” [1] nearly 20 years ago. This is one of the reasons why some still use CASE toos simply as a mean to nicely document the

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specification of the system under developed [2]. Practitioners of Agile methods suggest using as simple tools as possible in order to accomplish one or another stage of ISD [3].

No doubt, with the advent of OMG's Model Driven Architecture (MDA) [4, 5] in 2001 the ISD automation processes gained a new boost. The OMG vision was that the models would be specified using UML and UML CASE tools would automate model-to-model transformations, especially forward engineering transformations: Business model (or Computation independent model – CIM) -> Platform independent model (PIM) -> Platform specific model (PSM) -> program Code. Some CASE tools already claim that they fully support MDA; however, in most cases this remains just a claim as some aspects of MDA itself still lack clear definition and are open to various interpretations, and the Repositories of such CASE tools do not store sufficient amount of domain knowledge in order to fulfill such claims [6].

UML alone is not enough to fulfill the main objectives of MDA at the moment. From our point of view, main problems with MDA arise when trying to define and specify Business model (CIM) using UML; yet another issue with MDA that has to be solved is the definition of mappings to realize the transformation step "CIM -> PIM". Objects and classes are core concepts for the object-oriented (OO) system analysis and design, and building the Class model of a system at the Platform independent level is among the main objectives of the OO software development. However, there is still no clear, well-developed process proposed to help the software engineers solve this problem successfully. Following the principle of MDA and assuming that UML Class model is a part of Platform independent modeling (that can later be transformed to one or more PSMs) it is obvious that the source of knowledge for the Class model development (generation) should be a Computation independent model and System requirements model (e.g. Use case model, that may be assumed as a part of CIM, or PIM). However, despite the progress in analysis techniques ISD still suffers from poor requirements acquisition and full-scale business modeling often is not even recognized as an activity of the ISD. According to [7], 80% of software development projects fail or fall well short of their goals, or significantly overrun their budgets or schedules because of inadequate consideration of the business requirements.

The necessity to establish an explicit, logically motivated link between the business environment and the ISD processes (and, therefore, the IS itself) is relevant and recognized a long time ago, yet, as it has been mentioned already, there are not so many solutions found up to date. We found it the most promising to use the Enterprise model (EM) as the integrating link between the business environment and the ISD [6, 8]. Enterprise modeling stage is set as a starting point of the IS development life cycle here, and the Enterprise metamodel represents a structure for business domain knowledge accumulation – this conforms to the MDA vision of model-driven system development. Moreover, we believe that the use of the Enterprise model in the ISD eliminates, or at least narrows, the existing gap between CIM and PIM, and also gives a great benefit for automation process of the "CIM -> PIM" transformation.

The main purpose of this article is: to present the core of the Enterprise metamodel (EMM) and proposed Class metamodel (CMM); show how the elements of EMM are mapped to the elements of CMM; represent basic principles of the Enterprise model-based generation of the Class model. CMM can be presented as an extension to UML metamodel, but this is not the topic of this article.

2 Current Situation in "CIM -> PIM" Area

There is a great number of Enterprise modeling methods and approaches (such as CIMOSA, GERAM, IDEF suite, GRAI etc) [9], standards (ISO 14258, ISO 15704, PSL, ISO TR 10314, CEN EN 12204, CEN 40003 etc.) and supporting Enterprise modeling tools. Moreover, CASE tools which appear in contemporary market and are intended for the development of Information systems, include graphical editors for Enterprise modeling and analysis techniques. Business process modeling, as an integral part of Enterprise modeling, gradually becomes acknowledged as a part of any ISD process. However, the integration of Enterprise modeling techniques into the ISD process is still not sufficient.

MDA is one of the most significant attempts to standardize the object-oriented (OO) ISD process that is complemented with the Enterprise modeling (Business modeling) stage. Even though MDA declares Business modeling (CIM) as one of the stages of ISD, where CIM specifications should be transformed to PIM specifications [4,5], it still remains more like abstract declaration with no clear definitions or rules, in other words, these transformations hold an empirical character. According to OMG and some other scientists, CIM is not obligatory and, if such model exists, could be used just as a guiding specification in the process of platform independent model (PIM) development [10, 11].

At present CASE tool developers concentrate on "PIM -> PSM" and "PSM -> Code" transformations; some tools generate DB schemas as well. However, modern MDA CASE tools (such as *AndroMDA*, *ArcStyler*, *OptimalJ*, *Together* or *MagicDraw UML*) do not support automated "CIM -> PIM" transformations, as there are no such well known methods that could be implemented at the moment. Class model of a system is a core model of the whole IS design. Nevertheless, there are no well defined methods of automated building (generation) of such Class models (on PIM level) from the business models either. Some supporters of Agile Model Driven Development (AMDD) say that in order to get correct PIM models transformations from CIM should be performed manually [12] (empiric knowledge). There are some approaches that propagate the development of the Class models from the user requirements gathered on system analysis stage – scenarios and Use case models are the most common examples in this case [13, 14, 15, 16]; RUP and ICONIX are among the most well known methods propagating Use case model-driven development of Class models. Some methods propagate the development of conceptual schemas based on linguistic analysis of the requirements [17]. However it should be mentioned that very often user requirements specified in a form of Use case models are insufficient in order to develop a Class model of a system, and Use case models with high level of detail become very complicated and hardly acceptable by the problem domain experts. Authors of this article support the idea of automated Class model development from the main source of domain knowledge, i.e. Enterprise model [6, 18].

3 Enterprise Metamodel

The implementation of MDA approach in UML-based methods, that are capable to process Enterprise modeling activities, is highly desirable. However, the UML itself does not satisfy the needs and requirements for the domain knowledge modeling in the area of IS engineering. IS engineering requires business-specific constructs and the Enterprise metamodel (accepted by users as business domain experts and IS developers) from which Enterprise models of specific business domain could be developed.

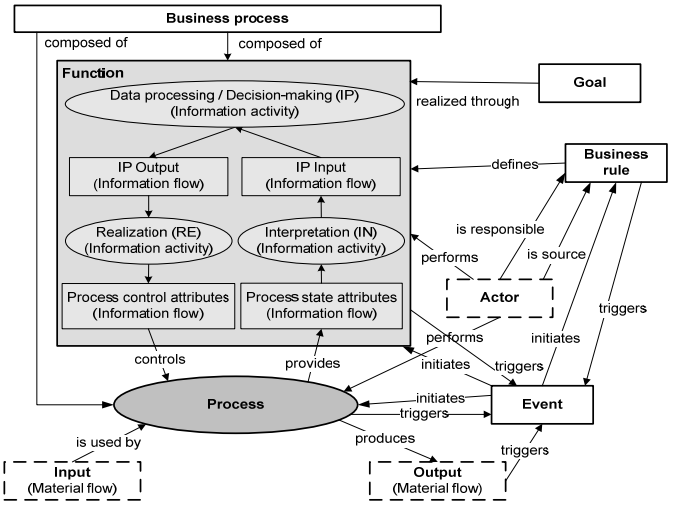

Fig. 1. Conceptual schema of the EMM

In [6, 18] basic concepts of the Enterprise metamodel (Fig. 1 and 2) were presented. At the core of the EM is the interaction of *Function* and *Process*. A *Process* here is a partially ordered set of steps, which can be executed to achieve some desired material end-result. A process consumes material resources (it is an input of the process) and produces some material output – production. From the management point of view a *Process* is defined by two sets of attributes: a set of a *Process state attributes*, and a set of *Process control attributes*. A set of Process state attributes includes process *Input* (material flow) attributes, process *Output* (material flow) attributes, and the attributes of the *Process* itself. A *Function* is set to control the flow of one or more processes and the resources assigned to these processes. A function is comprised of the predefined sequence of mandatory steps of information transformation; these steps are called *Information activities* and can be of type *Interpretation*, *Data processing/Decision-making (Information Processing)* or *Realization*. Inputs and outputs of information activities are *Information flows*. A sequence of information activities composes a management cycle – a feedback loop. Making reference to the System and Control Theory, one can state that a process can be effectively controlled only if some feedback loops are implemented [19, 20].

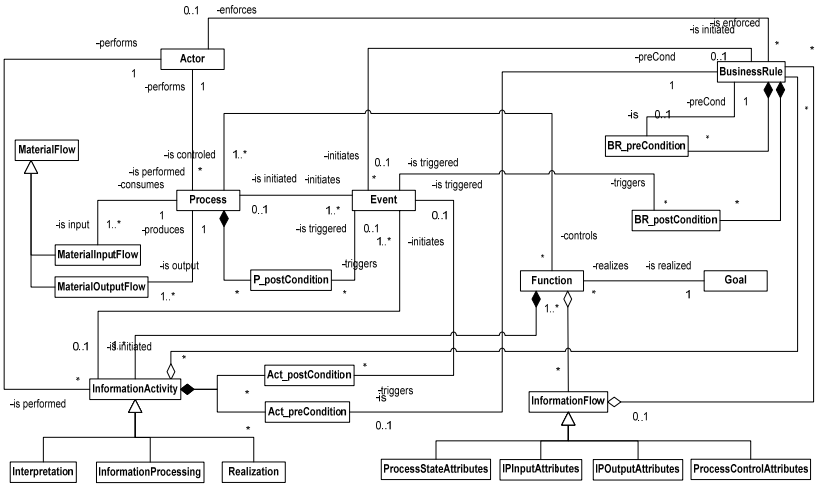

Fig. 2. Enterprise metamodel (UML notation)

Elements *Process*, *Function* and *Business rule* are triggered by occurrences of one or more events (*Event*). Processes, functions and business rules are performed by certain actors (*Actor*); construct *Actor* is an active resource (human, org. unit, application or machine with control device). Construct *Goal* represents a hierarchical structure of business goals of the organization. Goals of the organization are realized through (influence) management functions and directly influence the content of these functions (i.e. *Business rules*). Business rules are interpreted as the integral part of the decision-making mechanism of the organization. A decision-making mechanism in the proposed EMM is implemented through the composite construct *Function*. Construct *Business rule* in EMM defines conditions, constraints, and calculations to be associated with particular *Function* (its *Information activities*). Talking in object-oriented manner, function encapsulates a well-defined fragment of business logic that is expressed in a form of business rules. More about Business rules integration in EMM, and EMM itself, can be found in [6, 8, 18, 21].

4 Class Metamodel

In OO methods Class models are typically used: as domain models to explore domain concepts; as conceptual/analysis models to analyze requirements; as system design models to depict detailed design of OO software. Class model is also a part of OMG standard, namely Unified Modeling Language (UML). Class model in UML-based CASE systems serves as a main source of knowledge for the development of Information system prototype: DB specification, graphical user interface (GUI), application code. However, from the ISD perspective UML metamodel is too complicated and heaped with unnecessary elements [22] and it seems that every new

version of UML gets more and more complicated. From the article's author point of view it is important to note that UML metamodel does not have sufficient set of constructs, essential for Business modeling (e.g. business rules) as it does not impose none of the fundamental business logic (e.g. feed-back loops, business rules, types of business objects etc.). In this article Class metamodel is proposed. The Class metamodel is based on UML metamodel, but also incorporates constructs from the Enterprise metamodel (Fig. 3).

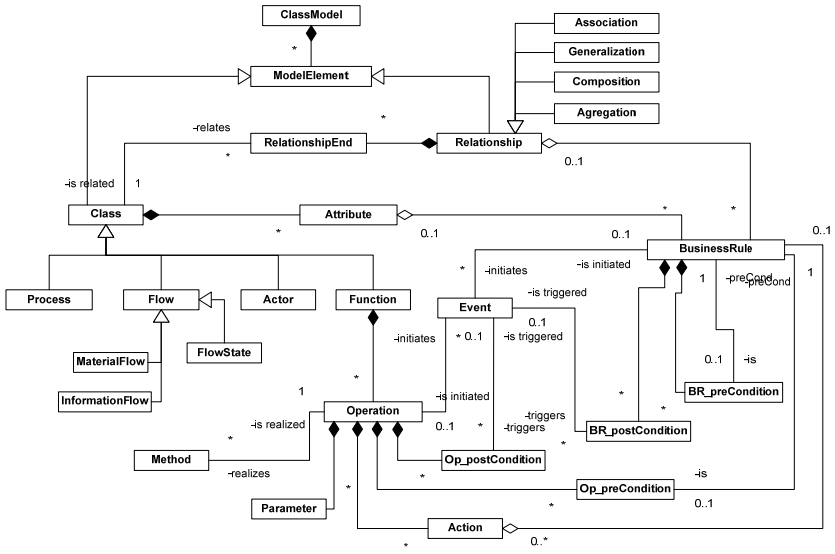

Fig. 3. Proposed Class metamodel (UML notation)

Core constructs of the proposed Class metamodel (Fig. 3) are as follows:

- Class model (*ClassModel*) is composed of the model elements (*ModelElement*). Class model elements can be either classes (*Class*) or relationships (*Relationship*) that hook these classes to each other. Each relationship has at least two connection ends (*RelationshipEnd*) and also may have some constraints or structural rules (*BusinessRule*) that specify that relationship.
- We enriched construct *Class* with certain subtypes: *Process, Flow, Actor* and *Function*. Such modification is based on the specification of the Enterprise metamodel (Fig. 1 and 2). The classification of classes is not a new idea – P. Coad's UML modeling in color, Robustness diagrams are just a few examples of various class stereotyping techniques. Techniques that classify classes pursue certain practical goals. In our case this classification is made in order to make a close link between the business environment (Enterprise model) and the IS design models (in this case, Class model).
- Classes of type *Flow* may have states (*FlowState*).
- Traditionally, classes have attributes and operations. In the proposed Class metamodel every class may have attributes (*Attribute*), but the operation level

(*Operation*) is specific only to the *Function* type classes. Construct *Operation* represents algorithmically-complex operations, and algorithmically-simple operations (such as Create, Connect, Access, Release) are not modeled in order to reduce the complexity of the class models. Classes of type *Function* are at some degree similar to the controller type classes in Robustness diagrams. Class attribute (*Attribute*) may have number of constraining rules (*BusinessRule*).

