Collaboration and the Knowledge Economy: Issues, Applications, Case Studies
Paul Cunningham and Miriam Cunningham (Eds)
IOS Press, 2008 Amsterdam
ISBN 978–1–58603–924-0

Next Generation Modelling: Metamodels As Mediators Between Domain Experts and Ontologies in AsIsKnown

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Abstract: This paper presents a Next Generation Modelling approach initially applied in the EU-Project AsIsKnown (FP6-2005-28044) that combines a human-oriented with a document-oriented knowledge modelling approach to define a well-formalised and human-readable knowledge base. Beside traditional ontology management approaches, the meta-modelling approach – applying graphical models – is additionally applied to involve domain experts from different areas when externalising their knowledge. In such a way, graphical meta-models are seen as the mediator between well-formalised ontologies and human-readiable graphical meta-models. Through the integration the systems benefit, as the ontology can be partly maintained by domain experts using meta models, and the graphical models get empowered by ontology features such as semantic checks or reasoning.

1. Introduction

Knowledge management is a key for the success of enterprises as according to Lynch [1] 80% of information in enterprises is unstructured and understanding this "hidden" intelligence is the key to improve the interaction with information [2]. The goal of AsIsKnown is creating a common knowledge space for the home textile industry in Europe by enriching knowledge flows between knowledge workers with semantics of the domain and externalise the aforementioned "hidden" knowledge in a well-structure knowledge bases.

The paper focuses on the approach, to use graphical meta models to externalise the "hidden" knowledge out of the head of the domain experts and find mediator mechanism to map this semi-structured knowledge base into an machine interpretable well-structure ontology. In the following the paper distinct between the

- Human-oriented knowledge modelling, which focuses on the externalisation of implicit knowledge from domain experts through the use of graphical meta-models,
- Document-oriented knowledge modelling, which is concerned with formalisation of various input formats to built a well-structured knowledge base using techniques such as Natural Language Processing (NLP) and data/text-mining, and
- Applying meta models as a mediator between these two knowledge bases.

The underlying assumption is that knowledge becomes more important, semantic technology reached a sufficient level of maturity and the collaborative approach summarized in the Web 2.0 phenomenon motivates a collaborative modelling [3], [4].

This paper selected the EC-project AsIsKnown (FP6-2005-28044) [5] to demonstrate the initial step of the Next Generation Modelling in a concrete application scenario. One of the research challenges of AsIsKnown is to support the formalisation of implicit knowledge of domain experts from different areas such as sales representatives, product managers or market trend analyzer and explicit knowledge in form of trend handbooks, system log data, product catalogues and producer databases.

Current techniques of semantic modelling start from a technical point of view, assuming that the knowledge modeller has expertise in formal modelling languages. But in reality domain experts usually do not think in terms of concepts and relations but rather in a language they are familiar with. Therefore the modelling method PROMOTE® (see [6], [7] and [8]) was selected as it provides a graphical modelling language for non-technical end-users to build up a knowledge base. Within the project the human-oriented knowledge base has been implemented by a service called Smart Profiler (SP), whereas the document-oriented knowledge base has been implemented by a service called AsIsKnown Ontology System (AIKOS). Both systems provide a common knowledge base to the other services, which is mediated by a meta-modelling framework. Therefore the Smart Profiler acts as the central repository of meta-data that can be accessed by all AsIsKnown components

In the following section, the paper will briefly present the research challenges of the project and introduce the related work on the problems of end-user driven ontology building and visualisation (section 2). Section 3 deals with the introduction of the graphical meta models by using the PROMOTE® approach. The technical implementation of the approach is dealt with in the subsequent section 4. The paper concludes by providing lessons learned and an outlook on upcoming challenges in the field.

2. The Knowledge Modelling Challenges

2.1 Problem Statement

Semantic Technology has been improved over the last years and has become mature and established in the area known as the Semantic Web. Standards like OWL, a list of free accessible tools like ontology editors and promising features like using inference systems make semantic technology attractive when dealing with knowledge bases. It is therefore well accepted, that there are many applications that can benefit from Semantic Technologies. From an application point of view, however, Semantic Technology comes with two major drawbacks:

1. Although there has been a lot of research in semantic technologies, the tools are more advanced from a technical point of view, requiring experts in order to use them.
2. Finding agreements between domain experts when building and evolving ontologies is difficult and time consuming, as the domain experts do not know how to describe their knowledge and the ontology expert has difficulties to make samples in the domain experts' fields.

