MoKi: the Modelling wiKi

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Abstract. Enterprise modelling focuses on the construction of a structured description of relevant aspects of an enterprise, the so-called *enterprise model*. Within this contribution we describe a wiki-based tool for enterprise modelling, called MoKi (Modelling wiKi). It specifically facilitates collaboration between actors with different expertise to develop an enterprise model by using structural (formal) descriptions as well as more informal and semi-formal descriptions of knowledge. It also supports the integrated development of interrelated models covering different aspects of an enterprise.

1 Introduction

An enterprise model is "a computational representation of the structure, activities, processes, information, resources, people, behavior, goals, and constraints of a business, government, or other enterprise" [1]. Often, an enterprise model focuses in the description of two specific aspects of an enterprise: (i) its processes and activities, and / or (ii) the business domain within which the enterprise operates. Other aspects of an enterprise, like goals, human resources, organisational structure and roles, competencies, etc. may also be important assets to be described in an enterprise model. This is due to the central role that enterprise models are playing in the development of a large number of applications, including Internet and (Semantic) Web based applications.

Building an enterprise model requires a number of skills. These skills span from *knowing* the different aspects that have to be described in the models to having the ability of *encoding* such knowledge into formal statements, to having the ability of *integrating* different aspects, such as structure, activities, processes, information, resources, people, behaviour, goals, and constraints into a uniform and coherent vision. Given the complexity of enterprise modelling, it is unrealistic to assume that any one person possesses all the above skills, and the contribution of multiple actors is necessary. For this reason enterprise modelling is inherently a *collaborative* activity. Our research focuses mainly on collaboration between actors with different skills. Naturally we also recognise the relevancy of other aspects of collaboration such as resolution of conflicts of opinion or interest (considered for example in Collaborative Protégé [2]), or more fundamental requirements regarding access rights, simultaneous modification of models, versioning etc., but we plan to consider them at a later stage of our work.

To support actors with different skills, we envisage a system in which content can be represented at different degrees of formality. Domain experts need to create, review and modify models at a rather informal/human intelligible level. Knowledge engineers need to check the quality of the formal definitions and their correspondence with the informal parts they intend to represent. In order not to increase the overhead of human work, translation between different levels of formality must be as automated as possible. To support a coherent development and integration of the different components of the enterprise model, such a modelling tool must support the modelling of all the relevant aspects of an enterprise in a collaborative, cooperative and integrated manner. This is in order to exploit the synergy of "having to think the same thing out only once".
MoKi (Modelling WiKi) is developed in order to meet this vision:

1. It supports access to the enterprise model at different levels of formality (informal, semi-formal, and formal);
2. It integrates modelling of several aspects of an enterprise; and
3. It ensures a coherent development of the formal part.

2 Conceptual framework

The key modelling aspects that MoKi aims to support are collaboration and integration. This section goes into detail about how we understand these terms and why they are relevant in the context of enterprise modelling.

2.1 Collaboration

Developing an enterprise model is inherently a collaborative activity, since a variety of skills are required which are unlikely to be found in a single person, as has already been argued above. In practice, different actors have very different expertise in encoding content into formal languages, or may know only of specific aspects of an enterprise. At this point it is necessary to understand that as a direct consequence different contributors, as members of a *modelling team*, also have different requirements on the modelling environment, especially with regard to the presentation of the models' content. The primary goal of our research with respect to collaboration is to derive requirements on a modeling environment by actors with different background knowledge and to develop appropriate ways to access models accordingly.