- Class operation (*Operation*) is composed of actions (*Action*), and may have parameters (*Parameter*) and methods (*Method*) that realize the operation in the certain programming platform. Class operations may also have pre- and post-conditions (*Op_preCondition*, *Op_postCondition*).
- Action (*Action*) represents single business rule (*BusinessRule*) of type *Computation*, *Action* or *Inference* (more on that can be read in [8, 21]). These rules may have pre- and post-conditions (*BR_preCondition*, *BR_postCondition*).
- Business rules and operations may be initiated by events (*Event*), but also may trigger the activation of events themselves.

5 Principles of the Enterprise Model-based Generation of the Class Model

5.1 Correspondence between Elements of the EMM and CMM

Mappings among the source and target models have to be identified before the algorithm of EM-based Class model generation is presented. It is shown how the elements of Enterprise metamodel are mapped to the elements of Class metamodel (φ: *EnterpriseModel* $\rightarrow$ *ClassModel*) in Table 1.

Table 1. Mappings among the elements of EMM and CMM.

EMM element	Mapping	CMM element
<EMM.ModelElement>	φ1	<CMM.ModelElement>
<EMM.Function>	φ2	<CMM.Class>,<KMM.Function>
<EMM.Process>	φ3	<CMM.Class>,<KMM.Process>
<EMM.MaterialFlow>	φ4	<CMM.Class>,<KMM.Flow>,<KMM.FlowState>
<EMM.InformationFlow>	φ5	<CMM.Class>,<KMM.Flow>,<KMM.FlowState>
<EMM.Actor>	φ6	<CMM.Class>,<KMM.Actor>
<EMM.Event>	φ7	<CMM.Event>
<EMM.InformationActivity>	φ8	<CMM.Operation>
<EMM.Attribute>	φ9	<CMM.Attribute>
Rel-ships among EMM elements	φ10	<CMM.Relationship>,<KMM.RelationshipEnd>
<EMM.BusinessRule>	φ11	<CMM.Action>, <KMM.BusinessRule>
<EMM.BusinessRule>	φ12	<CMM.Relationship>,<KMM.RelationshipEnd>, <KMM.BusinessRule>
<EMM.BusinessRule>	φ13	<CMM.Attribute>, <KMM.BusinessRule>

Mapping "φ2: <EMM.Function> $\rightarrow$ <KMM.Class>,<KMM.Function>" means that the element *Function* of EMM is mapped to the CMM elements *Class* and *Function* (*Class* being the core element of CMM and *Function* – type of that class). The same

principles are applied to all of the mappings in Table 1. It should be mentioned that a set of mappings {φ1, …, φ13} is sufficient to develop all the elements of Class model on the Platform independent level.

5.2 The Algorithm of Class Model Generation

The algorithm of Class model generation (Fig. 4) on the basis of business knowledge stored in CASE system's Knowledge base (EM) will be presented in this section.

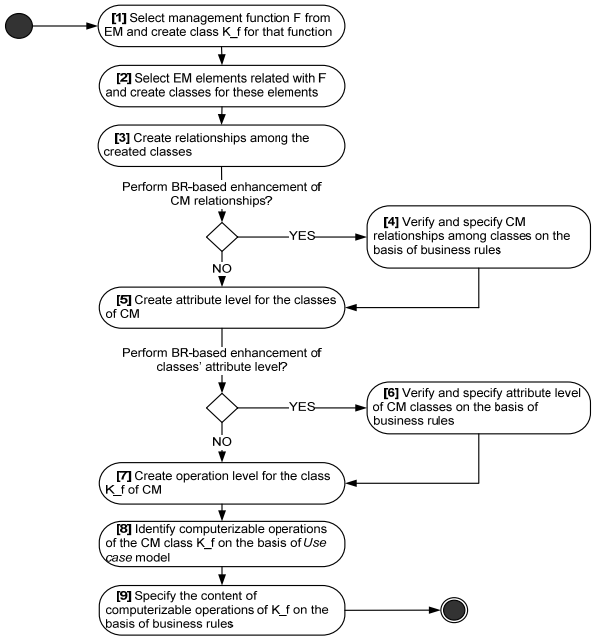

Fig. 4. Class model generation algorithm (at the PIM level)

The core of the algorithm is composed of the set of mappings {φ1, …, φ13} and the set of rules of Enterprise model analysis and data querying. Sequence of the processing of these rules is managed by the CM algorithm itself.

Theoretically speaking, Class model can be developed on the basis of any element of EM (instance of an element), however, actual practical use one can gain from the Class models generated from the selected management function, technological process or structural element of the EM. The core business object for generation is selected according to the purpose of the future IS (or subsystem of IS). If the certain function of EM is selected (e.g. *Workload management*), the scope of the IS design will be narrowed to that segment of the business domain (i.e. to the particular management function *Workload management*); one should select a technological process (e.g. *Furniture construction*) of the EM if the goal is to prepare specifications for the computerization of all the management activities of that particular

technological process; if one is willing to computerize some particular work place (e.g. *Accountant*) in the organization, Class model generation should be performed on the basis of the selected structural unit of the EM, and the scope of the Class model development will be narrowed to the structural and functional aspects of that particular work place. This article concentrates on the Class model generation on the basis on the selected management function.

Class model generation algorithm (on PIM level) may be divided into four main stages (Table 2): (1) generation of the classes of CM, (2) generation of the relationships among the classes, (3) generation of the attribute level of the classes, (4) generation of the operation level of the classes. These stages may be further decomposed into steps.

Sequence of the execution of the steps reminds of the traditional Waterfall model where every step is processed one after another one time. However, this sequence may be interrupted by the user (system analyst/designer) at any point and become iterative.

Table 2. Stages, steps and mappings of the Class model generation algorithm

Stage	Step	Mapping
Stage 1. Identification of business objects of the problem domain and generation of classes for the Class model.	*Step 1.* Select management function F from EM and create class K_f for that function.	φ1, φ2
	Step 2. Select EM elements related with F and create classes for these elements.	φ1, φ3 - φ6
Stage 2. Identification and generation of relationships among the classes of the Class model.	*Step 3.* Create relationships among the classes.	φ10
	Step 4. Specify and augment relationships among CM classes on the basis of business rules.	φ12
Stage 3. Generation of the attribute level of the classes.	*Step 5.* Create attribute level for the CM classes.	φ9
	Step 6. Verify, specify and augment attribute level of CM classes on the basis of business rules.	φ13
Stage 4. Generation of the operation level of the classes.	*Step 7.* Create operation level for the CM class K_f .	φ7, φ8
	Step 8. Identify computerizable operations of the CM class K_f on the basis of *Use Case* model.	-
	Step 9. Specify the content of computerizable operations of K_f on the basis of business rules.	φ7, φ11

Let us shortly describe 1-9 steps of the algorithm in some more details:

Step 1. Generation process begins with the selection of the certain management function *F* (i.e. the instance of the EM element *Function*) from the EM. After the function *F* is selected, new Class model *M1* is created and the class *K_f* is created in *M1*. The name of *F* and the stereotype <<Function>> is assigned to the class *K_f* .

Step 2. Analysis of EM and data querying is processed. During this process instances of the EM elements *Process*, *Actor* and *InformationFlow* that are related to *F* are collected. Structural elements (*Actor* instances) and material flows (*MaterialFlow* instances) that have relationships with the selected processes (*Process* instances) are also collected. For each collected instance of the EM elements *Process*, *Actor* and *InformationFlow*, *MaterialFlow* a corresponding class in *M1* is created. Names of the classes correspond to the names of the instances of the EM elements, and stereotypes of these classes are assigned with regard to the type of the particular

EM element (i.e. *Process* -> <<Process>>, *InformationFlow*, *MaterialFlow* -> <<Flow>>, *Actor* -> <<Actor>>).

Step 3. The relationships among the classes of *M1* are specified with respect to the corresponding relationships among the elements of EMM. For example, if there is an association between the *Process* and *Function* in EMM, then there will be an association created between *M1* classes that have stereotypes <<Process>> and <<Function>>. In other words, Enterprise metamodel is the main guide in the process of the generation of relationships among the classes of CM.

Step 4. The relationships that were generated on Step 3 can be automatically validated and augmented with respect to the particularity of the problem domain. This is achieved using Business rules. Business rules can specify additional relationships between certain classes or augment the existing relationships with stricter cardinalities and other constraints (the latter may not be visible in graphical view of the Class model). Business rules-based specification and augmentation of the Class model is quite complicated activity that was presented and extensively discussed in [23, 24], therefore this topic will not be further elaborated in this article.

Step 5. Attributes of the instances of the EM elements are mapped to the attributes of the corresponding classes of *M1*. Some system attributes of the instances of EM elements (e.g. system name, id) are also stored in the attribute level of the classes as system attributes – this is done in order to maintain close link between EM and CM. System attributes of EM allows us to track changes in business environment and react accordingly.

Step 6. The attributes that were generated on Step 5 can be automatically validated and augmented with respect to the particularity of the problem domain. This is achieved using Business rules. Business rules can specify additional attributes specific to a certain business object or specify constraints on certain attributes. Again, for more details on this step, refer to [23, 24].

Step 7. Algorithmically complex operations may be owned just by the classes of *M1* that have stereotype <<Function>>. Operation level for the class *K_f* is generated on the basis of the information activities (*Information activity* – Fig. 1 and 2) that compose the management function *F* in EM. Each information activity is mapped to one operation of *K_f*. If the operation is quite complex, it can be further decomposed into a set of operations of lower complexity, however, it is advisable to perform such actions on the Enterprise modeling level (one can model a hierarchy of information activity workflows on the Enterprise modeling level [25, 26]).

Step 8. Operation set generated on Step 7 is a complete set of operations of the particular management function, however not all of them are necessarily computerizable. The best way to identify computerizable operations is to merge then with the use cases of the Use Case model (developed for the same problem domain) and find the overlaps. Not overlapping operations of the class *K_f* are automatically identified as non-computerizable and gain invisibility property (these operations can be changed to visible at any time later). Process of the Enterprise model-based development of Use Case models is presented in [25].

Step 9. The Repository of the Enterprise model stores not only structural rules (Terms and Facts) but operational rules (Computational, Inference, Action rules, Constraints) as well. Operational rules is used to formally specify the content of the

computerizable operations of *K_f* declaratively. This is a third additional step of business rules-based specification and augmentation of CM.

It should be noted that Steps 4, 6, 9 can be performed independently, without a reference to other steps of the algorithm. Such approach was demonstrated in [23, 24]. This means, that the developed class model can be additionally validated and augmented using business rules at any time later.

The generated PIM level Class model can be additionally customized and be transformed into one or more PSM level models. In order to utilize the existing "PIM -> PSM" transformations, the proposed Class metamodel should be presented as an extension of the UML metamodel (this can be achieved using UML extension mechanisms).

5.3 Experimental Realization of the Algorithm

The prototype of the algorithm has been implemented as an add-on to the CASE tool Visio 2000. Short illustration of how the algorithm works is presented in Fig. 5 and Fig. 6 – it is just enough to illustrate the main principles of the algorithm (Fig. 4). Fig. 5 presents the interaction of the management function "Order estimates management" and process "Order fulfillment". Problem domain is presented in a form of modified workflow models in the environment of *Provision Workbench* CASE tool. The workflow model is captured into EM using certain algorithms [25].

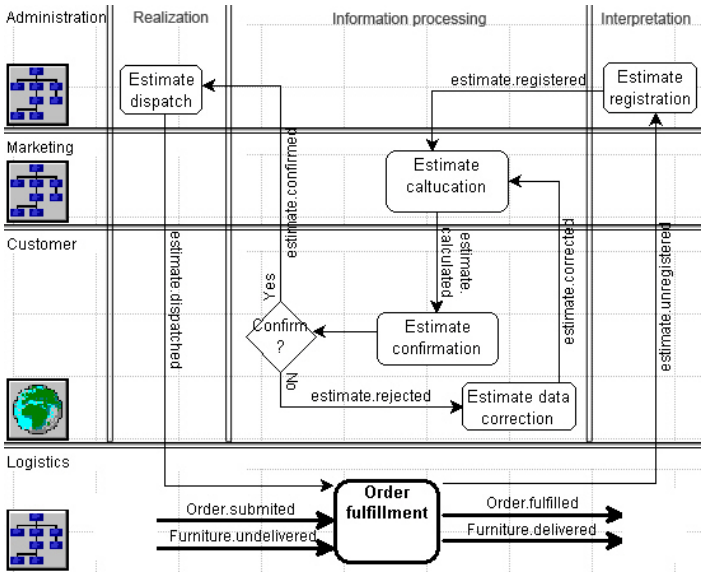

Fig. 5. Workflow model of the problem domain "Order estimates management"

Actors of the problem domain are deployed on the left side of the model (Fig. 5). Actor *Logistics* performs technological process *Order fulfillment*. The process has

material inputs – material flows *Order.submited* and *Furniture.undelivered,* and outputs – material flows *Order.fulfilled* and *Furniture.delivered* (*.submited*, *.undelivered*, *.fulfilled*, *.delivered* are the states of corresponding flows). Actors *Administration*, *Marketing* and *Customer* perform certain information activities that compose the management function "Order estimates management". These information activities are of the particular type (*Interpretation*, *Information processing or Realization*). Information activities have their inputs and outputs – information flows; these flows may also have states. Remark: we assumed that information activity "Estimate data correction" will not be computerized; therefore it was hidden in the operation level of the class "Order estimates management" (Fig. 6).

