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# Using UML for Modeling Business Processes in an Information and Knowledge Integration Domain

Carlos Alberto Malcher Bastos
Laboratory of lnformation and Communication Technology Management (GTECCOM), Fluminense Federal University
Rua Passo da Pátria 156 B1-D 442, Boa Viagem, Niterói, RJ, CEP 24210-240, Brasil
camalcherbastos@id.uff.br

Mônica Rodrigues Moreira
Laboratory of lnformation and Communication Technology Management (GTECCOM), Fluminense Federal University
Rua Passo da Pátria 156 B1-D 442, Boa Viagem, Niterói, RJ, CEP 24210-240, Brasil
monicarodriguesmoreira@gmail.com

João Marcos Meireles da Silva
Laboratory of lnformation and Communication Technology Management (GTECCOM), Fluminense Federal University
Rua Passo da Pátria 156 B1-D 442, Boa Viagem, Niterói, RJ, CEP 24210-240, Brasil
jmarcos@id.uff.br

José Viterbo Filho
Computing Science Institute, Fluminense Federal University
Rua Passo da Pátria 156 Bl D-442, Boa Viagem, Niterói, RJ CEP 24210-240, Brazil
viterbo@ic.uff.br

Abstract: In this paper, we present the graphical representation of the business modeling project developed for a Brazilian National Land Transportation Agency. We describe briefly an Information Asset identification, Knowledge identification and mapping, information life cycle completion and process description as part of the adopted methodology. We shows the adopted graphical representation and highlights some emerged challenges and how they have been handled. We discuss the advantages of the integrated information – knowledge graphical representation as a tool for business organization management. We argue about the need for an extension of the Unified Modeling Language(UML) towards the creation of business models that systematically Integrates knowledge and information description. Finally, we introduce new ideas on how to facilitate the building and the maintenance of the graphical representation of the models.

Keywords: UML, Information Modeling, Knowledge Modeling, Business Modeling, Systems Development

## 1 INTRODUCTION

A visual model of a business can provide important insights into whether it is doing the right thing and how it might be improved. The Unified Modeling Language (UML) (OMG-UML, 2015), the de facto standard visual modeling notation for the analysis and design of software systems, (Jurjens, 2002), can be used effectively to create such models.

Nowadays, a business company must not rely only on their future vision and its information systems without a strong integration between: Its business future vision, human capital, relevant and reliable information structure, and knowledge management. These business dimensions must be fully integrated and business modeling, including new technologies and methods for information and knowledge management and integration, are highly strategic.

But as the models increases and incorporate other dimensions of a business strategy plan, these models becomes a kind of polluted, complex and hard to maintain.

Once their most valuable set of informations is identified, i.e. Business Information Assets (Ren and Glissmann, 2012; Wareham, 2003; Huang and Ding, 2009), or IA for short, the process of modeling increases complexity. And more complex if information and knowledge área are treated together for full integration.

The Knowledge and Information Management Modeling Project (KIMM Project) was a national demand for the entire business modeling of the Brazilian National Land Transportation Agency (ANTT) and occurred on 2011-2014 period (Bastos 2011). It was a major opportunity to apply the concepts of UML for Business Modeling based on Eriksson-Penker methodology (Eriksson and Penker, 2000, Sparks 2007) along with other methodologies for Information and Knowledge Modeling, and Ontology application (Li and Wang, 2009; Bastos et al., 2013a; Bastos et al., 2011). Their problems were essentially the same for most modern organizations: several different systems with redundant information, difficulties for selecting needs for training staff, spread knowledge for new employees (since the seniors were retiring), and so on.

For this project, many tools were evaluated in order to assess if they met the requirements for modeling each of the four different axes by four different teams: Information Flow team, Business Requirements team, Knowledge team, Ontology team and Transport Experts Team. Many of the tested commercial tools met the needs of all teams, but Enterprise Architect by Sparx Systems was the chosen as the most adequate to integrate all complementary models.

For this large scale business modeling project, and with new concepts being applied, some difficulties emerged that the actual UML version does not fully cover. Although it was possible to model those situations using UML version 2.X concepts (OMG 2011), the number of elements and hyperlinks grew up very fast. Soon, some

new ideas were conceived to facilitate modeling and maintenance.

This paper has two aims. To describe some of the challenges that emerged during the graphical modeling representations using commercial UML based tools and to show the advantages of the integrated information – knowledge graphical representation as a tool for business organization management. We discuss some suggestions for treating such challenges, showing that improvements may be made by extending some concepts described in (Eriksson and Penker, 2000), tackling the complexity of this problem and we also discuss the powerfulness of the representation to the organization management objectives.