To support collaboration between the modelling team, and to allow great flexibility in the cooperative modelling activity, we therefore adopt a *collaborative modelling* paradigm, illustrated in Figure 1. This paradigm is inspired by recent Web 2.0 collaborative solutions, of which wikis are one example, and was already proposed in [3, 4] as a way to support modelling activities. In this paradigm all the actors asynchronously collaborate toward the creation of an

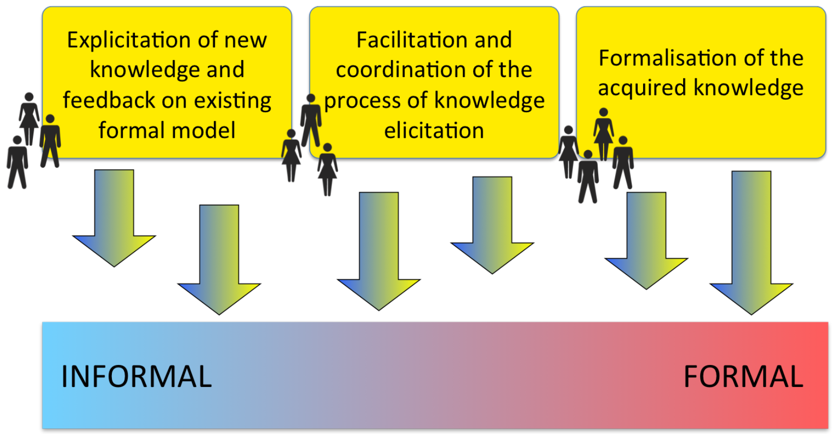

Fig. 1. Collaborative Modelling

integrated enterprise model by inserting knowledge (either formal or informal), by transforming knowledge (from informal to formal) and by revising knowledge. The domain experts enter the missing knowledge - using a form of informal language - into the models or provide feedback on the formal models created. The system semi-automatically translates part of the informal knowledge into a formal specification and vice-versa. Asynchronously, the knowledge engineers can refine the formal model by inserting new elements, by modifying existing knowledge or by asking clarifications to the domain experts. The usage of a robust collaborative technology, as the one provided by the wiki, allows the provision of state of the art functionality like simultaneous access and online communication via the platform.

Another important characteristic of our approach lies in the capability of the system to maintain the alignment between the informal specification of the enterprise model and its formal version. This can provide an added extra value, as the documentation contained in the informal part is often critical to fully understand its formal version. Traditionally, the main goal of enterprise modelling is the production of an integrated formal model in which the different aspects of an enterprise are integrated in a unique model. This integrated formal model is an artefact that nevertheless requires a strong connection with its informal part in order to be fully exploited both by humans and machines. Thus, to support the exploitation of an enterprise model also by humans we adopt a structure (also referred as *the meta-model*) which not only contains the formal meta-model of the enterprise, but also the informal versions of this knowledge.

2.2 Integration

Relevant to our idea of modelling different aspects of one enterprise is that the various models are interconnected, and thus constitute an *integrated* model.

In the current implementation of MoKi, we focus on an enterprise model describing the domain, the processes and the competencies of an enterprise; Figure 2 shows the current version of the integrated enterprise meta-model considered. The choice of these aspects, which constitute typical parts of an enterprise model,

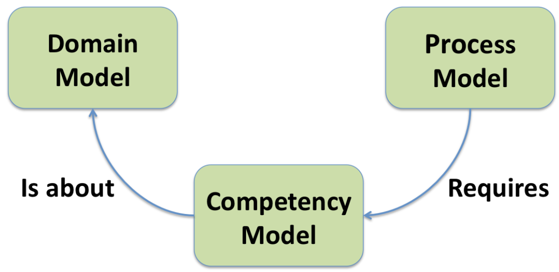

Fig. 2. The current version of the integrated enterprise meta-model considered in MoKi

was originally motivated by the EU-project APOSDLE[4] in which MoKi was first developed and used. Nonetheless, MoKi has also been used in different contexts already (see Section 4). Also, more complex enterprise models can be considered, and we have designed our approach with the explicit intent to be open and extendable to other aspects of an enterprise.

Below, we specify what we mean by domain, process and competency model, and illustrate how we see integrated modelling using these spcific aspects.

The *domain model* provides the description of the business domain within which the enterprise operates. It is a conceptualisation of the entities and the relations between them, which are relevant to the activities of an enterprise. This description is provided in terms of concepts, relations and objects. Following the growing popularity of Semantic Web technologies, we decided to base our representation of a domain-specific model upon the OWL ontology language[5]. This approach allows one to express classes, properties, instances, and axioms among them.