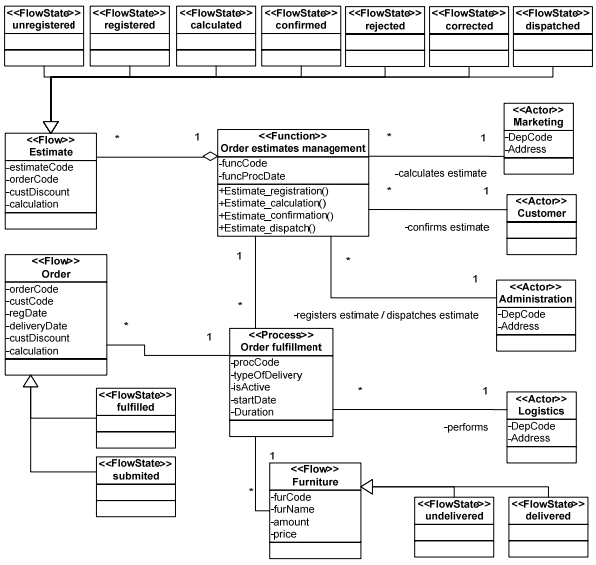

Fig. 6. Generated Class model for the management function "Order estimates management"

It should be pointed out that not all of the knowledge of the business domain can be represented in graphical notation of the workflow models. Business rules are not visible in the graphical notation of workflow models – they are gathered using another specialized tool [8] and kept in formalized textual form apart from the workflow models. Features (attributes) of business objects cannot be visualized in Fig. 5 as well, but they are stored in the Repository of EM. Each stereotype of the Class model has its own color in the original project of Visio 2000, but it is not possible to show such colorful view in the article, therefore, all classes are filled with no color (Fig. 6).

The developed Class model is independent from any platform. In order to develop PSM models, new platform specific classes may be added and even the existing classes restructured. The boundaries of the developed Class model are restricted by the selected management function "Order estimates management".

Algorithmically complex operations are assigned to the stereotyped <<Function>> class. Classes with stereotypes <<Process>>, <<Flow>>, <<Actor>> may be assumed

as entity (or persistance) classes which on the stage of DB schemas (or other data models) development are transformed into tables (entities) – these classes supply data for the operations of <<Function>> class. On the stage of user interface development <<Actor>> classes may indicate the need for boundary classes as well.

6 Conclusions

Nowadays efficient IS development and Enterprise modeling are directly related issues. Enterprise modeling can be a source of enterprise knowledge that adds value to the business process and also influences methods of ISD. Some of the ISD approaches use Enterprise models as a source of structured knowledge about the real world (business domain) in ISD life cycle stages, such as user requirement analysis and specification, development of detailed IS project solutions and other. According to [7], MDA will not reach its goals unless the Business model (CIM) is formally connected to other layers of MDA (first of all to PIM) as well. Not the less important is to maintain such developed models and they will not be maintained unless they are connected to the code – this includes the Business model as well.

One of the main goals of this article was to show how Enterprise model could be used for ISD purposes. Enterprise model becomes a main source of knowledge in various processes of ISD, such as model development, augmentation and validation. Moreover, the usage of such EM facilitates the automation of model development and therefore the automation of the whole ISD. This article concentrated on the issues of Class model generation. The proposed solution narrows the existing logical gap between Business modeling and ISD stages and also automates the process of ISD at some degree.

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Leverage Coefficients-based Recommendations Formation in Social Network [1]

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Abstract. On the basis of the drawbacks of the current recommender systems additional functionality to the social network, namely, recommender system with management possibility is proposed. In order to implement such additional functionality to the social network, the following elements of a new method are proposed and presented in this paper: metamodel of the recommendation; algorithm of leverage coefficients-based recommendations formation; algorithm of leverage coefficients-based recommendations interpretation. Prototype of the recommender system is also presented in this paper.

Keywords: social network, recommendation, recommender management system, leverage coefficient.

1 Introduction

With the development of novel technological solutions and constant growth of information quantities, the interaction and communication activities among people and various organizations become more and more computerized. People and organizations form various virtual communities in order to share their knowledge and experience more efficiently. Such virtual communities are the core of social networks.

Social network is a structure that consists of nodes and ties [8]. Nodes define the members of social network (persons, organizations). Ties among nodes identify connections among members of social network [3]. The size of the network is directly related to the size of the community it covers. The transfer of social network into virtual environment (internet social network) enables users to communicate even more efficiently. The main features of such environment are remote (from any place) asynchronous (anytime) communication (information trade) [10].

There are two types of user functions in social network: administrative functions (management of the information about the user, his interest areas, contacts etc.) and functions of participation in social network activities (information upload, search, review etc.). [9].

Social networks usually store huge amounts of information, and that may negatively influence user social actions and reduce possibility to find useful information quickly. However, social network should be able to present not only the

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main information for the user, but also additional information that could be potentially useful for the user according to his profile or the actions he performed. One of the ways to present additional information in social network is recommender systems (RS) [17].

Recommendation is a description (formal or informal) that defines what additional information should be presented to the user the social network. Recommender systems (RS) can be of the different types and different complexity.

Despite the positive side of RS they are not perfect. Among the main drawbacks of current RS one could mention the following: there is no possibility to modify structure of recommendation or evaluate the environment parameters of the user; one cannot change the level of personalization and relevance of the additional information as well.

On the basis of the drawbacks of the current RS authors of the article suggest additional functionality to the social network, namely, recommender system with management possibility. The process of recommendation formation in this system is defined by the algorithm. The particularity of the recommendations formed with this algorithm is that these recommendations are based on leverage coefficients – this feature allows one to define the most suitable level of flexibility and personalization. Such recommendations provide proper additional information to the particular user [18]. The recommendation is stored in the system as a composition of atomic elements – this feature enables the analysis and modification of recommendations, avoiding flexibility and personalization problems that are a very common problem in others recommendation systems.

2 Integration of Recommender Systems in Social Network

Types of RS, their formation and integration possibilities are analyzed in this section.

Flows of information are intensive and contain lots of information in social networks. That's why there is a lot of additional information that can be potentially useful for the user of the social network. Social network augmented with RS provides new useful possibilities to distribute information among the members of the network.

Among other useful functions social networks contain functionality that allows one to inform users about various kinds of news, new users etc. Social network can find not only new information, but also the information, that can be potentially useful for the user according to his interests areas set in his profile [16]. Such potentially useful information may contain the most popular articles, goods or services (i.e. all the information that users exchange in the system). All this functionality of the social networks is provided by the recommender systems.

RS can be analyzed in different views. Depending on a view different classifications may be applied [6]:

- Static an dynamic;
- Depended on the user, his queries or actions;
- Automatic and user initiated.

According to the first classification, recommender systems can be *static* and *dynamic*.

Static recommender systems are formed and deployed in the particular place of the website window. This type of RS is used when the additional information does not hold dynamic character. The aspect of dynamic fluctuation of information is not evaluated in this type of RS.

Dynamic recommender systems are used when the selection of additional information is based on the *personal information* (profile) [4] or the *performed actions* [13] of the particular user. If selection of additional information is based on the personal information, the system provides information that is associated with user interest areas. E.g. if the user is marked in the profile, that he likes cats, RS can suggest him to contact others users, who are interested in cats or read articles about cats. If selection is based on the actions of user, system can suggest the user to make similar actions, e.g. if the user buys some goods, the system will suggest him to buy some similar goods.

Actions of a dynamic RS can also be *initialized by the user*, e.g. the user sends notifications to other users about goods, services or some actual information. Another type of dynamic RS in this classification is *automatic RS*. In this case the system itself selects and presents information to the user according to the circumstances [15]. These recommender systems are called **automatic dynamic recommender systems**. Recommendations in these RS are formed using special formation methods [12, 2]. Automatic dynamic RS can implement three types of these methods:

- *Content-based* recommendation formation methods [1]. Here the selection of additional information is based on the user's profile, e.g. the system analyzes the content of the text and looks for the keywords that are similar to the keywords of the user's profile and when the similarity is of the suitable level, the content is presented to the user as additional information;
- Methods that form recommendations on the basis of the *results about the communication among users* [11]. Methods of the second type analyze various aspects of the communication between users: the strength of the ties among the users, common interests, taken actions etc. On the basis of these results RS forms recommendations [19]. These methods analyze information that is calculated real-time as well [7];
- *Hybrid* methods [5, 14]. Hybrid methods utilize the combination of the methods described above.

Some automatic methods have self-learning feature for making better decisions for selecting additional information [2].

It should be pointed out that not all RS can offer proper functionality. That is why particular usage of the RS described above depends on the specifics of the social network itself and the complexity of the recommendations that is needed.

The analysis of recommender systems identified some drawbacks and problems that do not have solutions yet:

- There is no possibility to modify recommendation, unless the program code itself is changed. This, of course, may become very expensive and difficult to accomplish, because the features of recommendation are already in the code.
- Recommender systems analyze the connections between the user and the object that will be offered, but other circumstances like time, living place, age, contacts with other users are not evaluated. This results in poor level of personalization of the recommendation.

– Newly involved users have no connections and no activities. RS has to evaluate that and to offer the additional information with lower level of relevance. There is no possibility to change this level in existing recommender systems. This problem concerns not only the new but also the mature users of social networks, because high level of relevance between the user and additional information precludes possibility to present additional information of the lower level of relevance.

Summarized comparison of RS is given below (Table 1.).

Table 1. Comparison of types of recommender systems (RS)

Type of re-commendation / Criterion	Static	Dynamic				
		Partially dynamic		Full automatic		
		By the action	By the profile	By the content	By the commu-nication	Mixed
Level of personalization	-	+	+	+ (high)	+ (high)	+ (high)
Possibility to change level of personalization	-	-	+	-	-	-
Level of relevance	+	+ (low)	+ (low)	+ (high)	+ (high)	+(high)
Possibility to change level of relevance	-	-	-	-	-	-
Possibility to change structure of presented additional information	+	+	+	-	-	-
Possibility to change criterions for selection of additional information	+	+	+	-	-	-
Demand for gathering additional data	-	+ (high)	-	-	+ (high)	+

3 Adding Additional Functionality to Social Network

Additional functionality to social network was proposed after the evaluation of the existing methods of recommendations' formation (Fig. 1). The core of our proposal is automatic leverage coefficients-based recommender system of the social network.

Stage of Business logic is augmented with two additional processes: „Selection of additional information using recommendations" and „Presentation of the additional information to user".

Input and output flows of the first process are as follows:

– Inf.f.[1] – initial data, which is selected according to the environmental parameters (user actions, user profile, etc.);
– Inf.f.[2] – queries for the selection of the particular recommendation and its parameters. These queries are formed after the analysis of initial data (Inf.f.[1]);

– Inf.f.[3] – data about the particular recommendation and information, which is selected according initial data. Selected elements of the recommendation are as follows: elements of formula of leverage coefficient, weights, output data structure. Input and output flows of the second process are as follows:
– Inf.f.[4] – additional information that is selected by the recommendation with respect to the values of leverage coefficient;
– Inf.f.[5] – additional information that is customized to the particular user according to his profile settings.

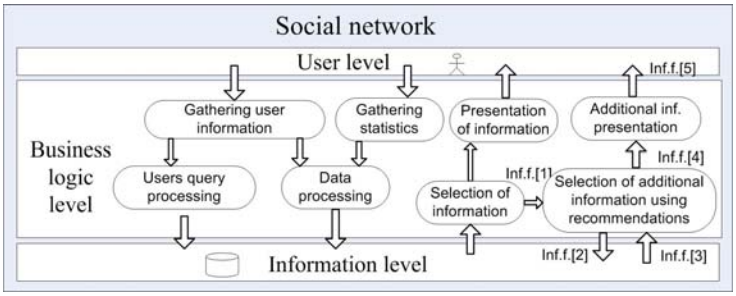

Fig. 1. The process in social network's business logic level that is extended with recommender subsystem

In order to implement such additional functionality to the social network, the following elements of a new method were proposed and presented in this article: (1) metamodel of the recommendation; (2) algorithm of leverage coefficients-based recommendations formation; (3) algorithm of leverage coefficients-based recommendations interpretation.

4 Metamodel of the Proposed Automatic Recommendation

Metamodel of the proposed automatic recommendation is presented and described in this section (Fig. 2). The elements are as follows:
– One of the elements composing automatic recommendation is the *Informal description* – it specifies the purpose and goals of the recommendation.
– Another element is *Initial parameters*. Initial data is selected according to those parameters. Initial parameter can be one of the two types: (1) Initial parameter of the system (such parameters define circumstances of when the recommendation should be presented, i.e. user identification, parameters describing user environment); (2) Initial parameter of the recommendation (such parameters define data that should be selected according to the particular recommendation).
– Every selected initial data element gets *leverage coefficient* value which is calculated by the formula. *Leverage coefficient* lets the system to decide what information according to the appropriate user can be useful to him.
– The formula itself is not stored as an element of recommendation, though elements of the formula are. Formula consists of *variables*. Variable can be one of the two

types: *ontology element* or *query*. Values of the variables are digits, i.e. values of ontology elements or results of the queries.

– Formula variables have *weights*. Weights are defined by the expert. Expert groups *ontology elements* and gives these groups weights of influence. The expert can also define the structure of the *output data*, which will be presented to the user. It consists of the elements of ontology. *Initial data*, *output data* and *leverage coefficients values* are received using adequate queries (*Selection of initial data, Selection of output data,* and *Receiving of the variable's value*).