In spite of the presence of a number of ontology building methodologies the involvement of the domain expert in the building process is mostly lacking and the visualisation techniques do not consider domain specifics, which hampers the accessibility of ontology modelling by domain experts.

The approach followed within AsIsKnown aims at using domain-specific graphical models as mediator between domain experts and ontologies, based on the assumptions that domain-specific models require less modelling expertise than common ontology specification languages, the models have a formal background as far as they are based on a meta-modelling framework and that meta-models can be transformed into ontology syntax.

Therefore the following goals have been derived:

1. Introduce the concept of meta-model and ontology integration.
2. Provide a modelling environment supporting this approach and enabling collaborative modelling using technologies commonly known as "Web 2.0".

2.2 Research Challenge: Meta-Model and Ontology Integration

One of the conclusions of the WonderWeb market report [9] is that the lack of "visualization" and "multi-modeling paradigm support" is a serious market barrier for semantic technologies.

This conclusion is driving the research challenge of Next Generation Modelling, by involving different roles of knowledge workers using different means of formal knowledge expression. The following two challenges can be identified.

- Multi-modelling paradigm requires research in the field of meta-model mapping, semantic loss and the interpretation of OWL as a meta-model.
- Research is required in the field of graphical representation of domain-specific meta-models – that domain professionals are already familiar with –, as well as concerning these meta-models' relation to the complexity of an ontology.

The goal of the Smart Profiler in AsIsKnown is therefore to represent objects in the language of the domain experts. In the context of AsIsKnown, the sales expert models sales process in a business process notation, the trend analyst models customer profiles in a self-defined notation and the product manager models products and categories in a concept map notation. All three notations are mapped to OWL applying semi-automatic and manual steps.

2.3 Research Challenge: Meta-Model and Ontology Modelling Environment

In traditional ontology development approaches the ontology expert is responsible for the modelling and resolving conflicts. The direct involvement of domain experts in the modelling task enhances this process of ontology development. To enable the direct participation of domain experts the development of a collaborative modelling environment is needed. The technical research challenge of the project is how a system using and extending Web 2.0 technologies can be built. The aim is to use the Web 2.0 principle to enable collaboration, so that domain experts from everywhere can contribute to the ontology building process. The experts can comment on existing models by using a wiki or extend the ontology with new models. The modelling environment also has to consider integrating existing modelling tools ranging from informal, unstructured, text-based to semi-structured and formal ones. The core challenge of the Smart Profiler is hence to apply a Service Oriented approach by providing a range of different modelling services, that use the same meta model core, who acts as a mediator between all modelling services.

2.4 Related Work

The idea to involve domain experts into the building process of an ontology is based on the observation that currently there is a high dependency on few ontology experts and a time and cost-intensive period of ontology generation.

According to Uschold and King [10], Grüninger and Fox [11] as well as Noy and McGuinnes [12] there are top-down, bottom-up or inside-out approaches. The graphical meta-model as an end-user interface extends the top-down approach in providing additional methods for end-user knowledge acquisition. According to the Methontology Methodology described in Fernández, Fómez-Pérez and Juristo [13] the knowledge acquisition phase – using expert interviews – will benefit in providing a graphical representation in the language of the expert. According to Swartout, Ramesh, Knight and Russ [14] describing the SENSUS methodology, the natural language processing will be supported by an end-

user driven grouping of concepts via the graphical modelling and additionally providing relations to concepts by applying natural language processing in the textual description of the graphical objects.

In this sense the above-introduced concept is not seen as a complementary approach to ontology building, but as an extension of existing approaches to simplify the knowledge acquisition of end-users.

Current graphical representations of ontologies like OWLViz, Jambalaya, OntoViz, OntoVista, TGViz, Kaon, OL Graphs, RDF Gravity, Vizigator, VisioOWL visualise concepts, instances and relations to support the ontology engineer, but do not support a domain-specific graphical representation.

In this sense the above introduced concept of the Smart Profiler is seen as a new form of a domain specific graphical representation of an ontology using PROMOTE®.

3. Externalising Domain Expert Knowledge

As this paper focuses more on the innovative part in introducing a graphical meta modelling method for ontology generation, the traditional ontology building process applied in AsIsKnown is not explained in this paper. For more information on this and a brief overview on the state of the art in ontology building please refer to [15], [16].