The *process model* provides a description of the patterns and procedures occurring in a business domain of an organisation. The very core of a process model is a control flow. In the e-learning application scenario described in [3] it was enough to consider a task to be either atomic or composed of a bag of subtasks, regardless of any execution control. In this case a simple hierarchical structure representing the task/sub-task relation was sufficient and we adopted an OWL ontology that encodes the part-of relation. In a different situation where tasks were complex structures described in the BPMN[6] language [5], a more complex model was adopted, in which processes are described by means of the primitives

[4] See www.aposdle.org.
[5] www.w3.org/TR/owlfeatures/
[6] Business Process Modelling Notation `www.bpmn.org`

defined in an OWL ontology that represents BPMN[7].
The *competency model* describes the attitudes and the capability of people employed in an organisation to fulfill their tasks and to reach their objectives and goals. Elements of the competency model are competencies, which express knowledge about domain concepts. Tasks are related to competencies, in that a competency may be required to perform a task, and vice versa the (successful) execution of a task indicates that person possesses a certain competency. Such a competency model allows describing users in terms of knowledge about concepts of the business domain and skills to perform the tasks of the process model. Clearly, such a competency model serves as connection between domain and process model. Practically, this connection is established by assigning tasks to competencies (domain model element plus skill type) which are required for performing the task. In the e-learning application scenario described in [3], the competency model was built focusing on the support of individual learning in the process of working tasks [6].

3 Enterprise modelling using MoKi

MoKi is based on Semantic MediaWiki (SMW) [7], extending it to offer particular support for enterprise modelling. Based on a predefined meta-model as the one described above, MoKi adds to SMW the following groups of functionalities: (i) import functionalities to load existing models from various formats, (iii) modeling functionalities for model management and representation (iii) export functionalities to translate models developed within MoKi into standard formats. These functionalities are described in more details throughout this section.

The choice of developing MoKi on top of a semantic wiki was made for several reasons. Wikis provide a state of the art robust collaborative tool, which enabled us to focus on the aspect of collaboration between actors of different skills and still getting an environment with more broad collaboration support. Due to the growing popularity of wiki-based web sites (e.g. wikipedia), users are quite familiar with wikis and the editing of wiki pages. Furthermore, the SMW framework already provides many important functionalities such as access control and permissions, tracing of the activity, semantic search, and so on, without the need to install specific client applications. Finally, only a web-browser is required on the end user side to use the system. The second important reason for choosing a semantic wiki was the fact that the wiki can provide a uniform tool and interface for the (informal) specification of the different components of an enterprise model (domain, processes, and competencies in our case). This is in opposition to the usual procedure, where dedicated but often disconnected, modelling tools are used to model each aspect. The usage of a uniform tool for the integrated modelling of different aspects of an enterprise provides a great opportunity to make modelling easier for domain experts. It is also a prerequisite for modelling different aspects of an enterprise in a truly integrated way, as described above. As a final reason for implementing MoKi on top of a semantic

[7] `http://dkm.fbk.eu/index.php/BPMN_Ontology`

wiki, the natural language descriptions inserted in a semantic wiki can be structured according to predefined templates, with the help of semantic constructs like properties. As a consequence, the informal descriptions in natural language contain enough structure to be automatically translated in formal models, thus allowing the reuse of informal descriptions for automatic ontology creation.

3.1 Describing knowledge in a MoKi page

MoKi integrates different views over portions of knowledge. The main idea behind MoKi is to associate a wiki page[8] to each (simple or complex) element of the formal models so that this page contains an informal but structured description of the element itself. The typical page contains[9]:

– An informal description of the element in natural language (images or drawings can be attached as well). The purpose of this part is to document the model and clarify it to users not trained in the formal representation (e.g., reference to source documents, notes about modelling choices and open problems, etc.). Comments can be added by each user and are not translated to the formal model;
– A structured part, where the element is described by means of triples of the form *(subject, relation, object)*, with the element itself playing the role of the subject. The purpose of this part is to represent the connection between elements of the same model (like class/sub-class relation between elements of the domain model, or task/sub-task relation between elements of the process model) as well as connections between elements of different models (like a relation denoting required knowledge between elements of the process and the domain model).