This paper is organized as follows: Section 2 describes the KIMM project and its relevance. Section 3 introduces some explanations about the graphical representation of the KIMM and its models. Section 4 indicates how some new ideas could improve the KIMM and Section 5 concludes this paper.

## 2 KIMM – KNOWLEDGE AND INFORMATION MANAGEMENT MODEL

This section briefly introduces the business information and knowledge modeling process, partially published (Rezende et al., 2012; Bastos et al., 2014; Bastos et al., 2013a; Rezende et al., 2013; Bastos et al., 2011; Viterbo et al., 2013).

The Information and Knowledge Management Model was born in 2011 with a demand of a huge challenge from ANTT, the Brazilian National Agency for Terrestrial Transport, which demanded the complete modeling task of their business, informations and knowledge mapping. Some of the reasons that motivated the development of the project can be listed as follow:

- Several existent information systems are independent among each other creating incompatibilities and overlapping;
- Conflicting or redundant information;
- Lack of knowledge about the strategic information assets, its flow, its structure, semantic formalization and related knowledge;
- Lack of information integration among different organizational units;
- Lack of information critical analysis;
- Knowledge is disperse and difficult to access;
- Lack of knowledge about the company's intellectual capital and its location;
- Low information reliability for the decision making process.

In order to solve these questions, a brand new Knowledge and Information Management Model was designed. To build an Information Model (IM) and a Knowledge Model (KM), it is important to start with a research about the organization involved in order to have a good overview about their objectives and functioning. This management model enables the organization to identify other possible practices to be adopted and also other information assets (IA) that can be incorporated into IM and KM model. Based on the identification of IAs, surveys are implemented in order to build models, making use of an iterative approach.

Whenever possible, formal models are built, using a specific tool for modeling that supports the integration of the models and its future implementation.

IM and KM model adopts Enterprise Architect by Sparx Systems in order to transform business vision and strategies into effective changes.

Based on the current situation understanding we plan what we desire for the future and establish the necessary actions for change. The IAs identified in the current situation (as is) are the basis for the following surveys and preparation of models, being one of the integrative elements of IM and KM model.

All IAs identified are analyzed from a systemic view and a proposal for structuring / restructuring them, necessary to fulfill the business requirements can be incorporated into the modeling of the desired situation (to be).

IM and KM models represent a synthesis of the results of various research fields: managing, R&D, production engineering, systems and software engineering, transportation engineering and ontology. So, model integrates different knowledge areas, which are traditionally presented separately in the literature.

To build IM model, the following formal specific models are produced:

1. A Map of Information Flow establishing, at a high level, how the information is handled, considering life cycle of information: we analyze, for each Information Asset, the seven stages taken by information: collection, validation, processing, storage and retrieval, distribution and spreading (Zack, 1999) and gaps to be fulfilled are identified.
2. A model of business requirements that describes the services provided by the organization and the logical model of information (structural view of information) necessary for the performance of these services. The use cases model defines business requirements into an appropriate standard to be met by the development of information systems. And the information model establishes the business objects (information) to be managed by the relevant information systems and specifies the need to share these objects between systems (Kruchten, 2003; Craig, 2005; Benevides, 2010);
3. Ontology Models are also used to structure the Agency information for remove ambiguities, inconsistencies and incompleteness; allow the computer systems creation for decision support using a semantic information basis and define a glossary of terms specifying the meaning and the relationship between them (Guizzardi, 2005).

We emphasize the close relationship between IM and IT Management. To enable the correct storage and use of information is fundamental to get IT support, a set of business support systems developed and or managed by

IT that respects the component models for IM (Viterbo et al., 2013).

For building KM Models, formal models are also produced (Bastos 2011):

1. A knowledge model based on mapping skills, knowledge and professionals, related to IAs processing. Knowledge models identify the forms of knowledge construction and mobilization skills by professionals, relevant to business processes and information flow. KM Model map and represent knowledge / skills / professional, analyze knowledge flow, the steps of collecting and mobilizing knowledge to generate innovation (Sabbag, 2007) and the processes of knowledge conversion (Nonaka and Takeuchi, 1997), supporting the construction of an architecture and propose tools and practices that may support KM in the organization.
2. The workflow construction of the current situation, detailing the procedures used by employees to conduct activities in the processing of IAs, enables a better understanding of the functioning of the organization. We can identify gaps in knowledge flow, associated to the steps of capturing, mobilization and innovation, and the processes of knowledge conversion.
3. A Knowledge Tree that allows visualize in a hierarchical way all knowledge identified, showing all expertise that can be shared (Levy and Authier, ´ 1995).