The model based PROMOTE® approach uses graphics to support domain experts in expressing their knowledge. The method has been developed in the EC project PROMOTE (1999-11658) [17] and since then continuously improved in commercial projects [18] and in EU-Projects [19]. PROMOTE® builds on a meta-model as conceptual framework [20]. The meta-modelling approach has already been successfully applied in ADONIS [21] and provides flexibility by allowing customisation. In this sense PROMOTE® is seen as an instance of a meta2-model such as MOF implementing the formal specification of the PROMOTE® meta-model [22]. For a report on the state of the art in meta modelling please refer to the meta model literature survey by Karagiannis [22].

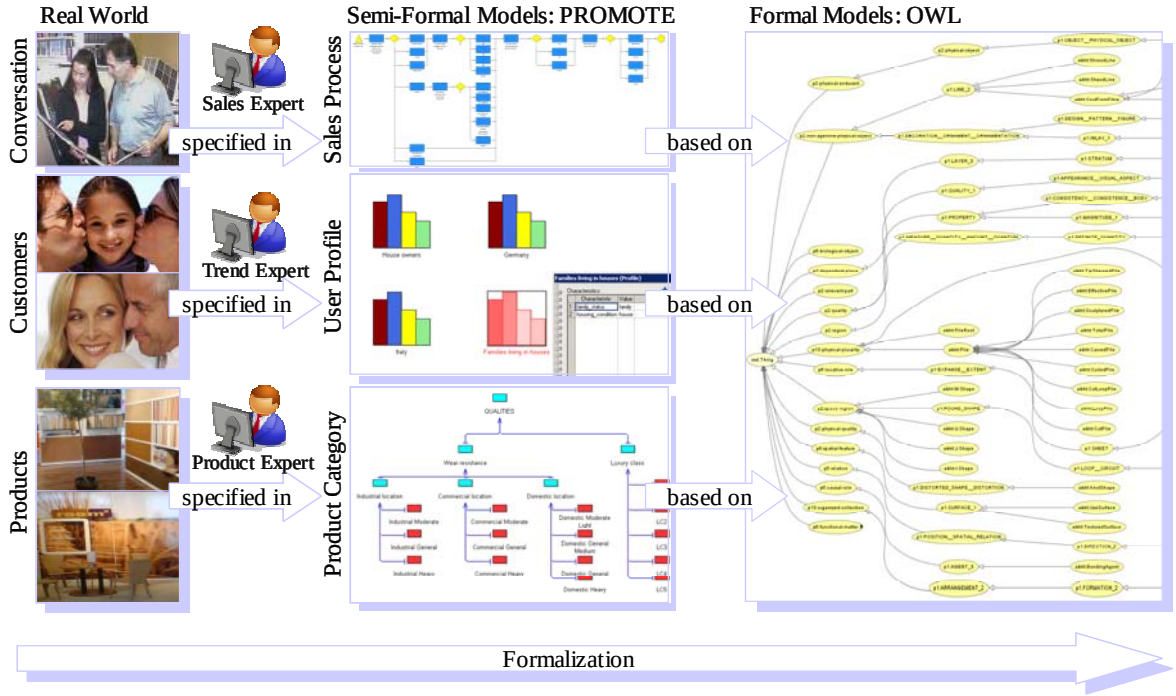

Figure 1: PROMOTE® model stack

Figure 1 depicts how PROMOTE® supports the involvement of domain experts in modelling. According to the identified sub-domains: the sales conversation between

customer and sales person can be modelled via process flows and business rules, the customer profile can be modelled via profile models referring to characteristics and preferences, the product categories can be modelled using concept maps. PROMOTE® is used to implement domain specific graphical representations of the ontology to involve domain experts more tightly in the ontology building process. A basis for the model is built by the AsIsKnown ontology that contains the relevant concepts from the home textiles domain. The ontology is used for the validation of the models concerning terminology and semantic and supports correct modelling. Moreover it enhances search and discovery of products by offering inference functionality.

PROMOTE® is a graphical modelling language to model knowledge and therefore has modelling concepts that have a specific meaning e.g. the process sequence can be used to describe the sales process, the profile objects are used to describe user groups and user behaviour and concept maps specify structures (see Figure 1). The provided modelling concepts are defined in the modelling languages. The transformation from PROMOTE® towards OWL is based on transformation rules for the modelling languages. Each modelling concept gets a mapping to the corresponding ontology construct. These mapping rules are manually specified and automatically applied when storing a model. By storing the model, an XML representation of the model is generated and the defined model concepts are parsed. Each identified model concept is then transformed by previously defined mapping rules that map the PROMOTE® XML representation to an OWL representation. Therefore each PROMOTE® model – e.g. a sales process - can be transformed into a valid OWL representation, imported into the ontology base, and manually integrated into the existing ontology. In that case PROMOTE® is an additional source of knowledge that externalises the implicit domain expertise.

