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An Interdisciplinary Approach on Operational Knowledge Process Modeling and Formal Reasoning

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An Interdisciplinary Approach on Operational Knowledge Process Modeling and Formal Reasoning

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Abstract: On the one hand models can be used as navigational tools respecting mental processing capabilities of persons. On the other hand models can be analyzed automatically by information systems to deduce relevant content for knowledge management IT-components as E-Learning-Applications, KM-Portals, document management systems, etc.. Therefore models of knowledge intensive business processes are a natural integration layer for persons and information systems providing the relevant context to interpret and handle information the right way. It has only to be solved how to interface these models efficiently from a person as well as from an information system point of view.
Key Words: knowledge management, topic maps, semantic web, reasoning, KMDL, process, model, human interfacing, mental model
Category: H.1.0, H.1.2, H.5.2, H.5.3, I.2.4, I.2.m, J.1

1 Introduction

Since business process oriented knowledge management approaches (BPO-KM) become more and more mature, they're still facing several hurdles which obstruct companies from accessing "the source of lasting competitive advantage" [Nonaka and Takeushi 2001]. Today's BPO-KM approaches have already evolved strongly, but there are only a few who discuss integration into operational business processes environments [Riempp 2004]. Some approaches provide a framework which enables KM to be handled in a project-like manner, which leads to treat KM as a special discipline that is driven beside operational business processes, mostly targeting on process optimization.
This paper introduces an interdisciplinary approach, especially focussing on the integration of three modeling areas, which are Business Process Modeling [Section 2], Human Oriented Interfacing [Section 3] and Formal Reasoning [Section 4]. Thereby we intend to facilitate an operational integration in daily business scenarios [Section 5].

2 The KMDL Modeling Approach

We are using KMDL *(Knowledge Management and Description Language)* for modeling knowledge intensive business processes [Gronau et al. 2005]. KMDL is used in several practical projects (e.g. Kraft Foods, Bosch or KarstadtQuelle, see also [Kopecny and Höpfner 2004], [Häfen and Kopecny 2005]) analysing and optimising knowledge intensive processes. KMDL consequently considers the differentiation between tacit and explicit knowledge introduced by [Polanyi 1966] which is hardly covered by other business modeling approaches although it is vital for knowledge management purposes. KMDL covers the well known knowledge conversions [Nonaka and Takeushi 2001] between both forms of knowledge. We will introduce KMDL principles by using an extreme simplified knowledge intensive business process known from software engineering [Fig. 1]. Such models can be modeled with the tool K-Modeler[1].

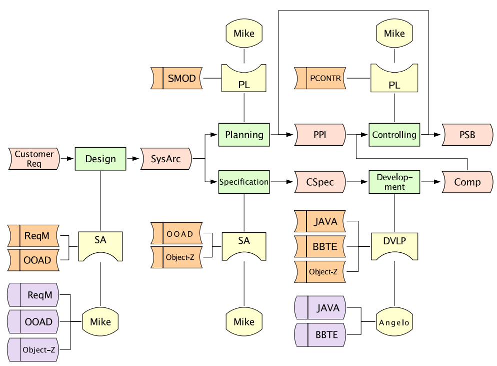

Figure 1: Example of a knowledge intensive SW Engineering process

The foundation of business processes are tasks (e.g. *Planning* or *Specification* in figure 1) structuring the succession of activities. Tasks process input information (e.g. a system architecture *(SysArc)* in figure 1) and produce output information (e.g. a project plan *(PPl)* or a component specification *(CSpec)*). These information objects represent explicit knowledge as described above. Tasks are executed by roles (e.g. a project leader *(PL)* or a system architect *(SA)* in figure 1). A role is executed by a person (e.g. *Mike* in figure 1). A person performs typically more than one role. Each role has special requirements (e.g. *OOAD*[2] or *Object-Z*[3] in figure 1) which are necessary to execute a task properly. These role requirements represents tacit knowledge which should be known by a person to perform a role. Each person (e.g. *Mike*) is assigned a set of knowledge

[1] see `http://www.k-modeler.de` for details
[2] The ability to perform object oriented analysis and design (OOAD) activities.
[3] The ability to read, understand and create formal object orientied specifications with a specification language called Object-Z.

objects (e.g. *ReqM*[4], *OOAD* and *Object-Z*). Knowledge objects represent tacit knowledge as described above and correspond with role requirements already explained. By comparing the knowledge requirements with the knowledge objects assigned to a person it is possible to deduce how qualified a person is to perform a task. We will cover this more deeply in [Section 4].