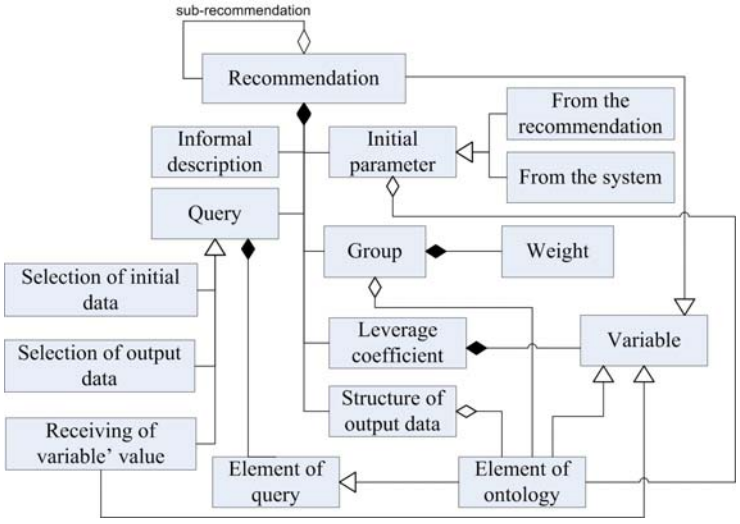

Fig. 2. Metamodel of the recommendation

Recommendations are interpreted a separate element of the social network. What is very important, they are not stored in the program code any more. This feature enables the expert to modify recommendations if needed – it is very useful in social networks (or in other web sites) where dynamics of information flows is very high. The modification of recommendations is performed by changing the parameters of elements of recommendation.

5 The Algorithm of Leverage Coefficients-based Recommendations formation

Core element of the leverage coefficients-based recommendations formation method is the formation algorithm itself.

It is important to note that the same principles for recommendations formation should be applied to all recommendations in the system in order to avoid the recommendations overlaps. The amount of recommendations in social network is not finite; it depends on the on the demand to publish additional information as well as on

the specifics of problem domain itself. Usage of system recourses has to be estimated by the expert according to the complexity and amount of recommendations and density of updates. In order to optimize the usage of the system resources, formulas of leverage coefficients may be optimized, eliminating all unnecessary elements. The timing of calculation of leverage coefficients values should also be taken into account – calculations can be performed in real time or periodically.

The essence of the algorithm is the process of calculation of the values to the leverage coefficients' that will be used for the selection of additional information. The particularity of this method is that the user gets information, which is selected according to his profile and other parameters characterizing his environment. This feature partly enables the system to restrict the overflow of the additional information given to the user. It is impossible to avoid excessive additional information completely, because the amount of additional information is a very personalized parameter that differs from user to user. Before the recommendation formation process starts, the expert has to analyze the problem domain and define:

- users or groups of users,
- goals of recommendation,
- composition of recommendation,
- period of data update for recommendation.

After the evaluation of these aspects recommendation formation process may begin. Basic steps of the algorithm of leverage coefficients-based recommendations formation is presented in Fig. 3.

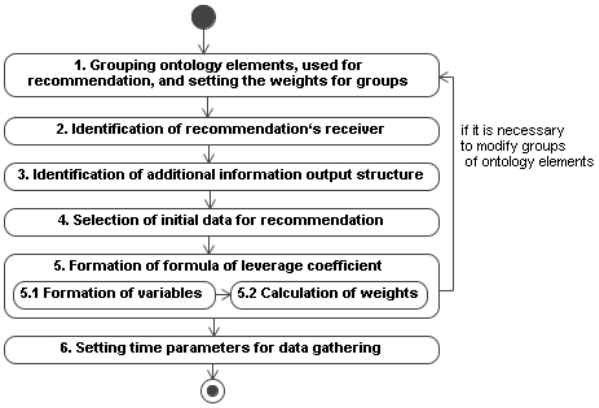

Fig. 3. The algorithm of leverage coefficients-based recommendations formation

Let us briefly discuss basic steps of the algorithm:

STEP 1. Grouping ontology elements used for recommendation, and setting the weights for the groups

Expert analyses problem domain and the description of informal recommendation and groups the elements of ontology of problem domain. Some remarks:

– The expert selects the ontology elements that will be used in formation of recommendation. Later, in case there are any changes, expert can easily modify these groups (add new elements, groups, delete them);
– Groups get weights. The weight shows the influence of every grouped element, which means that elements from different groups will have different influence in formula of leverage coefficient.

Groups are made for every recommendation, i.e. they are not the same for all of recommendations, because even the same elements in different recommendations can have different weights (influence).

In order to avoid overlap of ontology elements, ensure the correct performance of recommender system and reduce inaccuracy of calculating of leverage coefficients' values some limitations for forming the groups in the system are risen:
– The expert cannot put the same ontology element into two or more groups. If he wants to change the weight of the element, he should move it to another group or change the weight of the entire group;
– When the expert deletes element or entire group, he should pay attention, if they are already involved in some formula of leverage coefficient, because in case of element deletion the formula may get incorrect;
– The expert can set weight for each group of elements, bet the total sum of all groups in the recommendation should be equal to one. The amount of elements in each group is not limited.

STEP 2. Identification of recommendation's receiver

The second step is to identify the receiver of the recommendation, i.e. a person who (and when) will get an additional information. In order to do that, expert has to analyze the following aspects:
– Under what conditions (*when?*) the additional information is presented to the user. It can be some kind of user actions, e.g. opening a particular page of website. According to that system present one or another recommendation;
– What parameters identify the adjustment of recommendation to the user. This aspect identifies *who* will be the receiver of additional information. Some additional parameters, which identifies user environment, are identified as well – these parameters enable to personalize the additional information

The first aspect is analyzed during the integration of recommendation, and the second one – during the formation of the recommendation, to improve it's usefulness. These parameters are input data (*initial parameters*) to the recommender system from the main system. There can be general recommendations in the system, which do not have parameters about the user identification, but additional parameters from the main system about the user environment can be given to recommender system anyway.

STEP 3. Identification of additional information output structure

When the receiver of recommendation is defined (input parameters), the expert has to define output structure of additional information, which will be presented to the user. Recommendation does not control user interface, nevertheless, it gives a set of data elements to the system, which is responsible for the user interface.

Elements of the output structure can be two types: *main* and *additional*. The main elements are related to those ontology elements, which have leverage coefficient's

values, because according to those values, additional information is selected. Additional element for the output structure can be any ontology element.

STEP 4. Selection of initial data for the recommendation

The expert controls the selection of initial data (Fig. 4.) in this step. Recommender system selects data on the basis of the queries formed by the expert. Queries are formed using initial parameters from the STEP 2. Selected data defines a range of the recommendation ("B" subset in Fig. 4).

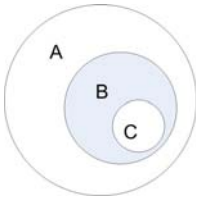

Fig. 4. Data subset selection for formation of recommendation

Remark: Fig. 4 represents three sets of data: set A is entire set of data of the problem domain; B is a subset of A – this subset is formed using initial parameters from the system and from the recommendation (see Step 2); C is a subset of B – this subset is formed using values of leverage coefficients and represents selected additional information that will be presented to the user.

STEP 5. Formation of formula of leverage coefficient

Recommender system calculates leverage coefficient value for every selected data element in subset "B". Every recommendation has its own formula for calculation of leverage coefficient value. Recommendation can have only one formula. Depending on the complexity of recommendation there can be one or more elements in the formula. Complexity of the element (which can be: ontology element, query or function) also depends on the requirements for the recommendation.

The structure of formula for the leverage coefficient is given below (1):

$$f(obj) = a \cdot f_1(obj) + b \cdot f_2(obj) + .. + k \cdot f_k(obj) + .. + n \cdot f_n(obj). \quad \textbf{(1)}$$

obj – element of the subset "C", for which RS has to calculate value of leverage coefficient;

$f_1(obj)$ .. $f_n(obj)$ – variables (functions) of the formula;

a .. *n* – weight of formula elements; weights show the influence of the particular in the formula;

f(obj) – value of the leverage coefficient, which is calculated for the object *obj*.

The expert gets formula variables from the informal description of recommendation. Weights of formula elements are inherited from the groups of these elements.

Formation of variables. The expert can get information about proper variables in the formula from informal description of the recommendation. This step is very

important, because the proper choice of variables enables the RS to present the additional information to the user with the most appropriate personalization and relevance level. The formula has to be optimized eliminating all unnecessary elements, which can complicate the selection of additional information.

Variables of the formula can be on the three types:

- Ontology element;
- Query, which returns numerical value;
- Function, which according to the initial parameters returns numerical value.

Ontology element used in the formula must have numerical value. Value can represent:

- Some kind of quantity value (e.g. number of user visits);
- Object's quality value (e.g. rating of the article). Every object may have different quality values depending on which recommender system selects the most suitable objects as candidates to be presented as the additional information for the user.

Queries are used, when values of the variables are not saved in the system. The expert has to form the query and it will be saved in the system.

Functions are the most complicated variables in formulas of leverage coefficients. Functions are assumed as sub-recommendations. They are used when the values of the leverage coefficients cannot be calculated directly. In this case, value of the variable is equalled to the value of the leverage coefficient of sub-recommendation (Fig. 5). When the recommender system initializes the calculation of leverage coefficients' values, it starts from the lowest level of recommendations (S level in Fig. 5) and ends up in the highest level (0 level in Fig. 5).

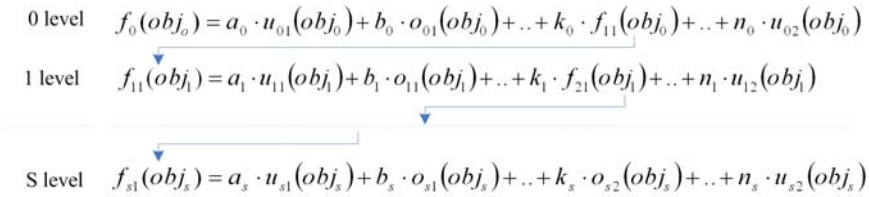

Fig. 5. Formula of leverage coefficient with hierarchy of sub-recommendations

$f_0(obj_O)$ – the main function of leverage coefficient;

a_0 – the weight of formula's variable. Its index shows the level of (sub) recommendation;

$u_{01}(obj_0)$ – query to get a numerical value of some characteristics of the object *obj* (e.g. rating of the article). The first index of *u* identifies the level and the second one – query's number in the formula;

$o_{01}(obj_0)$ – ontology element. Its value is selected for the object *obj*; the first index identifies the level and the second one – element's number in formula;

$f_{11}(obj_0)$ – formula's leverage coefficient of sub-recommendation. The first index identifies the level and the second one – its number in the main formula.

It has to be noted, that the expert may use only those ontology elements, which belong to the element groups made in Step 1, when he forms a variable of any type in the formula.

Calculation of weights. The next step after the identification of the formula's variables is the calculation of weights of each of these variables. Weight is calculated according to the ontology elements which belong to the particular variable of the formula. Weights of ontology elements are acquired from the groups of ontology elements. There are some rules for calculating the weights of variables:

- If the variable is ontology element, its weight is the same as the weight of ontology element's group;
- If the variable is query, its weight is calculated as the average of all weights of ontology elements composing the query;
- If the variable is function, the calculation of its weight starts from the lowest sub-recommendation level. Formula of the lowest level has only queries and ontology elements, so their weights are calculated using the first and the second rule. The total weight of sub-recommendation is calculated using formula given below (2):

$$weight(\ function) = \frac{s_{U[1]} + s_{U[2]} + s_{O[1]} + .. + s_{O[n]} + s_{U[k]}}{n + k}. \quad \textbf{(2)}$$

weight (function) – weight of the recommendation (or sub-recommendation);

$s_{O[n]}$ – weight of the variable that is ontology element;

$s_{U[k]}$ – weight of the variable that is query;

n+k – the total number of ontology elements and queries in the formula (n – amount of ontology elements, k – amount of queries).

STEP 6. Setting time parameters for data gathering

When the expert defines all the elements of the formula of leverage coefficients (weights and variables), he has to set the time period that defines how often the data for each variable has to be refreshed. Data can be refreshed in real-time; however, if the time for execution of queries or sub-recommendations is too long compared to the time needed for selection of data about simple ontology elements, the expert may set a certain time period for these actions.

6 The Algorithm of Leverage Coefficients-based Recommendations Interpretation

The process of recommendations formation is separated from their interpretation. Such approach enables the expert to modify the elements of recommendation without interruption of the work of social network. During the recommendation formation process elements are saved in the repository, and in the interpretation mode

recommender system selects proper elements and provides personalized additional information to the user.

Basic steps of the interpretation algorithm are presented below (Fig. 6).

Fig. **6.** Basic steps of the interpretation algorithm

Social network transfers *initial parameters F1* to the RS (the process of the identification of initial parameters was presented in STEP 2). Another set of *initial parameters* (about recommendation) RS gets from the Repository. Full set of initial parameters *F2* is used for the selection of *initial data F3* (the process of the selection of initial data was presented in STEP 4). For every data element RS calculates the *value of leverage coefficient F4*. Flow *F4* is used for the selection of personalized additional information with respect to the information output structure of the recommendation (it is described in STEP 3 in more details). The result of recommendation interpretation (*F5*) is transferred to the social network and presented to the user.

It should be noted that the interpretation algorithm is the same to all recommendations, which were developed by the proposed method. This feature enables the transportation of the recommendations to other social networks (provided these networks use the same recommendation formation and interpretation algorithms).

7 Prototype of the Recommender System

The proposed algorithm of leverage coefficients-based recommendations formation was implemented in the prototype of recommender management system. This system supports the process of automatic formation of recommendations. Compared to the manual formation of recommendations (when the expert has to write all the program code for the recommendation) the proposed RS reduces time costs of recommendations formation and maintenance, moreover, it reduces the number of human mistakes. A part of manual work is reduced to the definition of the elements of recommendations and the calculations are assigned to the RS (calculation of leverage coefficients values, data selection etc.).