This natural language based, but also structured, description provides a natural bridge between formal and informal representation of knowledge. The user fills a page via forms (see the Semantic Forms extension[10]), so he/she does not need to know any particular syntax or language to participate in the creation of the enterprise model. All the actors involved in the modelling activities can also interact with each others and exchange further ideas and comments using the *discussion* SMW's built-it functionality. An example of a MoKi page describing an element of the domain model is shown in Figure 3 while an example of a MoKi page describing an element (task) of the process model is shown in Figure 4.

8 Wiki categories could have been used as well to represents the concepts of the domain model. However, when we started developing the tool, the support for categories in SMW was rather preliminary, so we decided to represent domain concepts using standard pages.
9 Note that in this section we use the term "model element" to indicate a basic component of the model. For instance, a concept or a relation of the domain model is a model element, a task of the process model, a competency, and so on.
10 http://www.mediawiki.org/wiki/Extension:Semantic_Forms

The important point to stress here is the usage of semantic forms to realise appropriate templates to guide domain experts in providing their informal, but structured descriptions. Templates are the key to customise MoKi for modelling different kinds of model elements (e.g. domain concept, task, competency etc.) with respect to which knowledge shall be specified about the kind of element.

3.2 MoKi functionalities

MoKi provides several groups of functionalities to support modelling, all of which can be accessed via a wiki's style menu. This section contains a description of the functionalities currently available[11]. Concerning future extensions, MoKi is built in a modular way in order to facilitate the plugging-in of new or existing state-of-the-art tools.

Import Functionalities. We provide three types of import functionalities:

- *Import of available domain/task formal models.* With this functionality the user can set up MoKi with an already available domain or task model instead of starting modelling from scratch. From the technical point of view, the XML serialisation of the OWL formal model is parsed in order to obtain its relevant elements, and a page is created for each one of them. All pages are collected in a XML file, which then is given as input to the `Import pages` functionality available in SMW.
- *Input of structured lists of elements.* With this functionality the user can create new elements of the models by inserting lists of concepts (resp. tasks), organized according to predefined semantic structures, e.g. a taxonomy or a partonomy (resp. task/subtask decomposition structure). Figure 5 shows the loading of a list of concepts organized according to a partonomy in the domain model. Also this functionality takes advantage of the `Import pages` functionality available in SMW.
- *Text analysis functionalities.* To support the utilization of available unstructured knowledge relevant for the modelling activity, MoKi includes an extension which allows to extract relevant terms from digital resources, and to cluster such terms according to their relatedness. These functionalities are provided by the KnowMiner, an advanced text analysis tool developed by the Know-Center. The corresponding extension works in analogy to the extensions realised for Protégé in earlier work [8].

Model Management Functionalities. This set of functionalities provides the basic functionality each modelling tool necessarily provides: Creating, editing and deleting model elements. Depending on the type of element, pre-defined templates are loaded when it is created or edited. Such templates contain for

[11] A demo version of MoKi can be tried out on-line at the MoKi web site: moki.fbk.eu. A detailed description of the current version of MoKi is contained in the MoKi manual, available at the same web site.

