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Revision Support for Modeling Tasks, Topics and Skills

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Abstract: Whatever purpose models are created for, they need to be evaluated in order to ensure that they will serve their intended use. Unfortunately, model evaluation is a significant effort and no standard clear-cut evaluation methodology exists today. In this work we introduce our approach of distributing the evaluation effort over the whole modeling process. This is achieved by providing (partly automated) feedback on the models in different stages of development. We illustrate our approach based on the specific goal of modeling tasks, topics and skills for the adaptive work-integrated learning system APOSDLE.

Key Words: knowledge management, knowledge representation, modeling, model evaluation, semantic technologies
Category: M.4 (Knowledge Modeling)

1 Introduction

Intelligent automated support for knowledge workers is a key challenge for knowledge management research. To cut down on the time wasted by knowledge workers in searching for information both on their desktops or on the intra- and internet, a variety of intelligent technologies have been proposed. Examples include systems for semantic information processing of online documents as is the goal of the Semantic Web, knowledge-based systems [Buchanan & Smith, 1988], or adaptive systems [Jameson, 2003]. What all these systems have in common is their commitment to a conceptualization of the domain [Gruber, 1995]. Systems for work-integrated learning need a representation of tasks on the one hand and of users in terms of their respective skills and preferences on the other hand

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in order to provide personalization [Fischer, 2001]. In a more general context, such conceptualizations of the domain have also been termed *enterprise models* [Fox & Grüninger, 1998]. In addition to a description of processes and activities, key concepts and skills, enterprise models often describe also other aspects of an enterprise such as organizational structure. The quality of the models underlying an intelligent system baselines the quality of the support that can be achieved with it. The focus of this paper is to introduce tools that trigger model revisions iteratively throughout a process of modeling tasks, topics and skills.
The modeling process and tools have already been applied in six domains in the context of the APOSDLE project[2]. These domains comprise requirements engineering, statistical data analysis, innovation management, industrial property rights, a software library and simulation of electromagnetic phenomena.

2 Revision Support as Integrating Evaluation into Modeling

Our approach to evaluation is to give feedback on desired qualities of the models as immediately as possible during modeling. We see evaluation not as separate activity with the purpose to "grade" the models (after they have been created) but as an inherent part of the modeling activities. This includes that revisions must be triggered in case the models are found to be lacking in any aspect. Furthermore, model evaluation has to be done with respect to the purpose for which the model was created. Such an approach is related to the idea of "competency questions" [Fox & Grüninger, 1998] which specify which queries a model should be able to answer. Our integrated modeling method (IMM) [Rospocher et al., 2008] adheres to these principles and is similar to [Angele et al., 1996] but extends this approach by additionally integrating the modeling of skills.

2.1 Tasks, topics and skills

As argued above, knowledge-based systems that aim at delivering context-based, personalized information to workers at their workplace need to be aware of tasks, topics and skills within a given business or learning domain. The knowledge base whose creation is supported by the IMM therefore consists of three submodels which are constituted by these different elements (see Fig. 1).
A *task model* provides a formal description of the tasks the prospective user of the system (knowledge worker, learner) can perform. The task model identifies and groups tasks occurring in a business domain. In a task model, the control flow and other interdependencies between tasks are described. A *domain model* provides a semantic and logic description of the topics within a business or learning

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domain as well as the relationships between them. A *skill model* establishes a relationship between the domain model and the task model. A task is mapped to those topics of the domain model knowledge about which is required in order to perform the task successfully. That way, a skill is defined as knowledge about a specific domain topic together with the ability to apply this knowledge within the specified task. For conceptual clarity, skills are modeled as entities separate from topics. Building skill models as *overlay* of the domain model is popular in the context of adaptive learning systems [Brusilovsky & Millán, 2007].

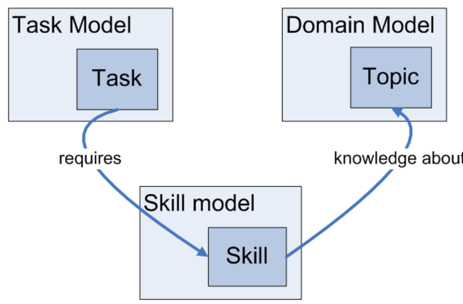

Figure 1: Knowledge base constituted of tasks, topics and skills.