Heisig 2009, as cited in Batista, 2012 points as KM critical success factors: human (culture, people, leadership), organizational (process and structure), and technology / infrastructure and applications) and management processes (strategies, objectives and measurement). Two models act as integrating elements of IM and KM models: first, the ontology model, that defines formally the manipulated information and semantic processes, domains and functions, ensuring the reliability of information and facilitating the integration of knowledge.

The modeling of each domain is relevant because it formalizes the information and treats them semantically to ensure consistency, correctness and completeness. This modeling enables the effective exchange of information for different users, can be individuals, workgroups or computer systems.

The second integrator element is the improvement model. An evaluation of the current situation status (as is) with the projection for the desired situation (to be) in which the stages of information life cycle, knowledge flow and knowledge conversion processes are complete for all IAs, leads to the proposition of improvements recommendations, which are reflected in the desired situation models (to be

The main distinguishing feature of the model is to use a specific methodology that brings together several theories, methods and tools in the areas of IM and KM. The combination of complex elements in an integrated model is the innovative element resulting from this work.

# 3 THE GRAPHICAL REPRESENTATION OF KIMM

## 3.1 Graphical Representation Goals

The main issue for the ANTT Business Modeling Project was that the entire agency must be modeled. Considering the size of the agency and the number of business activities, it was a immediate consensus that only graphical representation techniques and tools were able to handle the huge amount of information.

The main idea was that only with graphical models it would be possible to see a whole integrated vision of the entire agency process, decision making process, and so on. All the models should be available to IT experts, managers and decision makers, with each of them choosing the business vision that best fits for him.

On the other hand, with all the models together, it would likely be easier to manage the unavoidable business updates, even though the update itself would cause slightly higher overhead and be updated by different practitioners.

So, the chosen tool should be able to register the Information Assets, Information Flow Models, Business Requirements, Ontology and Knowledge. It should also be able to implement connectivity between models and its elements, allowing someone to change views while navigating.

The models are fully interconnected by hyperlinks, and these links directs users to different models that fulfills the dimensions of a business. The model also comprehends an actual photography of the actual business situation, modeling the company process (AS IS) in order to rise incomplete information life cycle process and to show gaps. Those gaps are eliminated and a new model arises showing possible improvements (TO BE).

## 3.2 The graphical models: benefits and limitations

This section presentes the graphical models and discuss some benefits and some limitations of the actual KIMM. Those limitations are a valuable possibility to improve the model.

### 3.2.1 Information Asset Mapping

Figure 1 shows an example of an IA, where there are boxes that relate the IA with the associated services and information flows. An IA may have several associated information flows that go through different organizational units. Although this multiplicity could cause inconsistencies in process of the Information Assets, the act of representing all flows in the same model minimizes this risk. By clicking in the service box, one can navigate to Figure 2, which is the entrance to present the related business use cases and business objects. Figure 3 shows an example of business use case (BUC).

Each IA has a specific purpose and is strategically positioned within the institution organizational structure, so that the established information assets architecture form an umbrella layer that includes data, information and explicit knowledge, that can be structured, communicated and transferred according to need of each hierarchical level, agreeing with several authors idea (Davenport and Prusak, 1998).

### 3.2.2 Information Flows

One of the most important model into KIMM is the information flow model - Figure 4. One of the essential purposes of information flows is to equip managers with fundamental inputs to decision-making process, since flows comprise Information Assets which are considered strategic organizational information repositories. An effective and efficient flow of information has a multiplier effect with the power of mobilizing all organizational units turning into a driving force of organizational development. In this sense, the improvement of routines and procedures in the light of the information life cycle has become an organizational need meeting the challenges posed by information and knowledge management.

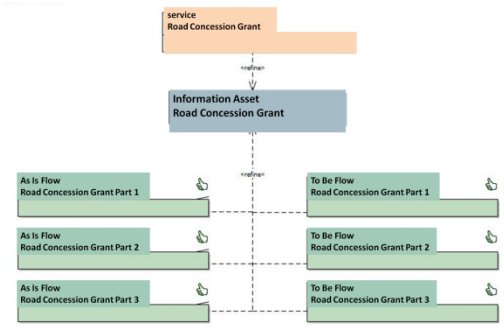


Figure 1: An example of an Information Asset from the KIMM Project. Adapted from (Bastos, 2013).