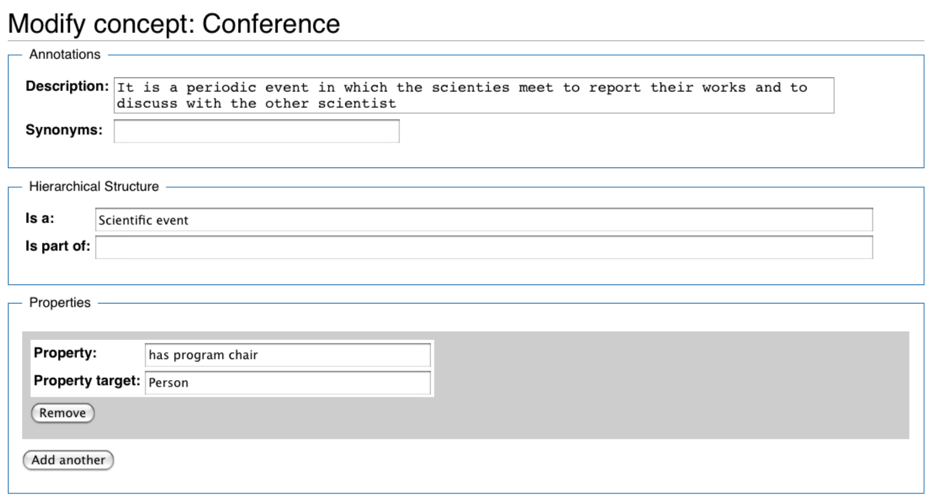

Fig. 3. An example of a MoKi page for a concept.

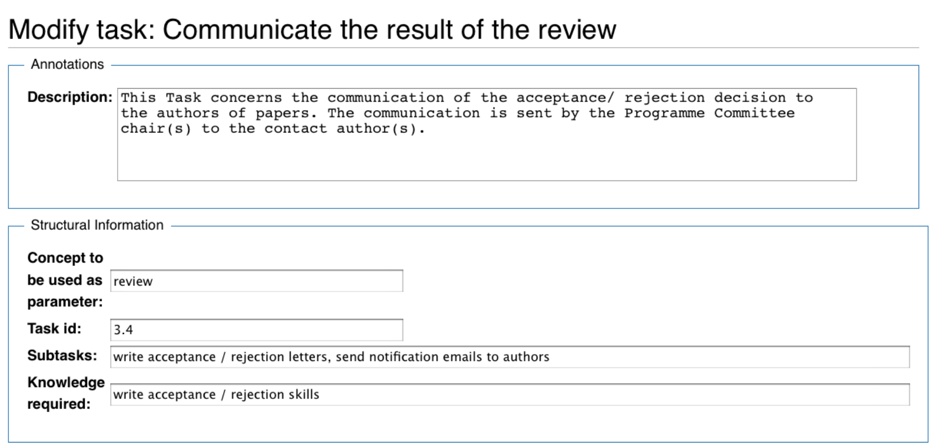

Fig. 4. An example of a MoKi page for a task

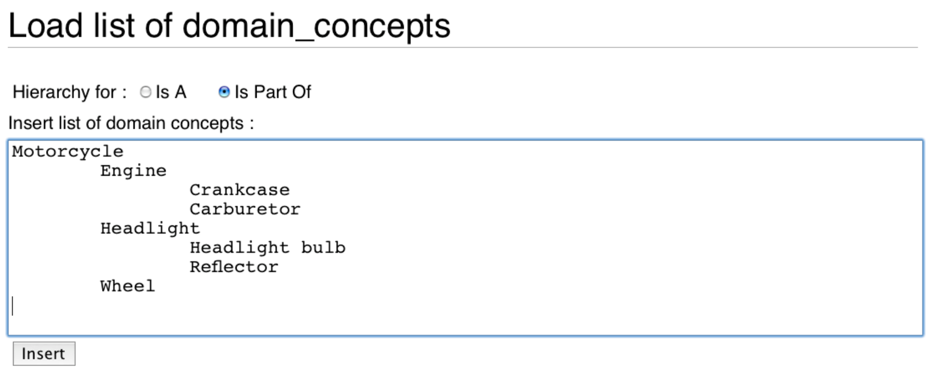

Fig. 5. Adding a list of concepts organised according to a part of hierarchy, via the `Load list of concepts` functionality.

instance properties for specifying a taxonomy or partonomy, or a sequence in the case of tasks.

Visualization Functionalities. These functionalities allow to produce different types of graphical overviews of the models: they help the actors to deal with the global picture on the models and not only with the single model elements. In particular, the tool allows two kinds of overviews of the model, a tabular-based one and a graphical-based one.

In the *tabular-based view*, the user sees a table listing all the elements of the domain model or the process model, where for each element some relevant information is shown, e.g. its description, the concepts of which it is a specialisation (for domain elements), its subtasks (for tasks), and more. A short extract of a list of element in a domain model is shown in Figure 6. This functionality is based on the `ask` query mechanism available in SMW.