Example In the domain of innovation management, a typical task is for instance “Carry out situation analysis”. “Core competency analysis”, “benchmarking” or “brainstorming” are exemplary topics in the domain. For this short example, one could state that in order to “carry out a situation analysis” one needs to have basic knowledge about “core competency analysis” and “benchmarking”. “Basic knowledge about core competency analysis” and “Basic knowledge about benchmarking” then consitute skills.

2.2 General requirements on formal descriptions

We argue that the following requirements for formal descriptions of tasks, topics and skills hold in general. Additionally, specific requirements on the knowledge base have to be derived based on every concrete system.

Tasks are typically utilized to provide support contextualized to the task at hand. In order to fulfil this goal, tasks need to have names and verbal descriptions that are intelligible to prospective users. Furthermore, they need to be at a level of granularity that would provide an appropriate answer to the question “What are you currently doing?”. Clearly, the modeled control flow needs to be correct.

Topics are typically needed to identify relevant resources to the user. Therefore, topics also need to have intelligible names and verbal descriptions. Furthermore, the specialization hierarchy between topics should be correct and the established relationships between topics should be meaningful.

Skills typically enable the system to personalize its functionality to the characteristics of an individual user. First, it is desirable that skills are required by multiple tasks in the domain[3]. Second, the relation between tasks and skills needs to be correct.

Naturally, the formal descriptions need to be satisfiable and consistent. Additionally, *completeness* (every task/topic/skill which is relevant is represented in the models) and *agreement* by preferably many domain experts are desirable qualities for the knowledge base. Any assessment of correctness must also include implicit knowledge, i.e. inferences that will be made by a system based on the explicitly asserted knowledge base.

3 Integrated Modeling and Model Revision

The integrated modeling methodology (IMM) provides a coherent framework to create models integrating tasks, topics and skills. Accompanied by a variety of semantic tools, the IMM establishes revision support as inherent part of the modeling process. An overview of the IMM, supportive tools, and techniques is given in Figure 2. The description below focuses predominantly on the aspect of revision support. An extended description of the IMM, its accompanying tools, and evaluation of both method and tools is given in [APOSDLE D1.6, 2009].

Note that the revision support given by the IMM is not a rigorous evaluation of taxonomic relations such as provided by OntoClean [Guarino, 2004]. Instead, it focuses on triggering revisions regarding multiple properties of an ontology such as usability, intelligibility, appropriate connectivity etc. as shall be made clear below.

3.1 Phase 1. Scope & Boundaries

In this phase the scope and boundaries of the application domain are determined and documented. This phase also encompasses collecting knowledge about the target domain. No differentiation between different kinds of elements such as tasks, topics or skills or structuring of elements needs to be made yet. At the end of this phase, the suitability of the chosen target domain for a knowledge based system should be confirmed. Furthermore, the scope of the application domain should be clear, and core concepts (tasks, topics, or skills) should be identified.

[3] Otherwise the skill model would become redundant and only a task model would be necessary (indicating whether or not someone has performed a given task.

IMM Phase	Modeling Tools	Revison Support
Scope	Knowledge elicitation techniques Textmining functionalities in MoKi	Interpretation guidelines
Tasks / Topics	MoKi	Modeling and revision guidelines Automated checks Ontology Questionnaire
Skills	TACT	Modeling and revision guidelines Automated checks

Figure 2: The IMM, tools and revision support.

Knowledge is elicited from domain experts and from digital resources. For the first, standard techniques such as structured interviews, card sorting and laddering are used. For the second, text mining functionalities such as term extraction and document clustering [Pammer et al., 2007] are offered. These functionalities are integrated in the MoKi (see next section for details), to allow easy integration of extracted terms into the modeling environment.

Revision support.

Revision support in this phase must identify the suitability of the application domain to the target knowledge based system. For instance, a rapidly changing domain is a counter-indication for the application of a model-based system. Beyond this, revision support in this phase is by nature system specific. As an example, for the APOSDLE system questionnaires help elicit the main tasks and learning needs of the prospective users and additional aspects of their workplace context which may affect the success of APOSDLE in the environment. These questionnaires are accompanied by written guidelines which provide first-cut rules to early identify potential problems [APOSDLE D2.8/3.5, 2009, Chap. 7.3]. The parallel approach to knowledge acquisition from different sources (experts and documents) helps to ensure completeness of the models.

3.2 Phase 2. Integrated Modeling of Tasks and Topics

The goal of this phase is to provide a complete description of the task and topic models and their inter-relations, starting from the knowledge elicited in Phase 1. At the end of this stage, the task and topic models should be correct and complete, verbal descriptions should be available, both models should reasonably overlap and be related to digital resources.