3 HCI Requirements in BPO–KM

The major aim of Human Computer/Machine Interfacing (HCI/HMI) is to adapt the interface between technical or other complex processes to humans. Principally this area of research is interdisciplinary and considers – apart from software technology and classic ergonomics – cognitive psychology. In this context cognitive psychology is related to human problem solving and cognitive process modeling. Both seem well suited to be adapted in the case discussed here.

What are the model requirements to provide an interface between human cognitive processes and BPO-KM? How can explicit knowledge be mapped, integrated and merged into a BPO-KM Model? Before this question arises, it is important to have a brief look on the HCI problem of BPO-KM:
A person who is involved in a business process has a specific mental model of this specific real part of an organization. Every time this person interacts with the process, externalization and internalization can take place, according to the conversion processes described in [Section 2]. The externalization leads to one or more specific information objects, which are objects of the business process. When internalization takes place, the internal, or *Mental Model* about the specific circumstance or fact (in this case the BP), will be aligned.

Mental Models are representing how an individual understands a specific part of the real world. Thus, [Dutke 1994] concludes, mental models are the base to plan and control activity. In supervisory control tasks of complex processes e.g. flying a plane or processing a chemistry plants, the interaction design (HMI) has a significant impact on the ability of a proper process handling and successful operation. Those interfaces are mostly graphical and built to fit to mental models to support cognitive work [Johannsen 2000].
Adapting this to business processes, we derive that an appropriate external (graphical) representation of a certain fact or circumstance (business process) can support cognitive processes (knowledge work) by fitting to the mental or cognitive model a person has. Thus, providing an adequate interface between the real world and the internal interpretation enables a defined and "standardized" externalization and also a supportive internalization.
Regarding the problem class discussed here, we analogously design in between the business process and the human who interacts with the process. Therefore

[4] The ability to perform requirements management activities.

we define five main requirements to the modeling approach: (1) it should provide a suitable knowledge representation, (2) it should cover and implicitly contain the business process model with all relevant objects, (3) it should cover HMI requirements supporting the mental model idea, (4) it should support a dynamical model, enabling permanent changeability and (5) due to the fact that BPs involve multiple persons, multiple mental models need to be handled within the modeling approach.

Regarding (1) we introduce semantic networks using Concept Maps as discussed by [Grillenberger and Niegemann 2000], technically based on Topic Maps which are mostly state of the art. Regarding (4), Topic Maps support an *autopoietic* system, which has the ability to autonomously evolve itself by using it [Widhalm and Mück 2002]. Furthermore they provide merging mechanisms to support (5). Semantic networks are significantly based on cognitive science findings and do therefore suite well to (3). Regarding (2), this approach contains a translation mechanism between business process model, modeled with KMDL see [Section 2], and (1), the semantic network for knowledge representation [Fig. 2]. Via this interface, models can be transformed from and to the knowledge representation model.

Apart from the visualization, there are important elements which cannot be visualized and potential deductions which are hidden due to graphical complexity. Hence, a deduction mechanism has be introduced to overcome this and to add reasoning and deduction capability to the model.

4 Formal Reasoning Approaches

Analysing models in the large is not appropriate for persons but for information systems. Imagine the task to identify all persons in a company (e.g. as complex as Siemens) which are not fully qualified to perform tasks they are planned for executing. This information is worthfull to optimize e-learning efforts, isn't it? Impossible? We will show exemplarily how to do it by using formal reasoning techniques known from the semantic web domain.

To handle models in the large we have to consider some constraints which are present in reality. *First* of all, no one will model complex aspects in one piece. Typically we have to consider a plenty of distributed models within an organization, each modeling local knowledge processing aspects. So it is necessary to integrate distributed models to one major model including all of the known facts. *Second*, no one will model every detail aspect but the essential. Therefore implicit facts have to be deduced from the essential which may be relevant for further analysis (e.g. conversions and resulting flows of knowledge not modeled explicitly). *And last but not least*, no one will understand a major model because of all the details obscuring the essential. Therefore mechanism are needed to filter relevant aspects out of a model.