In the *tree-based view*, called *IsA/PartOf Browser*, a tree-like view shows the hierarchy of the domain elements according to either the subclass or part of relation. This tree-like view, which can be see in Figure 7, is dynamically created from the content of the MoKi pages. The user has the possibility to expand/collapse only parts of the tree, thus allowing him or her to efficiently browse even large and complex models. Actually, this is not just a visualization, since the user can easily rearrange via drag 'n' drop the taxonomy and partonomy of concepts in the domain model, and the changes performed within the browser are propagated to the pages describing the elements involved. This functionality is an adaptation of the DHTMLx-Tree library [12], originally not meant for this purpose.

[12] http://www.dhtmlx.com/docs/products/dhtmlxTree/index.shtml

List domain concepts

Number of concepts in the Domain Model: 35

Concept	Description	Is a	Is part of
Carburetor			Engine
Chi-Square-Distribution	The chi-square distribution is the distribution of squared values of a standard normal distributed random variable.	Probability Distribution	
Comparing Means	The term comparing means refers to a group of statistical tests for identifying statistically siginficant differences between means from different groups.		
Covariate	A covariate (also covariable) is a variate occurring concomitantly with the variate of primary interest and measured for the purpose of making informed adjustments on the variate of primary interest. It is a correlational variable (usually a characteristic of the subject) included in an experiment to help reduce the error variance in statistical tests.	Variable	
Crankcase			Engine
Dependent Variable	The dependent variable (criterion variable) is the variable that is observed to change in response to the independent variables. The dependent variable reflects the impact of changes in the independent variable. This means, the values of the dependent variable are depending on variations of values of the independent variable.	Variable	
Descriptive Statistics	Descriptive statistics are used to describe the basic features of the data gathered from an experimental study in various ways. The core of descriptive statistics are measures of central tendency (e.g. mean, median, modal value), and measures of dispersion (e.g. range, variance).		
Effect	The term "effect" is used as an umbrella term for the different effects that can occur as a result of a two-way ANOVA (main effect, interaction effect).		
Engine			Motorcycle
Experiment	An experiment is a specific type of method used in scientific inquiries, and personal questioning, to find an answer to a question. The essence of an experiment is to introduce a change in a system (the independent variable) and to study the effect of this change (the dependent variable).		

Fig. 6. Extract of a tabular-based view of the domain model.

Export Functionalities. These functionalities support the automatic export of knowledge of the enterprise model into standard knowledge representation languages. At the moment, the formal representation of all parts of the enterprise model is an OWL ontology. On-going work is devoted to the addition of other formal languages especially for task/process specification. The process model and the domain model can be exported separately. Technically speaking, the starting point to the automatically created the OWL ontology from the informal domain model is the built-in Semantic MediaWiki `Export pages to RDF` functionality. Using this functionality, it is possible to generate a document in OWL/RDF format containing information on the properties used in the pages describing the model. However, since this functionality has been developed independently with respect to the use of the Semantic MediaWiki that we propose, an automated postprocessing of this file is necessary in order to be able to generate an OWL ontology consistent with the informal model designed. For example, a page describing a domain concept is mapped by the `Export pages to RDF` functionality to an instance of a top class `smw:Thing`, while in our approach it should be mapped to an OWL class. Similarly, the "is a" relation is mapped by the `Export pages to RDF` functionality to an object property named `is a`, while in our approach this relation needs to be mapped to the RDFS `subClassOf`