An example of graphic user interface of the RS prototype is presented in Fig.7. The RS was created using *Jena* framework, programming tool *Eclipse*, data repository *PostgreeSQL* and *Altova Semantic Works* for the formation of ontology. Ontology was used instead of the traditional relational database in this RS. Ontology was chosen because of its features that let the expert to define not only the objects of the problem domain but also semantic relations among them. The small part of the developed ontology for the RS is presented in Fig. 8.

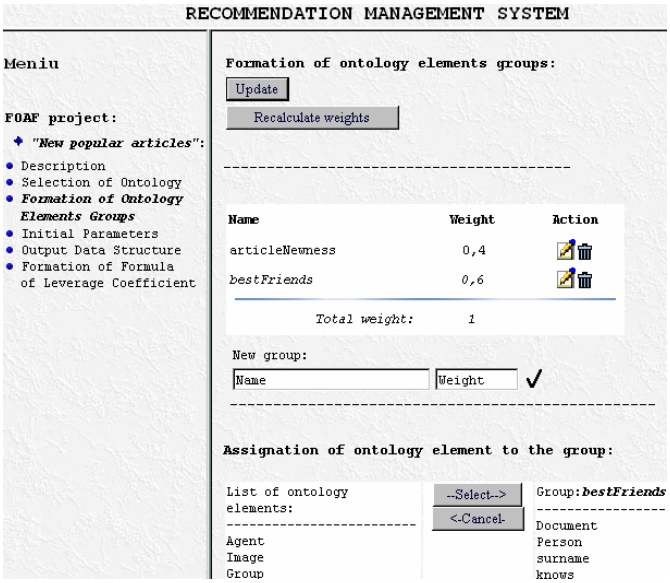

Fig. 7. The example of prototype of RS (Step 1. Formation of ontology elements' groups)

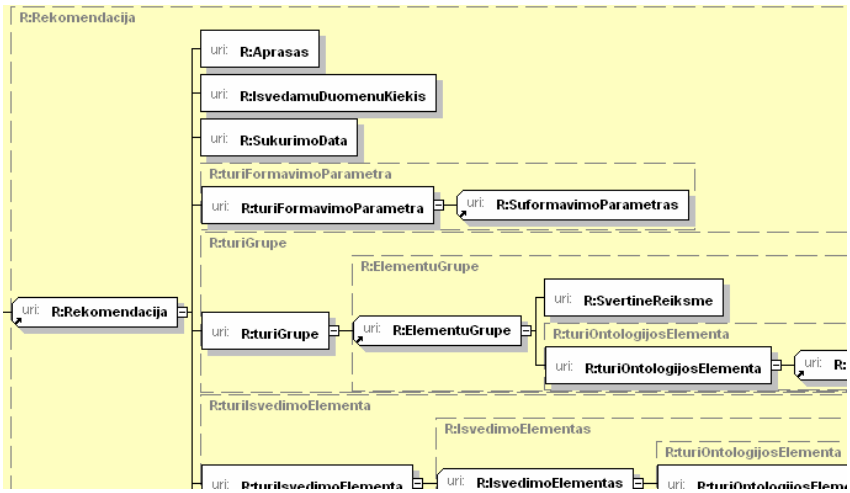

Fig. 8. The part of ontology of RS

8 Conclusions

On the basis of the drawbacks of the current RS authors of the article suggested additional functionality to the social network, namely, recommender system with

management possibility. In order to implement such additional functionality to the social network, the following elements of a new method were proposed and presented in this article: (1) metamodel of the recommendation; (2) algorithm of leverage coefficients-based recommendations formation; (3) algorithm of leverage coefficients-based recommendations interpretation.

The particularity of the recommendations formed with the proposed algorithm is that these recommendations are based on leverage coefficients – this feature allows one to define the most suitable level of flexibility and personalization. Such recommendations provide proper additional information to the particular user. The recommendation is stored in the system's Repository as a composition of atomic elements – this feature enables the analysis and modification of recommendations, avoiding flexibility and personalization problems that are a very common problem in others recommendation systems. The modification of recommendations is performed by changing the parameters of elements of recommendation.

The proposed algorithm of leverage coefficients-based recommendations formation was implemented in the prototype of recommender management system. Compared to the manual formation of recommendations (when the expert has to write all the program code for the recommendation) the proposed RS reduces time costs of recommendations formation and maintenance, moreover, it reduces the number of human mistakes. A part of manual work is reduced to the definition of the elements of recommendations and the calculations are assigned to the RS (calculation of leverage coefficients values, data selection etc.).

9 Future works

For the future it is planned to expand the prototype of the recommender system, based-on leverage coefficients; also to optimize the time of formation and interpretation of recommendations.

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A New Care Concept - Making Collaborative Home Care Work

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Abstract. In this paper we discuss the fact that more and more patients are treated in their homes by a set of organizations, sometimes with different ownership, we explore how this poses new and heavy demands on health care and home service staff to communicate and to collaborate. We investigate the need for improved communication and collaboration on different managerial and operational levels. In particular we point to the need for managers in different organizations to agree on ways of communicating and collaborating between the operational level and the importance of this during procurement of home care services. As a result the paper suggests a number of methodological measures, strategies and IT solutions, to support organizational development, coordination and collaboration.

Keywords: Collaboration, communication, home care, home health care, social care, IT support, management.

1 Introduction

Health care in Sweden is currently in a phase of great change. One important change is that more and more patients are treated and taken care of in their own homes instead of in hospitals. This includes also severely ill patients, for whom several different professions from health and social care may be involved in the care process. In order for the patient to get good total care, this poses essential demands on collaboration, cooperation and coordination among the involved care givers. The situation is complicated by the fact that different actors involved may have different frames of reference for communication, since they belong to different professions and

often also to different organizational units, sometimes with different owners, for instance private, county councils or municipalities.

In a previous paper [1], we accounted for an investigation among two Swedish communities, Stockholm and Umeå. The results indicated that there are indeed problems, when it comes to inter-organizational communication and cooperation in home health and social care. Most of these problems are due to lack of communication among the various units and individuals involved. In two subsequent papers [2, 3] we have analyzed the requirements this poses for collaboration and coordination. The findings stress a need for collaboration among managers, at strategic and tactical levels, and staff at the operational level, to facilitate and ensure a high-quality care for the patient. In particular, it found that managers from different organizations needed to collaborate more effectively in order to set up goals and routines for collaboration at an operational level. In addition, it showed that collaboration also has to be taken into account during procurement of health care and home services.

The aim of this paper is, in an explorative manner, further to study the need for collaboration between different health care and home service units and professions, in order to suggest organizational and/or IT-based solutions, based on a patient and process oriented perspective.

This involves:

- understanding, holistically, the forces influencing how a collaborative care process must work;
- identifying a need for new ways of working;
- allocating and accepting, differents types of responsibility in the patient´s care-process;
- suggesting change in information support including medical records as well as information related to planning and administration of care activities. The support needs in some parts of the process to be mobile (as many of the care professionals are moving to and from the homes where care is carried out).

Arguments are grounded in previous research and development in which the authors have been involved [4, 5, 6, 7, 8]. This background is complemented by the authors' own long experience as nurse in various operational and management functions within hospitals, primary care and in home health care, as well as with organizational and IT development for health care.

In the following we define how we use certain terms in this paper.,

- **patient care process** - the sequence of treatments and other activities, performed by health care or social care personnel for the patient, and in which the patient and often his relatives participate.
- **home health care** that can involve:
    - ***basic health care*** **-** provided by nurses and/ or nurse auxiliaries, and is in many cases, the responsibility of municipalities, but can also be outsourced to primary care units run by the county councils.
    - ***advanced health care*** – lead by doctors and provided by teams of doctors, nurses and other staff, and operated by the county

councils. This care often concerns severely ill children or patients in palliative care.

- **social care:** personal care that involves help with cleaning, shopping, providing food etc, and other care that may physically support the patient, such as help with outdoor activities or personal hygiene. This is in Sweden, the responsibility of the municipality and may in some places be provided by one of their own units, or by a private company that has a contract with the municipality.

To these 'definitions' we would like to add the "**new care concept**" to denote a setup of care services performed by a set of care providing units. This new concept employs a holistic view of the health and social care given to a patient, such that the patient perceives no border between different care giving units. The new care concept comprises a coherent set of activities, aimed at meeting the needs of a group of patients and in each case also adapted to the individual patient's (and close relatives') need. Structured collaboration between units providing care is a prerequisite. The new care concept improves upon existing procedures, routines and rules for communicating and coordinating activities, in order to achieve a better collaboration. The "new care concept" must be based on a clearly stated care strategy, and define how care should be conducted collaboratively and in the best interest of the patient.

For every single patient, a care plan should be laid out with clearly formulated goals. Ideally goals should be connected to plans for actions to achieve the goals, and also consider effects of chosen actions on economy (the units and also what lack of quality caused by the wrong or not adequate actions might cost), and on the staff's working environment. The responsibility for coordination and collaboration should be identified and distributed among the different actors taking part in the care activities. One of the largest problems is how to clarify the tasks, and recognise how different types of competence and different units can work collaboratively in the various activities of the patient process. Clarifying and explaining the "new care concept" for both care personnel and patients and their relatives is therefore important.

The rest of the paper is structured in the following way: The next section discusses briefly the notion of collaboration and the various forces influencing collaboration. It will also account for some related research. Section 3 discusses a need for communication and collaboration on different managerial and operational levels. In Section 4, we discuss the need for strategies or goals, methodological, organizational, and informational support that will be needed to support collaboration in health care at home. Finally, in Section 5 a few concluding remarks will be given. For simplicity, we use, where needed, "he" and "his" to refer to the patient, although he may be of either sex.

2 Collaborative home care

Two or more parties collaborate when they work together in order to achieve a mutual goal, i.e. perform a task that each one cannot cope with alone, or at least not as well, or at as low a cost. This implies that all parties in each particular case must reach a common goal statement through a consensus creating sub process. Usually a synchronous communication session is needed. The different parties have to

understand the basic circumstances, demands, and restrictions that the others face. For each patient group, the sub process can be supported by a typical care program, which requires that each party must be clear about how the work procedures and tasks are distributed. This care program can then be adapted to the individual patient and the needs and goals that are defined in the particular case.

Thus, collaboration between organizations is a complex matter, and existing research has focused on a wide variety of competing aspects. In research concerning collaboration within health care, Baum and van Eyk [9] studied what they name as interagency collaboration. Hudson [10] has studied joint commissioning across the primary health care-social care boundary in the UK. El-Ansari et al. [11] have focused on public health nurses' perspectives on collaborative partnerships in South Africa. El-Ansari et al. [12] investigated collaboration and partnership and the problems with measuring collaborative outcome. Lichtenstein et al. [13] have studied the effect status difference has on individual members in cross-functional teams. In [14], Åhlfeldt and Söderström stress the need for coordination in cross-border health care planning. However, few of these studies have focused on mobile health care at home and its specific needs.

It is also possible to find some research in the field of mobile work and information processing. In the health care area, Ammenwerth at al. [15] explore how mobile artifacts can be used for information processing in a hospital. Pascoe [16] describes how mobile artifacts increase the amount and speed of data being recorded out in the field; Najjar et al. [17] describe how wearable computers might increase the performance of quality assurance inspectors. Guerlain et al. [18] write about personal information systems for roving industrial field operators, and Heath and Luff [19] examine the ways in which mobility is critical for collaborative work.

Fig. 1 depicts some of the forces and stakeholders that influence how collaborative care should, and could work, and hence how the "new care concept" ought to be designed. Each of these stakeholders has its own needs and requirements that need to be taken into account and when necessary relaxed such as to arrive at a reasonable compromise that meets most requirements, at the same time as it focuses on the best interest of the patient.

It is obvious that different collaborating parties have different responsibilities and demands, as well as different aims and preconceptions about the collaboration. For collaboration to work, the parties have to communicate:

- over a distance, i.e. if the communicating parties are at different locations and have to use some kind of tool to bridge that distance, or
- over time, i.e. a place (a database) is needed, where information can be stored at one time and picked up and read at a later time.

When several parties collaborate, it is often difficult to formulate one single objective, since each organization has its own goals. It is, however, important that all involved are aware of the overall purpose of the work around an individual patient, and make sure that this is in accordance with their own (organizational) and with the patient's goals.

A simple case of collaboration is when a doctor in primary care needs to consult a specialist in a hospital. A less simple case is when a patient's problem and its treatment require many units and individuals to be involved.

An even more complicated case arises when several care units and professions are involved and when the patient suffers from several diseases. This kind of situation is not uncommon, for example, in palliative care where patients often have multiple needs. The last case is what this paper is about.

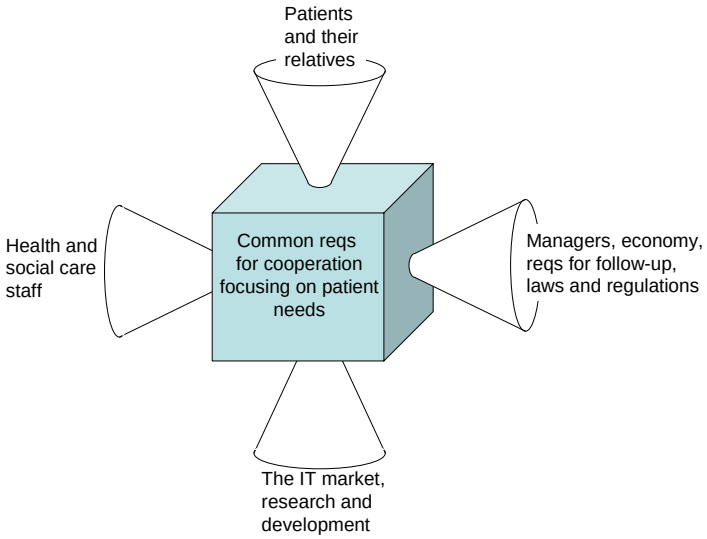

Fig.1. Stakeholders influencing collaborative care.