Modeling tool: MoKi.

Modeling in this phase takes place in MoKi [Ghidini et al., 2009], a wiki-based tool which extends Semantic MediaWiki (SMW) [Krötzsch et al., 2005] with the specific goal to support domain experts in creating the task and topic models. A demo version of MoKi is available on-line at `moki.fbk.eu`.
Users provide the descriptions of tasks and topics by filling out pre-defined templates provided in MoKi. Interaction with the models is simplified by providing convenience functionalities such as visualizing hierarchies as trees. The content of the templates is converted into OWL descriptions based on a specification of how to formalize the content of distinct fields. For instance, the topic template contains a field "is a". If for the topic "brainstorming" this field is filled with the topic "creativity technique", this gets translated into the OWL subsumption statement that "'brainstorming' is a subclass of 'creativity technique"'.

Revision support.

Model revision in this phase is supported through *guidelines* for modeling and reflecting on existing models. They are formulated as questions to the knowledge engineers and domain experts. For instance, one question regarding the domain model is "Should some concepts be grouped together below a common superconcept?" These manual checks are in practice highly integrated with actual modeling, and target all requirements on task and domain models as described above.
Second, *automatic checks* provide an overview over formal properties of the models such as missing verbal descriptions or isolated elements which are not connected to other elements. Such properties are directly computed from the OWL version of the models contained in the MoKi.
Finally, Phase 2 encompasses an automatically generated *ontology questionnaire* in which implicit knowledge in the models is fed back to the knowledge engineers and domain experts in order to assess its correctness. The underlying rationale is that, depending on the underlying formalism and complexity ("size") of the models, it is often not obvious which knowledge can and will be automatically inferred. For instance, in a domain model on innovation management the statement "Imaginary brainstorming is a creativity technique" was inferred from the explicit statements made in MoKi, that "imaginary brainstorming is a brainstorming technique" and that "brainstorming is a creativity technique". The objective is to trigger a reflection process on the side of the domain expert about whether the modeled hierarchy is modeled as intended. In case of disagreement, the ontology questionnaire offers the possibility to examine the reasons for unwanted inferences and to remove them selectively. In contrast to displaying the hierarchy in a tree view, as e.g. in MoKi or in Protégé [Protégé, 2000], the ontology questionnaire displays each subsumption in a separate line.

3.3 Phase 3. Modeling of skills

In this phase, the skill model is created by relating tasks to topics via a specific "requires" relation. The goal is to create a complete and correct model through multiple iterations, i.e. all but only relevant mappings between tasks and topics should be present after this phase.

Modeling tools: TACT.

The *TA*sk-*C*ompetence *T*ool (TACT) supports the activity of creating a skill model by assigning required topics to tasks. Obviously, the minimum required functionality consists of importing the task and topic models, assigning topics as required knowledge to tasks and exporting the skill model. TACT exports a skill model as an OWL ontology, and a symmetric import functionality exists. Furthermore, a functionality to compute a prerequisite relation [Ley et al., 2008] between skills exists. To provide an integrated modeling environment, TACT also offers a specific import functionality for the preliminary skill model created in MoKi through simply linking tasks and topics.

Revision support.

Revision in this phase targets the whole knowledge base, but particular emphasis is on revising the properties that refer to skills. In particular, a tight integration of task and topic models via the skill model must be ensured since this connectedness is the basis for personalization. TACT provides feedback on disconnected elements by highlighting tasks and topics which are not yet connected through the skill model.
Additionally, as in Phase 2, there is a set of automatic checks based on the OWL version of the APOSLDE knowledge base. Again, they uncover unconnected tasks and topics, as well as give an overview over skills which are only required for a single task (see requirements on the skill model in Sec. 2.2 for why this is undesirable).

4 Conclusion and Outlook

With this contribution we have introduced a suite of methods and tools embedded within the integrated modeling method for enterprise model creation. The IMM and tools have been specifically developed for the modeling activities required for the adaptive work-integrated support system APOSDLE. Within the context of the APOSDLE project the IMM as well as early versions of the tools have been applied and evaluated [APOSDLE D1.6, 2009]. In more recent work the described revision support was found to be very helpful for conveying desired model characteristics and improving the resulting domain, task and skill models.

Ongoing work is dedicated to an in-depth systematic evaluation of the method and tools with regard to perceived support and usefulness for knowledge engineers, as well as with regard to the quality of resulting models. Future work is directed towards improvement and integration of MoKi and TACT.

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