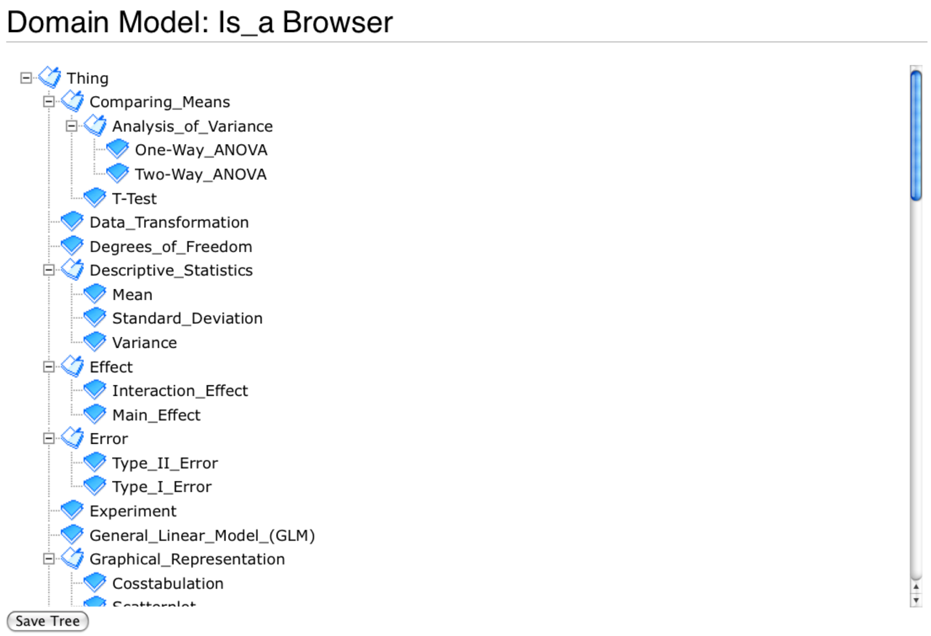

Fig. 7. The taxonomy of the concepts in a domain model shown via the IsA browser. Note the `Save Tree` button, which allows to save the class/subclass hierarchy after changes made via drag 'n' drop.

relation.

Reviewing MoKi against the claims made in the beginning of the paper, it:

1. Supports access to the enterprise model at different levels of formality (informal, semi-formal and formal) in that it (i) accommodates highly informal modelling based merely on hyperlink connected wiki pages as well as (ii) semi-formal modelling where pages and links are raised to a semantic level, and (ii) enables formal modelling by an easily accessible translation into formal models via an export functionality.
2. Supports integrated modelling of domain, processes and competences within an enterprise by providing one homogeneous interface for modelling all relevant aspects of an enterprise, and enabling knowledge engineers to interconnect models describing these aspects in a quite natural way.
3. Ensures a coherent development of the formal part by providing an import functionality which allows a re-translation of formal models into MoKi.

4 Use Cases and User Study

The MoKi has been successfully applied within the EU-project APOSDLE to develop enterprise models in six different domains: Information and Consulting on Industrial Property Rights, Electromagnetism Simulation, Innovation and Knowledge Management, Requirements Engineering (the RESCUE methodology), Statistical Data Analysis and Information Technology Infrastructure Library. Some of the experiences of an early usage of the system are described in [3]. In addition, MoKi is used in applications that go beyond typical enterprise modelling: the representation of medical guidelines encoded in the ASBRU language[13], and the collection of data for the Personal Health Record of the Province of Trento, Italy[14]. The work done in these projects, as well as the analysis of the usage of MoKi in APOSDLE constitutes an important step towards the improvement of the tool and realisation of the full framework.

User study A qualitative evaluation based on the usage of the MoKi between September 2008 and January 2009 by four application partners modeling five different enterprise domains in the scope of the APOSDLE project was carried out. The evaluation took the form of structured interviews with both open and closed questions. Interview questions targeted not only MoKi but the whole modeling process implemented in APOSDLE [10]. Modeling activities in APOSDLE involved domain experts, on-site knowledge engineers as well as external knowledge engineers. the interviews were carried out with the on-site and external knowledge engineers but not directly with the domain experts.
All participants reported a positive experience of MoKi. In particular, the import (easy integration of previously available knowledge) and export functionalities (translation into formal models) were highly appreciated. Also, the homogenous modeling environment for modeling different aspects (domain, task, preliminary competency model) was found to facilitate the process. Furthermore, the participants reported that MoKi did facilitate collaboration among the modelling team.