To conclude, cooperation between different health and social care units, as well as with patients and their relatives, is crucial for achieving good quality patientcare, and also to make the total utilization of resources as efficient as possible. It should also be stressed that the patient himself, and his relatives, are part of that cooperation.

3 Collaborating on different organizational levels

Collaboration among staff providing care takes place at a top management, a middle management and at the operational level. These levels exist within all health care and social care at home service organizations. Thus, there are often several organizations and organizational levels, each one responsible for its part of the total care provided for the patient. Cooperation can hence be understood both from a strategic/tactical and from an operational perspective. Fig. 2 shows the 7 different paths of cooperation that we have identified**.** It also shows where both vertical and horizontal intra and inter organizational coordination is needed, which is in line with complex organizations' continuous needs for both specialization and integration stressing the importance for coordination [20]. More specifically communication and/or collaboration is needed or desired (cf. Fig. 2):

1. Among top managers, to agree on shared strategies for health and social care, common goals and objectives, and a general level of collaboration.

2. Between top and middle management in the same organization. Top managers need to agree on strategy and policy for distribution of responsibility. The middle management level needs to agree on routines and policy for how cooperation is to be achieved.
3. Among middle managers in different organizations in order to design collaboration structures between procurer and producer, and in order to agree on terms for the delivery of care services.
4. Between managers and the operational staff. Knowledge of strategy, policy and routines need to be conveyed to the care personnel.
5. Among operational staff: Those who work with patients need to inform others about treatments and other activities that have been carried out, and about changes in plans, or in the patient's situation etc.
    a. Between different individuals and professions at the operational level within the same unit.
    b. Between different individuals and professions in different units. These staff needs to be able to coordinate health and social care, both from an immediate and a long term perspective.
6. Between care personnel and the patient and his relatives. Care staff needs to inform the patient and their relatives about plans, both in a short and a long term perspective, as well as of changes to the plans.
7. Between patients and relatives, for example, in supportive patient's associations. They can help the patient and his/her relatives understand the illness, its treatment, its consequences, and how it is possible to live with it.

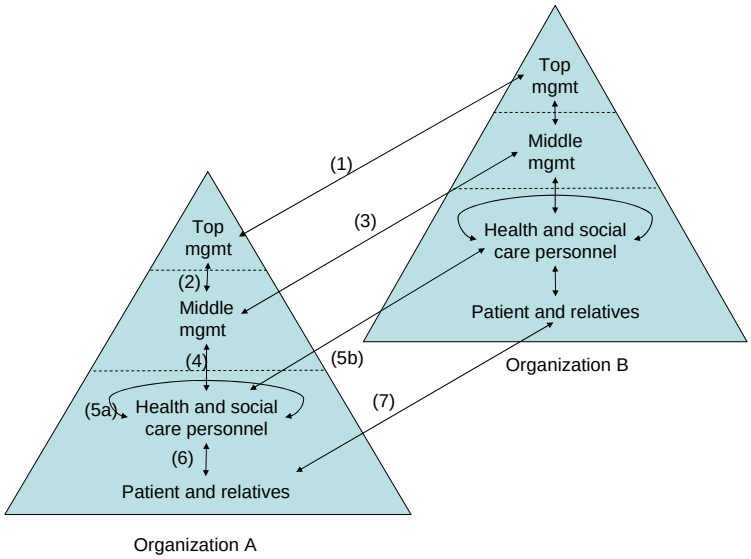

Fig. 2. "Levels" of cooperation in home care.

As mentioned earlier, collaboration may also take place among people from different units, for example, health care personnel from a health care unit that needs to

collaborate with personnel from the municipal home service (5b in Fig. 1) and staff from primary care. This also suggests that there has to be a working communication of policies and guidelines from their respective managers (4 in Fig. 1). Managers in both organizations need to decide how they want to organize this cooperation, and how it will be accomplished at an operational level.

Managers of today are more aware of the need for an information infrastructure. They are, hence, aware of the need for more knowledge when it comes to what kind of information they need, and how information can be made available, in order to bring about an effective communication around, and with, the patient. It is an every day occurrence that different parties are responsible for different tasks, and therefore responsible for different sub-goals of the overall goal. The main organizational problem is therefore to get both parties to agree on a holistic view of the care process, the different stakeholders roles, tasks, and restrictions.

A patient having health care at home usually meets a set of people, perhaps from different care providing organizations, and their perception is that they are working as a team.

However, these teams are seldom formally set up, but simply appear as a result of different organizations taking on different duties. Often the various actors around a patient have very limited knowledge of which other organizations, individuals and professions are involved in his care. Sometimes they meet in the patient's home, and because of that, may acquire knowledge of each others existence and roles. In other words, there is usually not much organized collaboration between people from different organizations, which makes it difficult to arrange effective collaboration that centers on the patient's needs and well-being.

4 Need for organizational development and IT support

For IT support to work, it is necessary for various people involved in providing care for a patient to have a reasonably common understanding of the meaning of terms and concepts they have to communicate. Unclear or ambiguous concepts are a problem in the whole health care sector. Here, like in other parts of society, it is not rare that even the most central terms are understood differently among different stakeholders. We believe that, to a certain extent this is something one has to accept and learn to live with, but at least we need to be aware of it. In this context it is, however, desirable to agree at least on terms and concepts that concern collaboration. The models, primarily information models, that have been developed in the projects InterCare [4, 5], Sams [6, 7] and MobiSams [8] are important contributions to this issue. These models build on a process that describes important information exchanges around the patient, regardless of which organization is responsible for the information. Based on these models, we also need to develop a new set of communicating communication services related to the different parts of the patient oriented process in such a way that all parts of the process can be kept together.

All involved should have access to the Internet by means of the usual tools (such as web browsers and e-mail). In addition to this, one may add 'synchronous and asynchronous tele conferencing tools' that may help people to meet or consult with each other without having to travel physically. It is necessary that all involved get an

understanding for each other's tasks. This can be accomplished by providing regular training, meetings, and workshops that gather representatives on different levels and of different organizations.

In the following we will provide a brief discussion of what types of more specific support that may be needed at each level.

4.1 Top management

Top management will need to physically meet in order to get to know each other, and to discuss informally what is needed in order to bring about fruitful collaboration. They have to set up goals, strategies, policies and restrictions for their respective responsibility for the collaboration in health care and social care.

In order to clearly state goals and policies, methodological help, such as modeling sessions lead by skilled facilitators, is often needed. Suitable templates may be set up to formulate the goals and policies. Various other means, such as disseminating learning materials among those concerned, could also be used.

To achieve collaboration and coordination it is important to jointly achieve a common mental model over the core problem, and the optimal core process on all levels. In addition, one should agree on an agenda for implementing and adjusting the optimal care process to suit all stakeholders, including the most important – the patient. It is the responsibility of top management to ensure that such a common mental model is achieved.

It would, also be advantageous if representatives for middle management and operational staff could take part in these meetings. In addition they all would utilize the normal kinds of communication media such as telephone, fax and e-mail. "Meetings" may also be organized by means of synchronous and asynchronous conferencing systems.

4.2 Top to middle management

Overall goals and requirements need to be conveyed to, and agreed among middle management. Requirements have to be further refined so that demands for routines, methods, templates and other tools are clarified.

To achieve this, the top and middle management need to meet. Help from requirements experts, as well as methodological support, such as various tools for modeling, designing and describing routines and processes, can aid in this process.

4.3 Middle management to middle management

Routines, methods, and templates have to be developed for ways to:

- state and express quality requirements. Devising protocols and methods for measuring quality in every day practice, which will become part of the normal way of working.
- plan on how to take collaboration into account during procurement. For this to work, both procurer and producer need to agree.
- design routines for collaboration and, in that context, how to utilize IT support for communication and collaboration between units on an operational level.

For this the managers will need some aid from experts as well as from various tools for modeling, designing and describing routines and processes.

4.4 Management to operational staff

Methodological support is needed for managers and operational level experts, to help them build the necessary routines for how to collaborate on an operational level. They also need means to disseminate decisions, to implement routines, and to help operational staff understand how they should best utilize communication, coordination and collaboration tools.

4.5 Between operational staff within same organization or in different organizations

The new ways of working should be described in process and conceptual models, which will also function as the basis for building the IT support. The MobiSams project had the intention to clarify the patient's own process, i.e. on one hand how it functions today and how the patient experiences it, but also how it would appear, should the suggested new ways of working and the IT tools be functioning.

The research projects Sams, Intercare and MobiSams have resulted in explicit knowledge on how improved and patient-centered collaboration among care providers can be accomplished. The improvements build partly on an enhanced way of working, and partly on a utilization of IT support aimed at strengthening collaboration.

The IT support developed in MobiSams comprises a set of services that are well defined and built for communication. They are able to exchange information in a structured way.

The services presently available concern:

1. Planning and coordination of the patient care process as a whole, including formulation of goals and objectives.
2. Allocation of tasks and resources. Clarification of the personal responsibility for achieving goals and objectives for each task. How goal fulfillment should be measured.
3. Planning and registration of the result from the care activities.
4. Registration of undertaken care activities. This should be done in such a way that goal fulfillment can be measured.
5. Follow up and evaluation of the care process

The MobiSams project has implemented these tools in a 'test-bed', where they can be tested together with new ICT techniques, such as mobile and handheld devices. The project and 'test-bed' were set up to facilitate learning, while developing the "new care concept" as an enterprise, including the ways of utilizing IT. Organizations and individuals that possessed knowledge about adequate platforms, architecture, networks and mobility technique suitable for making the applications useful in the care process participated in the work with the 'test-bed'.

It has also proved to be very useful to have web-based knowledge management tools, [21] for expert doctors and nurses to share knowledge and experience with field workers in home health care.

4.6 Between operational staff and patient/relatives

First of all, the patient and/or his relatives should have access to his own care plan and diary. To some extent the patient also ought to have access to his own medical record. Exactly what information, if any, the patient should be authorized to see, or possibly change, might be decided in each separate case, provided this does not lead to too much administration.

Tele conferencing tools for communication between patient and care giver has a great potential for reducing the number of patient visits to primary care or hospital and to make patients and relatives feel more safe [22].

Last, but not least, useful information for interested patients can be disseminated via the web. This can take place on the initiative of particular clinics or patient organizations, such as American Diabetes Association (see e.g. http://www.diabetes.org/home.jsp). These associations also provide tools for patients to monitor themselves and their disease.

4.7 Among patients/relatives

As mentioned above, patients' organizations can play an important role in spreading knowledge and experience among patients and their relatives. This can be achieved either by the web or by means of other physical or electronic channels. They may also provide fora where patients can meet to share experience. Nowadays there are also private "blogs" where particular patients or e.g. relatives of severely ill children share their feelings.

5 Conclusion

In this paper, we have discussed how more and more patients are treated in their home by a set of people from different organizations and how this puts new and complex demands on the communication and collaboration among health care and home service staff. We have further discussed the need for communication, collaboration and coordination on different organizational (managerial and operational) levels. In particular we have pointed out the need for organizational development and for IT support. More precisely we suggest that:

- there is a need for both methodological and IT-related support for managers. Managers on different organizational levels need to formulate and refine goals for collaboration and design work routines for collaboration when it comes to procurement of health and social care services, as well as for collaboration at the operational level.
- video and teleconferencing may be useful for this collaboration, both between managers and operational personnel, and for communication between patients or their relatives and healthcare staff.
- there is also a strong need for specialized software services to support collaboration and coordination at the operational level along the patient care process. This software has to provide both access to medical information for those that are authorized, and administrative support to help coordinate the daily work of health and social care personnel.

We need, however, to delve deeper into the precise requirements for this methodological and IT-related support at various levels. Among the primary issues that remain to be addressed in depth is how to define and measure quality requirements when it comes to health and social care.

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User Profiles and User Requirements in Mobile Services

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Abstract. The ongoing mobile revolution has dramatically changed our business and daily lifestyles. This paper analyzes user profiles and user requirements in mobile services in order to develop value-added services that meet users' needs and expectations. In this paper, a number of classifications of mobile services are presented and discussed. The heterogeneous user groups and their characteristics are analyzed. The discussion and analysis provides a stable ground for an innovative mobile service onion model which describes the relationships between mobile service categories, user groups, and their requirements. In order to prioritize and translate user requirements, a case study was carried out by using Quality Function Deployment (QFD) to analyze user requirements of senior citizens in mobile services. This paper contributes to the understanding of user profiles and user requirements in value-added mobile services in today's dynamic business environment.

Keywords: user profile, requirement, mobile service model, QFD

1 Introduction

Mobile service is defined as "A radio communication service between mobile and land stations, or between mobile stations." [1]. However, this definition doesn't fully capture the unique characteristics of next generation multimedia mobile services with wireless Internet connections. The increased number of mobile phone users has allowed for a growing variety of value-added services. In the past, telephones allowed for basic voice-based communication. Nowadays, with numerous individual value-added mobile applications, the mobile service providers are attempting to enter this growing value-added service market. Users are the basis for any new service adoption and diffusion. Their requirements for next generation mobile services shall not be ignored. The concept of mobile service shall take into account the expectations of its end users. Therefore, a more appropriate definition of mobile service would be *a service that is available through mobile radio access at anytime and anywhere possibly through heterogeneous mobile devices*. In this definition the keywords *anytime*, *anywhere* and *heterogeneous mobile devices* represent the demanding user requirements for next generation mobile services.