Once the sales process is incorporated into the ontology, the ontology can be used to align the modelling of other sales processes, by using checking mechanisms, which control the syntactic and semantic correctness of the model. The next model can therefore be checked against the ontology, to ensure a “common sense ontology” compliant modelling of the graphical models.

In case terms are not properly used, the ontology provides suggestions by following hierarchies, synonyms or by applying searches. The domain expert is involved in the evolution of the ontology, as when unsatisfied suggestions are provided, there is the possibility to insist on new terms. For the communication between the domain expert and the ontology expert, an annotated Wiki has been implemented, which enables a discussion on the terms used in the models. Based on the negotiation between the ontology expert and the domain expert about the graphical models, the Wiki-entries and the meaning of the terms, the transformation rules from PROMOTE® towards the ontology are adapted.

Currently the challenge of the semantic loss is solved by the manual integration process. The support of this manual integration is topic of ongoing research of the project partners.

4. The Project Implementation

From a technical perspective the Smart Profiler deals with the implementation of the Modelling Environment described in section 2.3. The Smart Profiler offers a web-based Knowledge Management System, providing a modelling environment that supports the usage of graphical models as a user interface for ontologies. This allows building and maintenance of ontologies by starting from a domain expert’s point of view.

The tools provided by the Smart Profiler support the acquisition and design of knowledge using models, the analysis of knowledge models, their distribution across the organisation, as well as their transformation into different formats including OWL.

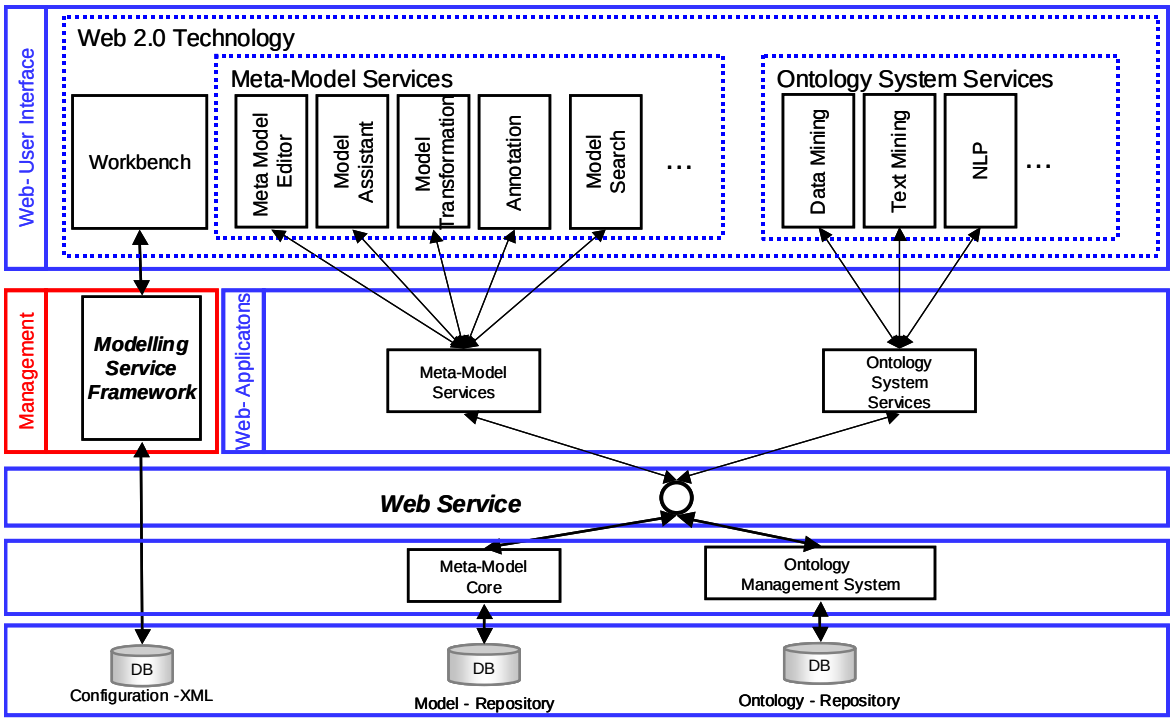

Figure 2: Integration of the Meta Modelling and Ontology Services in AsIsKnown

Figure 2 gives an overview on the implementation of the system. The Smart Profiler consists of a set of services organized in an SOA. In the figure they are referred to as "Meta-Model Services". The other part of the figure shows the AIKOS' part of the AsIsKnown system. The AIKOS' services are refered to as "Ontology System Services" in the figure.