Figure 4 shows several elements such as actors, regulations for the flow operation, improvements, inputs, outputs, etc, which are relevant for the IA and the information flow. The figure also shows the stages of the information life cycle, with a different color to represent each of them. Also in Figure 4, by clicking on the symbol ∞ that appears in each of the stages of the information lifecycle, one can navigate towards the knowledge model, presented in Figure 5.

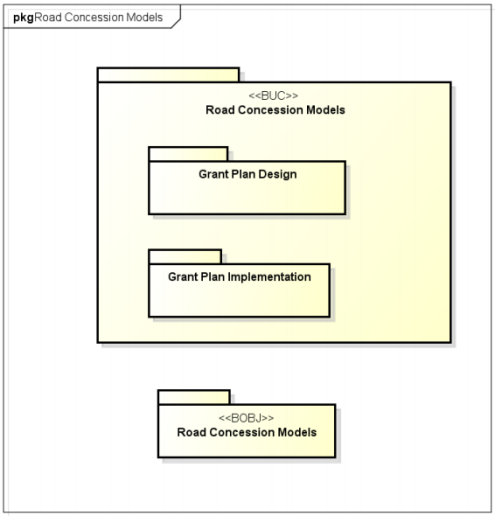


Figure 2: The Road Concession Models showing the Grant Plan Design Model and the Grant Plan Implementation. It also includes an Business Object Model (OBJ). Adapted from (Bastos, 2013).

### 3.2.3 Ontology Models

Ontology models has as main products organizational terms glossary and ontology conceptual model that formalizes the relationship between terms and serves as input for the development of ontology based systems. A universal glossary is a fundamental piece of modeling to better understanding of business and to unify concepts through the entire agency.

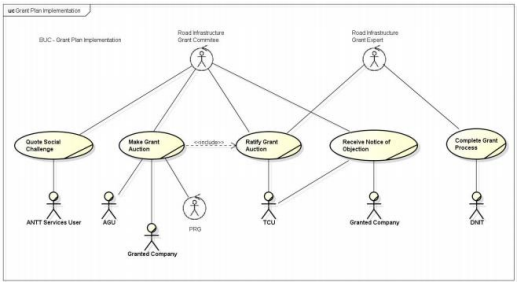


Figure 3: The Business Use Case for IA showing its Business Actors and Business Workers. Adapted from (Bastos, 2013).

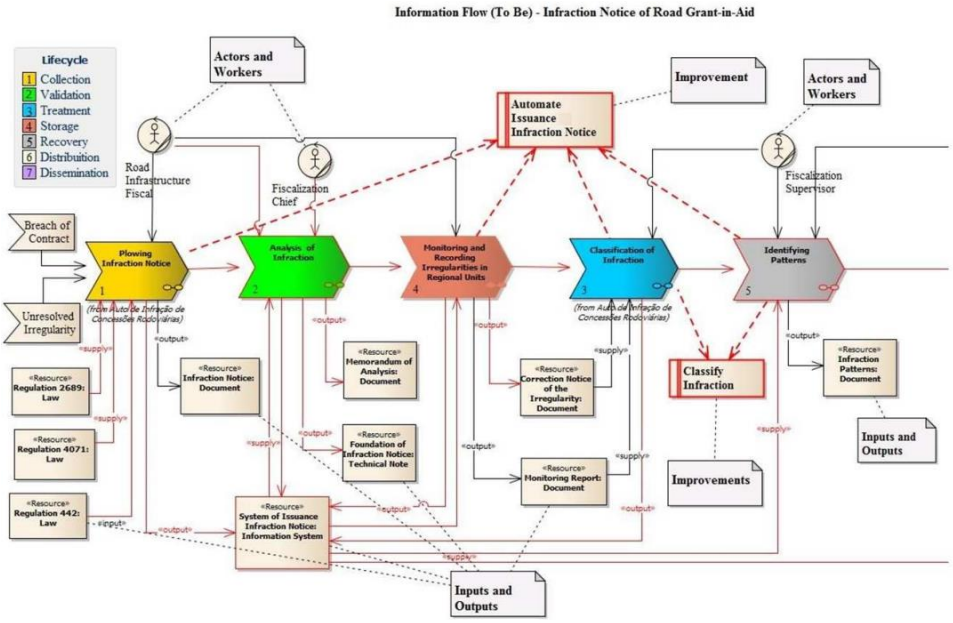


Figure 4: The Grant Plan Implementation Information Flow Model. A color scheme is applied to show the different information life cycle stages