In order to develop mobile services that meet uses' needs and expected value, we have to study users' attitudes towards adopting electronic media and factors that influence their attitudes and value perceptions about mobile services and their requirements [2]. User satisfaction is the underlying meaning for quality in mobile services. Therefore, in this paper, users and their expectations for different groups of mobile service are analyzed. An innovative mobile service model is proposed to classify and analyze users and their requirements. The service model and user analysis are used as a basis in a case study to further elicit and translate user requirements of senior citizens for using mobile services. The Quality Function Deployment (QFD) method is applied in the case study.

2 Mobile Services

The explosive growth of penetration and usage of mobile phones means that the scene is set for the widespread adoption of innovative mobile services [3]. As more and more mobile services are available to end users, it is necessary to categorize the services and study how they meet the users' needs.

In general, mobile services can be classified according to the major stages in the development of mobile communications and the service capacity, which are commonly described as generations. First generation (1G) networks were implemented in 1984 by providing analog voice services. Second generation (2G) networks were implemented in 1991 by providing digital voice services and short messages. Third generation (3G) networks were designed from year 1990 and implemented in 2000. 3G services are high capacity, broadband data services up to 2Mbps. Fourth generation (4G) mobile services were designed from year 2000 and the full implementation will be in a few years. 4G mobile services include enhanced multimedia and enhanced roaming services with data rate up to 100Mbps typically. As the digital communication infrastructure is enhancing, and the new services are always provided in line with the latest technology and infrastructure, it is hard to apply the stage-based classification to analyze users'needs.

Besides the different generations of mobile services, Balasubramanian *et al.* [3] developed a model to categorize mobile business value-added services. The categorization is along three dimensions: location (sensitive or insensitive), time (critical or non-critical), and application controller (receiver or provider). Each dimension has two values. The combination of each value forms the eight service categories (2×2×2=8). The categorization analyzes different situational contexts to use a variety of mobile services. It provides a theoretical background to conceptualize and predict mobile services, but does not relate the services with different user groups and analyze their satisfaction.

Moreover, Bouwman [4] classified mobile services into different categories based on the contents of the services: Mobile entertainment services, Mobile tracking & tracing services, Mobile community services, Mobile presence and instant messaging services, Business to employee services, and Mobile payment services. Some other researchers provide similar classification from the viewpoint of service providers, i.e.

operators or service developers [e.g. 5, 6]. A list of mainstream services is shown in Fig. 1.

Fig.1. Mainstream mobile services (modified from [6]).

Among these mainstream mobile services, the mobile services extends from the basic ones, e.g. simple call or SMS service, to more complicated and value added ones, e.g. mobile commerce or advertising. On the other hand, consumers' willingness to adopt and pay for a complicated and value added mobile service declines [6]. So there is a clear mismatch between the introduction of new mobile services and consumers' willingness to adopt, accept, and use these services. The situation is even worse in the 3G era because there is an obvious shortage of "killer services" which make use of high speed 3G networks and infrastructures. How to convince people to upgrade to 3G systems is therefore a challenging task.

As the mobile users form a heterogeneous group including people in different ages, genders, personalities, education backgrounds, incoming levels, careers, personal interests, and life routines, it is hard to let them all accept every new mobile service. It is necessary to divide them into different groups, investigate factors that predict or explain adoption, acceptance, and use of mobile services, and study their willingness to pay for the different services [7, 8, 9]. Therefore, we need to further study the market segmentation of mobile services. Besides the exiting categorization of mobile services, we shall take users' viewpoint into account, analyze the requirements for different user groups, and match the distinct user groups to an appropriate service category. It can alleviate the mismatch problem between introduction of new mobile services and people's willingness to adopt and pay for a mobile service.

3 A Mobile Service Classification Model for User Analysis

As discussed in the prior section, existing mobile service categorizations focus more on the technical dimensions of the services. Technological advances and service availability do not automatically lead to widespread acceptance and adoption [10, 11]. In order to elicit requirements to develop the mobile applications that meet customers' satisfaction, we have to shift our attention to the characteristics of their users. More specifically, mobile users are the subject, and their communication modes and their

interaction via mobile services drive the classification. That is to say, the mobile service classification model is built from the users' viewpoint rather than from the service provider's viewpoint. Analyzing the cardinality of communication between end users, we divide the services into three categories: one-to-one communication, individual data services, and many-to-many communication.

- *One-to-one communication* refers to the services consumed between two individuals. As a mobile phone is originally used as a device to transmit voice communication, it is a basic communication model commonly accepted by end users. According to the meanings of communication, services under this category can be further divided into the voice-based and the data-based. The former one includes Call and Push To Talk (PTT), while the latter one includes Short Message Services (SMS), Multimedia Message Services (MMS), Wireless Instance Messaging, email, etc.
- *Individual data service* provides a wireless access to an assortment of data services using a mobile device. It is also called mobile data service [12]. Services under this category have no direct communication channel built between end users. In this service category, the individual ones can either manage their personal information or contents or consume the services from a fixed professional service provider, such as mobile network operators. With high levels of mobile device penetration, the device becomes a social tool providing more value to people's daily life. The service provider can either send the information to a single user or broadcast it to a number of users, but the user uses the service without communicating with other end users. Such service may include commercial SMS and MMS services, digital contents downloading, ticket reservations, stock trading, navigation, and so on. According to the contents of the service, the individual data service can be further divided into personal information management (PIM), content service (e.g. music, graphics, video, game, book, etc.), transaction service (e.g. Banking, brokerage, shopping, auction, reservation, etc.), and information service (e.g. News, city guide, traffic, weather, catalog, navigation, etc.).
- *Many-to-many communication* is an emergent service that enables groups of people to communicate with many others. Nowadays, there are virtual communities that allow a group of people interact via the Internet. The mobile technology together with the wireless Internet connections further enhances such communities to be mobile. In addition to the one-to-one communication and individual data services, the communication between consumers becomes one to many and many to many, which we generally regard as a sort of many-to-many communication. A typical example is the Chat service which allows users to talk (voice-based or text-based) socially with others. According to the context of the communication, the many-to-many communication can be further distinguished between business community and entertainment community. Services under each community may have different focuses. The business community services are more like a mobile groupware tool that supports communication, cooperation, and collaboration of a group of people who work on the same subject, such as the open source communities. The service on shared calendar, contacts, or other contents is

normally emphasized, and the conference call is a must. The entertainment community services provide more support for social communication and entertainment.

These categories are not mutually exclusive. Services within a category can support services in another. A new service may be stemmed from the basic services such as Call or SMS. For example, the Conference call or Voice chatting is based on the basic Voice Call in one-to-one communication; the Transaction, Information, or Content services in individual data services embed the services such as SMS or MMS; the shared PIM is of course using the services of PIM.

4 User Analysis

Requirements are usually elicited from heterogeneous groups of stakeholders [13, 14]. Take the mobile service into account, operators, manufacturers, the third-party software and service vendors, and the end users are all valuable resources for requirements. As a mobile phone is a multipurpose device, different end user groups may be interested in only a part of services available. The different stakeholder groups represent distinct goals and express the requirements for a device and its application. They not only interact with the services, but also cooperate and negotiate with each other to provide their needs and wants. For example, operators work closely with mobile device makers and software developers to match their device portfolios to heterogeneous end users, such as teenagers, families, business travelers, and other key market segments. It is challenging and topical to explore the characteristics of heterogeneous stakeholders to identify potential predictors of further adoption and, eventually, mass acceptance of mobile services. In the following, we only focus on the mobile end users to analyze their characteristics, interests, needs, and characteristics.

4.1 User Profiles

Some research has addressed and verified that age, gender, education, and income are relevant factors in terms of mobile services adoption [9, 12, 15]. They are discrete perspectives that affect the consumers' attitudes and adoption to mobile services. For example, the oldest age group typically has lower willingness to use mobile services than any other groups, especially the youngest ones [12, 16]. Women show a higher willingness to user mobile service such as tickets reservation, while men show a significantly higher willingness to use mobile services for stock trading, remote control of home appliance, playing online games, etc [16]. Well-educated or high-income users are more likely to use mobile services [12].

Besides the discrete factors, user groups which have the common interests and attitudes toward the mobile value are another important perspective worth analyzing. Moreover, end users may take different roles and interact differently with mobile services in a variety of situational contexts, e.g. at home or in work. It is hard to

divide them into groups. To simplify our analysis, we distinguish the basic four groups of user roles rather than individuals: *ordinary users, business users, young/fashion explorers, and technology fans.* As an end user, he could be a business user in the work, an ordinary user after work, and a technology fan during his vacation. By taking different roles, he has different attitudes towards the adoption and use of mobile services. The characteristics, major value, attitude, and major interests of each user group is analyzed and summarized as user profiles in Table 1.

Table 1. User profiles of mobile services.

User group	Generic Characteristics	Major value	Attitudes	Major interests
Ordinary users	Personal safety, family-centered	Basic communication utility, cost-effectiveness	Concern about reliability, ease-of-use, control	Communicate with family members and friends
Business users	High income, time- and value-oriented	Efficiency and effectiveness, time saving, value function	Concern about reliability, security, ease-of-use	Communication with colleagues and cooperators
Trend-setters	15-25 years old, social and emotional, chasing fashion	Numerous appealing designs, features and functions, Brand	Excitement	Virtual communities, various entertainment, and digital contents
Tech-nology fans	Well-educated, high income, chasing high tech products and services	High tech support, innovative, high quality facilities	Excitement, Optimistically adopt new technologies, flaunt new features	Digital contents, virtual communities

- *Ordinary users* regard the mobile device as a simple communication tool, and expect that it is reliable to contact their family members and friends. Therefore, they would like to keep things simple, and lack motivation and enthusiasms to adopt new services in their daily routine. Quality and price are the basic criteria for service selection and adoption. Senior citizens to be analyzed in our case study in section 5 fall into this category.
- *Business users* rely on technology to increase their work efficiency and effectiveness. They are normally busy and switch between different tasks at the same time. They are eager to adopt a handy service to manage their personal information, to access the corporate information, and to efficiently do daily activities such as banking, travel reservation, routing and tracking, etc.
- *Trend-setters* refer to the 15-25 year old population who are social, open, and interested in different fashions and new experiences. They regard mobile phones and the services as a fashion object of totemic value, and decorate and customise their phones and the services to reflect their personality. Fast and easy access to entertainment is always appealing to them [17].

– *Technology fans* are attracted by innovations and new technologies, and would like to adapt themselves to the new things in their daily lives. The same as trend-setters, they like to meet different people and share experiences with others. However, most technology fans are well educated and have reasonable incomings.

4.2 Generic User Requirements

Before mapping the users groups with user requirements, it is necessary to study the generic user requirements.

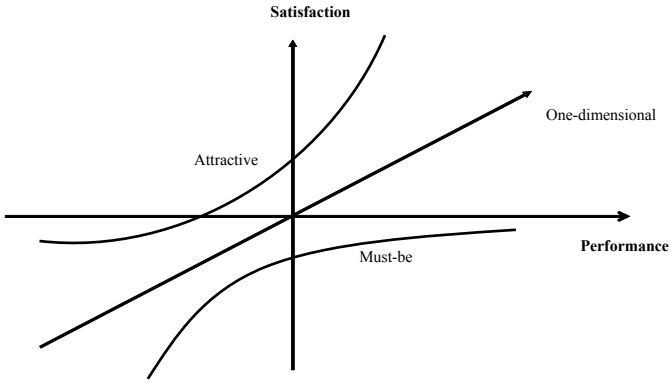

Fig.2. The Kano model.

Professor Kano and other researchers [18, 19, 20, 21] developed a diagram for characterizing user needs. This diagram can be easily applied in the mobile service domain to distinguish different types of user requirements. As shown in Fig. 2, the model divides products or services features into three distinct categories, and each of which affects users in a different way.

– *One-dimensional attributes* These attributes result in user satisfaction when fulfilled and dissatisfaction when not fulfilled. The better the attributes are, the more the user likes them. For example, the battery life for mobile phones is such an attribute. The longer the battery life, the more users like it.

– *Attractive attributes* Their absence does not cause dissatisfaction because they are not expected by end users and users are unaware of what they are missing. However, strong achievement in these attributes delights the user. For example, a high resolution camera phone will delight users for the camera function. A better resolution and a larger memory will always delight users more.

– *Must-be attributes*: Users take them for granted when fulfilled. However, if the product or service does not meet the need sufficiently, the user becomes very dissatisfied. For example, it is intolerable if a mobile phone is not able to send and receive SMS. Therefore the ability to send and receive SMS is a must-be attribute.

The Kano model is useful in guiding design and development of mobile services. The end user requirements can be grouped according to the Kano model. Designers and developers can therefore concentrate on one-dimensional and must-be attributes in case of time and resource limit.

The four user groups also have different concerns about the three categories of requirements in the Kano model. *Must-be attributes* in the Kano model are a must for all the four user groups. Ordinary users basically only care about the *must-be attributes*. Business users will care about the *one-dimensional attributes, e.g.,* the longer the battery life of a mobile phone the happier these business users will feel. Trend-setters and technology fans will show more interest on the *attractive attributes* in mobile services, *e.g.*, a camera mobile phone will delight users for the automatic flashlight function.

We need to look into user requirements of mobile services because meeting user requirements or human needs are the one of the most important criteria for quality in mobile services. A high quality mobile service means the service will meet or exceed the user expectations. The basic human needs were identified by Maslow [22]. Based on the Maslow's hierarchy of human needs, Krisler *et al.* [23] grouped the user requirements for mobile services into six focus areas: safety, belonging, control, privacy, self-actualization, and human capability augmentation. These requirements are from a user perspective.