The figure shows the main building blocks of the modelling environment. Starting from the bottom, the persistance layer is presented showing the repositories for ontology- and model data. The ontology repository stores ontologies in OWL format, while the model repository is a relational database for the storage of PROMOTE models. The former is accessible through the Meta-Model Core, while the latter is accessible through an OMS as depicted in the layer above. Both offer a Web-Service interface to their clients.

The layer above contains two types of services. On the left side Meta-Model Services are shown, providing functionality such as meta model editors, model viewer, model search engines, model import/export and transformation services, support for acquisition, analysis or simulation, as well as other services supporting the externalisation, capturing and maintanance of domain experts' knowledge. The ontology system's services support the capturing of knowledge from non-human sources such as documents and provide data mining, text mining, NLP and similar functionality.

At the top the user interface layer is shown, consisting of a web-based workbench integrating the different services.

Model exchange between Smart Profiler and AIKOS: There are two ways of performing this task. The simpler one is on a one to one basis, where graphically modelled ontology models are transformed into OWL syntax.

The more challenging integration step is to exchange semi-formal models, like sale processes or user profiles. For this purpose the Smart Profiler offers a rule based translation mechanism transforming models into ontology concepts as mentioned in the chapter before.

Lexical Translation: The AsIsKnown system supports the translation of input and outputs to the system into different natural languages. This translation is performed using the lexica of the AIKOS, which map lists of natural language terms to the concepts in the domain ontology. The Smart Profiler uses this functionality in order to be able to

understand requests, or to provide output in different natural languages. Having this mechanism in place the lexical translation is fully applicable for the product description, product categories and user profiles.

Term Checking: To align the terminology of the domain experts with the ontology each piece of information provided from outside the system needs translation towards the AsIsKnown language. To guarantee the correct translation into the AsIsKnown language, the Smart Profiler checks whether a term is AsIsKnown-compliant or not. The "Model Assistant" checks the correct usage of terms in models and provides reports as well as functionality suggesting terms in case terms are used which are not yet part of the language, including querying of the lexica and browsing in the ontology.

Semantic Checking: The difference between an expert modeller and a beginner in modelling is that the expert knows about modelling guidelines - procedures how to use the available concepts and how to apply the modelling language. In AsIsKnown this knowledge is made explicit in the ontology. A concrete model can be checked against the modelling guidelines on a semantic level. This service uses an inference engine within the ontology to compare models with the modelling guidelines and provides reports and suggestions for error handling. This mechanism helps improving the quality of the knowledge base.

Annotation: In order to enable annotations between the Smart Profiler and the ontology, there is an external annotation repository that stores the references from PROMOTE® models to OWL concepts. Applying the Service Oriented Approach, each of the modelling services can be accessed through a Web-Service interface. In case changes in the annotations occur each Web-Service is informed and is itself responsible for further actions.

Semantic Search: Currently the status of the integration in the project is the usage of discovery within AIKOS. The Smart Profiler offers a search interface to enable the search for modelling constructs, which covers the majority of search requests of the user. In case the concepts of meta-models are insufficient to answer the users request, the request is translated term by term into OWL and passed towards the ontology. An inference engine, searches term by term the ontology (e.g. parent-, children-, sibling-concepts) and sends back the results to the Smart Profiler.

The above-explained mechanisms are seen as the initial implementation of a Next Generation Modelling Framework that needs further investigation and implementation in future EU-projects.

5. Conclusion and Lessons Learned

This paper showed how domain experts from different areas are involved in the creation of a common knowledge base by externalizing and formalizing their knowledge using PROMOTE® and its meta-modelling approach. Through the use of graphical models domain experts directly take the role of knowledge modellers. The AIKOS ontology system allows the management of formalized and thus machine-interpretable models in form of ontologies.

Through the integration of these two knowledge spaces the solution further benefits, as ontology building is user friendly and can be partly maintained by domain experts. The Smart Profiler also benefits from the integration, as the quality of the models is increased by terminology and semantic checks and a translation service is provided. With the help of the ontology also new extensions like semantic search based on annotations are provided.

The use case in AsIsKnown showed that it is beneficiary to use meta-models as mediators between domain experts and ontologies, thus enabling Next Generation Modelling. The goal is that meta-moddels further converges with ontologies leading to a hybrid system based formulates the upcoming research challenges for Next Generation Modelling.

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