5 Related Work

Solutions to the problem of modelling various aspects of an enterprise were proposed in several works, both in terms of definition of the meta-model and in terms of methodologies to support the creation of the model itself: a detailed comparison between state of the art approaches and the one proposed in this paper can be found in [4].

Many tools are available to support the creation of formal models in general. Most of them, e.g. Protégé [11], were born as standalone desktop applications. Despite the development of pug-ins that support collaborative features (e.g., Collaborative Protégé) the tools remain barely usable by users with limited expertise of formal languages. The MoKi does not directly compare to such tools, since it is not a modelling tool for a specific formalism but rather for specific kinds of entities (concepts, tasks etc.). The support for concrete formalisms lies in the implementation of different export functionalities. Additionally of course,

[13] Part of the OncoCure project. See [9].
[14] Part of the TreC project. See trec.fbk.eu

MoKi aims to collect information about these entities at different levels of formality. Recently, wiki systems, and semantic wikis, have been applied to support collaborative knowledge creation and sharing. We mention a few of them, and assume for all that they offer "traditional" wiki functionality, i.e. web-based, easy text edition and linking to web resources, integration of multimedia content and versioning.
There is already at least one proposal in which the modelling of processes is done using the pure Semantic MediaWiki, see Dengler et al [12]. Semantic MediaWiki+ (SMW+) [13] is a further extension on Semantic MediaWiki with a focus on enhanced usability for semantic features. Especially, it supports besides the annotation of whole pages also the annotation of parts of text and offers additional funtionalities termed "knowledge gardening" functionalities. The latter are maintenance scripts at the semantic level, with the aim to detect inconsistent annotations, near-duplicate entries etc.
IkeWiki [14] and OntoWiki [15] are two more semantic wikis, both however are completely independent from pre-existing wiki systems. Java-based IkiWiki supports the semantic annotation of pages and links between pages with semantic. Annotations are used for context-specific presentation of pages, advanced querying, consistency verification or drawing conclusions. IkeWiki also directly supports reasoning on its knowledge base. Continued development of IkeWiki now takes place within the EU-project KIWI [16]. OntoWiki seems to focus slightly more directly on the creation of a semantic knowledge base, and offers widgets to edit/author not only single elements/pages but also whole statements (subject, predicate, object).
AceWiki [17] was developed in the context of logic verbalisation, and is based on research to verbalise formal logic statements, and inversely translate backwards English statements into formal logic. AceWiki is based on Attempto Controlled English - ACE, which allows users expressing their knowledge in near natural language (i.e. natural language with some restrictions). Note that although such content may look like natural language, in contrast to the informal fields in MoKi for instance, it is actually formalised, i.e. follows some rules. In contrast to this, the content of the informal parts in MoKi, e.g. the descriptions of the model elements, is completely unrestricted.
myOntology [18] is geared towards the collaborative and community-driven development and maintenance of lightweight ontologies. In particularit has been applied within the context of E-Commerce.

What MoKi offers in addition are two main contributions:

- The support for the integrated specification of multiple aspects (in the use cases described above, this meant domain, process and competencies).
- The bi-directional transformation between formal and informal models.

6 Conclusions

In this paper we have presented MoKi, a new tool for collaborative enterprise modelling. The general framework and the tool we envisage constitute a genuine contribution towards supporting a fruitful collaboration among people with different skills and levels of expertise in the modelling activities. The current implementation of MoKi, developed inside the APOSDLE EU-project already provides key functionalities towards the modelling of an integrated enterprise model in a collaborative manner, and constitutes a first version towards the realisation of the full framework.

Future work focus on improving the tool and make it more general. Examples of future work include: a better support for domain and process modelling, including better support to the modelling of all the elements of the formal models; the integration of the competency model in the MoKi[15]; better support to define templates and to adapt to different meta-models; support for validation of knowledge in the MoKi by means of the domain experts.

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[15] The creation of the competency model was initially envisaged and performed in APOSDLE via the TAsk-Competency Tool (TACT) [10], developed by the Know Center outside the MoKi. On-going work is focused on incorporating and extending the functionalities of TACT in the MoKi to fully support the modelling of domain, processes and competencies in an integrated manner.

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