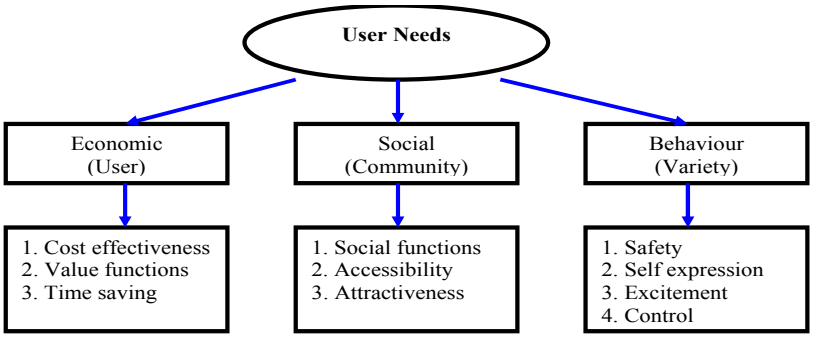

Fig. 3. User requirements for mobile services from a socio-cultural perspective.

Besides, usability is another important perspective that is concerned by end users [24]. It includes a variety of user needs such as smooth user interaction with the service, the experiences on using services, easy and timely access to needed information, and so on. Some authors argued that instead of from a technical perspective it is necessary to examine user requirements from a socio-cultural perspective because the focus on technology is usually disappointing for developers and researchers [25]. Therefore, instead of the above mentioned focus areas from a user perspective, the generic user requirements can be grouped into three categories from a socio-cultural perspective, i.e. *economic* need, *social* need, and *behavioural* need. Each of the categories can be further divided into more detailed user needs (see Fig. 3). *Economic* users focus on the economic perspective of mobile services. They

concern the features such as *cost effectiveness*, *value functions*, *time saving* etc. *Social* users regard the community perspective as their needs. *Social functions*, *accessibility* and *attractiveness* are regarded as important values for many-to-many communications such as chatting or mobile virtual games. *Behavioural* users concern a variety needs related to user behaviours, such as *safety feeling, privacy, self expression*, *excitement*, and *control*. For example, *excitement* means that new functions or new services that will delight the user.

However, this is a quite generic classification of user requirements in mobile services. The more specific user requirements will depend on the nature of mobile service itself (e.g. mobile virtual gaming vs. mobile payment) and its target user group (e.g. Trend-setters vs. Business users).

4.3 Target Group of Mobile Services

In order to support requirements elicitation for different mobile services, an innovative mobile service onion model is developed to map the different user groups with user requirements and various mobile services. The onion model combines our discussion on the three mobile service categories, the four user groups, the three generic Kano user requirements, and the three generic user requirements from socio-cultural perspective.

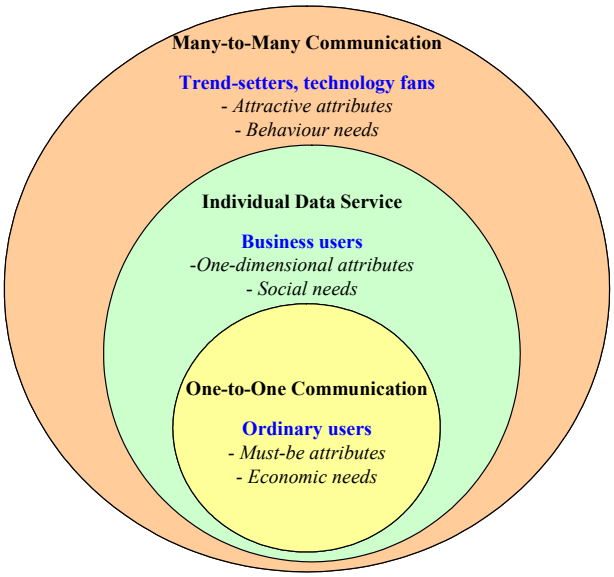

Fig. 4. The mobile service onion model.

As shown in Fig. 4, *One-to-one communication* services are basic and must-be. They are available in every mobile phone, and consumed by every end user. More specifically, they are the major services used by *ordinary users*. The *ordinary users*

may interact with the basic *individual data services* such as PIM and content services, but the cost and the associated value on the cost is their main concern.

Individual data services show one-dimensional attributes of mobile services. It means the better the service is developed, the more customer is satisfied, e.g. the faster data is transferred, the better service is regarded. *Business users* are the representative group to use *individual data services,* such as the mobile transactions and information services that improve the work efficiency and effectiveness. Besides the basic *One-to-one communication,* they might also use *many-to-many communications* for business purpose, such as multi-point conferencing. As such, social needs are dominant for *business users*.

Many-to-many communication services fall into the attractive attribute category. Trend-*setters* and *technology fans* usually are more interested in *many-to-many communication* services such as mobile gaming and virtual community services. They might also be fascinated by some kinds of *individual data services*, and would like to adopt them in their daily routine. They concern more about attractive features and behavioural requirements.

5 Case Study: Analyze Senior Citizens' User Requirement for Mobile Services Using QFD

In the above sections we have analyzed user profiles and user requirements in mobile services. However, how to elicit and analyze user requirements is a challenge. This is particularly true for mobile services because of the different user groups and various user requirements [13, 14]. The purpose of this case study is to give an example of user requirements elicitation and analysis for an ordinary user group: senior citizens. The reason for selecting this ordinary group is that there is a growing need for senior citizens in some countries to use mobile services. For example senior citizens in Finland have motivations to use mobile services for healthcare services due to sparsely populated situation in Finland. In fact in the northern Finland some senior citizens in countryside will have to use mobile services for nursing home purpose. This is also true for Japan where mobile service for healthcare is now a big industry. Therefore senior citizens are chosen as one subclass of the ordinary user group for user requirements analysis.

There are different methods and tools to elicit and analyze user requirements, such as interview, focus groups, brainstorming, protocol analysis, card sorting, prototyping etc [26]. In this section, we will use QFD to do a detailed case study for user requirements elicitation and analysis in mobile services for senior citizens. QFD is a customer-driven tool in implementing TQM [27]. It is an overall concept that provides a means of translating customer requirements into the appropriate technical requirements for each stage of product development and production [28]. QFD is also defined as a quality-based method for increasing customer satisfaction and value with products and services by translating the Voice of Customer (VOC) into design specifications and implementation instructions, ensuring that the organization will carry them out and give customers what they will pay for. Its power lies in the fact

that it lays bare an organization's processes and how these processes interact to create customer satisfaction and profit [29]. The Japanese view QFD as a philosophy that ensures high product quality in the design stage. The aim is to satisfy the customer by ensuring quality at each stage of the product development process [30].

This case study is about user requirements elicitation, analysis and specification for a subclass of ordinary users, more specifically, senior citizens (old people) using mobile services in a smart living environment. In order to identify the user (quality) requirements of senior citizens for mobile services an interview was conducted among three groups.

- *Senior citizens*: The first group is senior citizens. Generally these senior citizens require special care because of their physical features for example muscle strength or walking speed decrease along with aging. Therefore senior citizens may have unique requirements for dedicated mobile services such as "easy-of-use".
- *Family members of senior citizens*: The second group for interview is family members of senior citizens such as siblings, children and grandchildren of senior citizens. These family members were also interviewed for mobile service requirements and they usually have more concerns about the services for example "safety of the mobile services", "cost of the mobile services" etc.
- *Multi-disciplinary experts*: The third group is professional experts from various fields. In our team we have experts from different fields for example architecture, information technology, health care, medical technology, social science etc. There are usually tacit requirements from senior citizens. The multi-disciplinary team ensures that these implied requirements can also be identified by professionals through interview and brainstorming.

In the interview a questionnaire is designed with a list of pre-defined quality requirements to ask interviewees to indicate the importance of the requirements on a 5 scale with 1 meaning the least importance and 5 means the most important requirement. As a result of interviews from the three groups the following eight most important quality requirements for mobile services for senior citizens were identified i.e. *fast speed to handle emergency*, *good tele health care services*, *easy to understand terminology*, *clear menus and texts*, *voice-directed services*, *easy to navigate in services*, *easy to recognize last service*, and *cost effective services*.

Based on the identified quality requirements the multi-disciplinary team further identified eight technical requirements for design and develop mobile services for senior citizens. The identified technical requirements are explained in Table 2.

Table 2. Descriptions of important technical (design) requirements.

No.	Technical requirements	Description
1	Emergency function	Emergency fucntion is for fast emergency handling
2	Good tele health service provider	Tele health services are desired by senior citizens
3	Big mobile device screen	It will help reading and understanding
4	Simple text	The simpler the better for senior citizens
5	Images or moving pictures for navigation	Images can help understanding and navigation in services
6	Speech interface technology	It is used for voice-directed services
7	Reliable and fast network transmission	For secure and realibale mobile services
8	Cheap mobile devices	To be cost effective for senior citizens

In the above table the eight most important technical requirements were identified for mobile services design and development. For example the *emergency function* is a key design requirement for mobile services for senior citizens. In case of emergency there should be an easy-to-operate button or a service function to enable emergency call or alarm to a nearby hospital for fast medical treatment. Therefore *emergency function* belongs to *must-be attributes* in the Kano model. For senior citizens *good tele healthcare provider* is also a must-be attribute. *Big mobile screen, simple text, reliable and fast network transmission,* and *cheap mobile devices* belong to *one-dimensional attributes*. While *images or moving pictures for navigation* and *speech interface technology* are *attractive attributes*. After identification of the eight quality requirements and eight technical requirements the next step is to build the house of quality which is shown in Fig. 5.

To each quality requirement a degree of importance is assigned from 1 to 5 with 5 meaning the most important. The technical requirement importance rating w_j is given by the weighted column sum of each quality requirement by the quantified relationship values of technical requirement i th, formed by substituting 5 points for strongly related requirements, 3 points for medium related requirements, and 1 point for weakly related requirements:

$$w_j = \sum_{i=1}^{m} d_i \times r_{i,j}, \quad (1)$$

Where d_i = degree of importance of quality requirement i th, i = 1,2,...,m; $r_{i,j}$ = quantified relationship between quality requirement i th and technical requirement j th; i = 1,2,...,m; j = 1,2,...,n; w_j = technical importance rating for technical requirement j th, j = 1,2,...,n. In this case the computation of correlation matrix is left out because the technical requirements are not so many and there are weak or no interrelationships between them.

From Fig. 5 we have calculated both absolute importance ranking and relative importance ranking for technical requirements for mobile services. From the results we know the *emergency function* has an absolute ranking of 73 while *good tele health service provider* has a number 52. These are the two most important technical requirements (must-be attributes) for mobile services for senior citizens. For senior citizens they desire fast emergency handling so the first important mobile service is emergency service. Therefore in mobile services we must have such an *emergency function*. The second most important requirement from senior citizens is the providing of good tele health care services. With dedicated mobile devices senior citizens should be able to have remote health care conveniently. The third technical requirement is *speech interface technology*. Basically it will significantly enhance the user experience by using speech interfaces instead of press and click interfaces. This is particularly true for senior citizens for they prefer easy voice-directed services. The fourth requirement is *images or moving pictures for navigation*. This will greatly ease navigation in mobile services. *Big mobile screen* is listed as the fifth requirement

while *reliable and fast network transmission* is sixth technical requirement. The last two technical requirements are *simple text* and *cheap mobile devices*.

Relationships: ■ strong - 5 ◘ medium - 3 ○ weak - 1	**Technical Requirements**	Importance 1-5	Emergency function	Good tele health service provider	Big mobile device screen	Simple text	Images or moving pictures for navigation	Speech interface technology	Reliable and fast network transmission	Cheap mobile devices
Quality Requirements										
Fast speed to handle emergency		5	■					○	◘	
Good tele health care services		4	◘	■	◘	○	○		○	○
Easy to understand terminology		3	○	◘	○		◘			
Clear menus and texts		3	◘	○	◘	○	◘			
Voice-directed services		3	■	◘				■		
Easy to navigate in services		2		○	○	◘	◘	◘		
Easy to recognize last service		3	◘	◘				○		
Cost effective services		1							◘	■
Absolute importance ranking			73	52	26	13	28	29	22	9
Relative importance ranking			1	2	5	7	4	3	6	8

Fig. 5. The house of quality for mobile services for senior citizens.

After specification of user requirements the next step is the real design and development of dedicated mobile services for senior citizens. User requirements verification and management will be needed at late stages.

6 Conclusions and Future Work

Mobile services have become a key priority for many business organizations as mobile phones together with its supported communication infrastructure become widespread used in people's daily lives. It is important to understand end users' attitudes towards the mobile services, and match their needs with a proper service. This paper highlights the importance of setting out from an end user perspective when developing a variety of mobile services. It discusses and analyzes user profiles and user requirements in mobile services. Both generic user requirements and specific user requirements for mobile services are discussed. Taking into account the communication mode existing among mobile end users, the various mobile services are first classified into three groups, i.e. *one-to-one communication, individual data service, and many-to-many communication*. Four different user groups are then identified i.e. *ordinary users, business users, trend-setters,* and *technology fans*. These user groups are analyzed in details in terms of generic characteristics, major

values, attitudes, and major interests. The mobile service classification and the user profiles provide an enriched ground for an innovative mobile service onion model, which is built to describe the relationships among the three mobile service categories, the four user groups and user requirements for mobile services. This model can be used not only to assess whether a specific mobile service is likely to offer value for different user groups, but also to elicit and analyze requirements from different user groups. At the end of the paper, a practical and detailed case study is presented which utilizes QFD to elicit and translate user requirements for senior citizens in mobile services. This paper contributes to both a theoretical understanding of user profiles and user requirements in design and development of value-added mobile services, and a practical study to reflect the theoretical analysis.

Future work includes several case studies to demonstrate the pros and cons of the mobile service triangle model and mobile service classifications. A quantitative approach is also being developed to quantitatively describe and classify user requirements in mobile services.

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