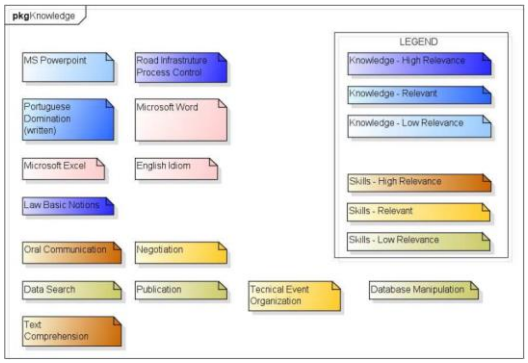


Figure 5: The Knowledge Model for the Grant Plan Implementation Business Model, explaining some mapped essential skills and knowledge. Adapted from (Rezende 2013)

### 3.2.4 Knowledge Models

Knowledge models help to map and distribute relevant informations, also detaching relevant and priority informations to decision makers. Once k-workflow and knowledge trees are modeled and validated, methods of transforming tacit knowledge to explicit can be implemented. In Figure 4 it is shown a tiny example, extracted and adapted from (Rezende 2013), of how the skills and knowledge are modeled.

Skills and knowledge requirements are all mapped as tags into a general model. After that, those tags are applied whenever they are necessary into each IA and its detailed models. An update into a skill or knowledge requirement can affect multiple other elements, but thanks to hyperlinks and mapping, one can measure the impact of updates. The tags are also colored following a scheme of relevance degree. It is possible to have more than one tag representing the same skill / knowledge, but never with the same color.

### 3.2.5 Limitations of the models

1. All the models together, interconnected by links, allows several business and process analysis, but none of them is automated;

2. In some analysis, the excessive hyperlinks makes navigation a tedious task;

3. The modeling software is not prepared to handle some knowledge methods as k-workflow and knowledge trees, forcing some adaptations to the model process. Those models had to be redone because learned lessons during the project, which was time consuming;

4. Some models still have modeling inconsistencies, due to different model integrations, as the workgroups (knowledge models) and actors / workers (requirement models). Some issues are still not fully resolved;

5. Ontology models were implemented, but support absent from the EA causes a lack of integration to other models in some aspects;

6. Some models should be compatible with other corporate tools and models, but there is no support.

All those questions are being discussed with experts teams in order to find out adequate solutions. It is expected that these new ideas help to reduce the models, without information and detail losses, facilitating the task of modeling and maintenance. The next section introduces a few of them.

## 4 THE NEED THE NEED FOR NEW EXTENSION TO UML

Traditionally, the UML has been highly associated with software development than with business process analysis and design. Although the UML standard

2.(Junior 2008) provides a set of behavioral models that covers process modeling, activities, actors, requirements and so forth.

Recently, the UML has been applied to Business Modeling with great success (Eriksson and Penker, 2000), and several contributions were published(Pourshahid et al., 2013; Lodhi et al., 2014; Weiss and Winkeimann, 2011; Thiagarajan et al., 2002; Lodhi et al., 2013; Betke et al., 2013). Despite the efforts of describing the operational process and its relations with information systems, none of them points toward to information, knowledge and issues ontology simultaneously.

Navigation between models is done trough hyperlinks, down to greater details. The models also include Business Object Models (BOBJ), that models essential information that can be seen as a start point to software modeling development - Figure 2.

Figure 3 shows a Business Use Case Model for the Grant Plan Implementation Model. In this model, Business Actors and Business Workers can be seen. Actors and workers have knowledge and skills as requirements, necessary to complete these tasks with efficiency and quality. Some business actors indeed are people representation, and some are companies or government institutions. They all have different requirements and responsibilities to take part into models.

The Knowledge models are a complete set of information covering, for example:

- individual skills
- group skills
- individual knowledge
- group knowledge
- business information
- relevant laws to business
- business requirements

In Figure 5 it is shown a tiny example, extracted and adapted from (Bastos et al., 2013b), of how the skills and knowledge are modeled.

Skills and knowledge requirements are all mapped as tags into a general model. After that, those tags are applied whenever they are necessary into each IA and its detailed models. An update into a skill or knowledge requirement can affect multiple other elements, but thanks to hyperlinks and mapping, one can measure the impact of updates. The tags are also colored following a scheme of relevance degree. It is possible to have more then one tag representing the same skill/knowledge, but never with the same color.

In figure 4 it is possible to note that a color scheme is also applied in order to identify the information life cycle stage. This model comprises elements representing new opportunities to improvement, inputs and outputs resources.

Some questions derived from the KIMM Project emerged along the Information Asset modeling and some experimental solutions were made necessary. The innovation of the KIMM brought some challenges and some concepts that are being evaluated for possible extension.

## 4.1 Collaborators

As the Rational Unified Process defines (Kruchten, 2003), Business Workers is a class that represents an human abstraction that acts into a system. The business worker interacts with others and handle business entities while instantiates business use cases.

Since the outsourcing of many activities is usual nowadays, a differentiation among employees and outsourced people (collaborators) were necessary from the point of view of identity management, human resources investments, law application issues, security and etc.

Maybe, a new element symbol for outside companies may be necessary since they have different needs and requirements for dealing with ANTT.

## 4.2 Team Work

From the knowledge point of view, a Team Work is a group of requirements associated to skills and knowledge and can be represent by one or more person, even including other teams, departments or partner companies / institutions.

It would be interesting to relate the actors to the Team Workers concept.

## 4.3 Information Flow Models

Although the UML activity diagrams were used in the beginning of the KIMM project to model information flow, this solution rapid faded in favor of workflow usual models and elements, since they are easy and flexible to work (Bocciarelli et al., 2014; Heidari et ai., 2013). Adoption of workflow symbols and tools looses some interesting characteristics of the UML sequence diagrams, as messages, but they proved in practice to be the right decision.

One of the most important model into KIMM is the information flow model - Figure 4. One of the essential purposes of information flows is to equip managers with fundamental inputs to decision making process, since flows comprise Information Assets which are considered strategic organizational information repositories. An effective and efficient flow of information has a multiplier effect with the power of mobilizing all organizational units turning into a driving force of organizational development. In this sense, the improvement of routines and procedures in the light of the information life cycle has become an organizational need meeting the challenges posed by information and knowledge management.

Hyperlink number reducing and less graphical elements would be interesting, reducing modeling and maintenance efforts. A possible solution is to threat an Information Flow as a sequence of requirements, since those requirements are already modeled.

An entity entitled "State Time" and/or "Action Time" should be incorporated, since it could indicate to

systems and business developers that a requirement or an Information Flow stage has a timeout to be done or a time/date to expire.

To resume, there is a strong feeling that time/date and elapsed time is necessary to include in some models.

### 4.4 Knowledge Models

For the knowledge models, different elements are modeled as requirements, but also colors were used to identify the relevance of those requirements.

An explicit symbol with qualitative and quantitative attributes should be designed to enhance people rapid comprehension, thus facilitating not also models, but the processing tools as K-workflow, data mining and others. It can bring benefits since human resource investments can be tailor made for specific needs as emerged from the models. Also better politics for training employees and coworkers from outsourced companies can be developed.

All the models, working together, allows the Organization to establish the requirements for a new complete task and select almost instantly whoever have those skills / knowledge, or not. It helps to design new training courses or to outsource tasks, leading to better decisions and saving resources.

One of the most desired features by teams, while modeling, was that actors and workers had attributes as knowledge requirements and human resources information. These requirements / information had to be mapped apart with help of hyperlinks, but it increased complexity and maintenance efforts.

Finally, symbols representing Possible Enhancements highlighting relationships with other models is being discussed since they deserve different symbols and a color scheme, given its importance.

## 5 CONCLUSIONS

As the KIMM project integrated four different views in a huge business modeling process, new challenges were faced. One of them was how to represent all the elements on EA. A great effort was undertaken through the use of hyperlinks to interconnect all the models.

Despite the fact that UML allows us to generalize new elements through stereotypes, enabling someone to create new building blocks based on existing blocks, but specifically for the problem at hand as it was done for the KIMM project, it was a general consensus between the modeling teams that new blocks with different shapes helps both: themselves and clients business analysts.

Assuming that new symbols can facilitate the visual comprehension of different parts on KIMM models, an interdisciplinary group is considering the issues for general improvements, information flows, knowledge representation, knowledge requirements, human resources and information resources.

Information requirements for steps into a information process flow and the knowledge requirements for a worker/contributor are being studied as if they were a object class (taking a step closer to software development), and remodeling some Information Assets as a case study is under development.

It is expected that with these results, a brand new and smaller model arises, but without loss of details, leading to a faster uptake of all models and a reduction in maintenance work thereof.

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