To handle this, KMDL models have to be transformed into textual correspondents (formal models). We are using N3 because of its understandibility, simplicity[5] and dissemination in the semantic web domain. KMDL models expressed textually in N3 are called KMDL-N3 models [Kratzke 2005, Kratzke 2006a, Kratzke 2006b].

The following excerpt shows a part of KMDL-model from [Fig. 1] in its textual N3 representation.

```
eg:CustomerReq a kmdl:Information.
eg:OOAD a kmdl:KDescriptor.
[...]
eg:Mike   a kmdl:Person;
          kmdl:executes eg:SA, eg:PL;
          kmdl:knows eg:OOAD, eg:ReqM, eg:Object-Z.
eg:SA     a kmdl:Role;
[...]
```

KMDL-N3 models can be processed by a set of commands [Kratzke 2005]. The commands are implemented in Python and are using reasoning capabilities provided by the inference engine CWM[6]. `cup.py` is used to integrate a set of models simply by merging them as well as to enrich models with rulesets to deduce facts not modeled explicitly. The following line enriches a model by a remote ruleset.

```
cat model.kmdl | cup.py http://www.eg.org/rules.rule > mwr.kmdl
```

Models enriched by rulesets can be deduced by `think.py` which infers further facts. `filter.py` is used to reduce models to relevant aspects for an analysis. Filters are very similar to rules but they are used to reduce not to enrich a model. E.g. by using the following filter (`educations.filter`) it is possible to deduce missing *knowledge descriptors* of persons which are required due to roles.

```
{ <kmdl.in> log:semantics :model.
  :k a kmdl:KDescriptor.
  :p a kmdl:Person.
  :p kmdl:executes [a kmdl:Role; kmdl:requires :k].
  :model log:notIncludes { :p kmdl:knows :k }.
} => { :p kmdl:missing :k }.
```

The following command line deduces all persons which know less than required.

[5] See `http://www.w3.org/2000/10/swap/doc/Overview.html` for a N3 tutorial.
[6] See `http://www.w3.org/2000/10/swap/doc/cwm.html` for details.

```
cat model.kmdl | filter.py educations.filter > education.result
```

Applied to the model introduced in figure 1 the following result (the missing knowledge per person) is produced. It can be easily transformed to XML in order to be evaluated by an e-learning application proposing online courses [Kratzke 2005].

```
eg:Mike kmdl:missing eg:SMOD, eg:PCONTR.
eg:Angelo kmdl:missing eg:Object-Z.
```

5 Integration: Impacts and Benefits

We may ask why enterprises and companies haven't reached the goal of a sustainable benefit by inventing and operating a BPO-KM method. Dividing BPO-KM in it's main components – BPO and KM – which are elementary dynamical, one general issue may be identified: current approaches hardly support these dynamics and furthermore they don't enable any deduction on BP models. Combining the three components as described within this paper, we're heading towards a model which allows to overcome this barrier. Apart from combining the three introduced modeling areas, it is necessary to integrate the model into day-by-day operations. Therefore we've enhanced the KMDL methodology, which originally consists of a more static procedural model [Gronau et al. 2005], focussing on the BP analysis phase, by providing a BP interface for operational purposes. The BP interface is derived from the KMDL model by transforming it into a concept map [Grillenberger and Niegemann 2000]. This representation is used as a HCI/HMI between knowledge worker (KW) and the business process [Fig. 2]. The KW will interact with the BP using the concept map[7]. He/She will be able to add or remove information or knowledge objects, arising from their own deduction or referring to other knowledge or information objects fitting into their specific domain. Furthermore the process components which are part of the concept map, can be added, changed etc. as well[8]. These changes may lead to a significantly changed BP model. This means that the overall BP structure may have changed, and the model may become inconsistent. Therefore the model can be retransferred from topic map to KMDL and then be detailed analyzed with the formal reasoning methods, using KMDL-N3 processors described in [Section 4]. Furthermore standard BP analysis can be done with KMDL tools. Those analysis and maintenance processes can be performed at every time to receive the most valid status of the BPO-KM.

KMDL-N3 offers several formal reasoning methods, e.g. to deduce flows of knowledge which are induced by process design. Furthermore it is possible to formulate restrictions on models. These restrictions can be used to assure necessary

[7] front-end is based on TouchGraph, see http://www.touchgraph.com
[8] see [Jørgensen 2004] who developed an interactive process model approach

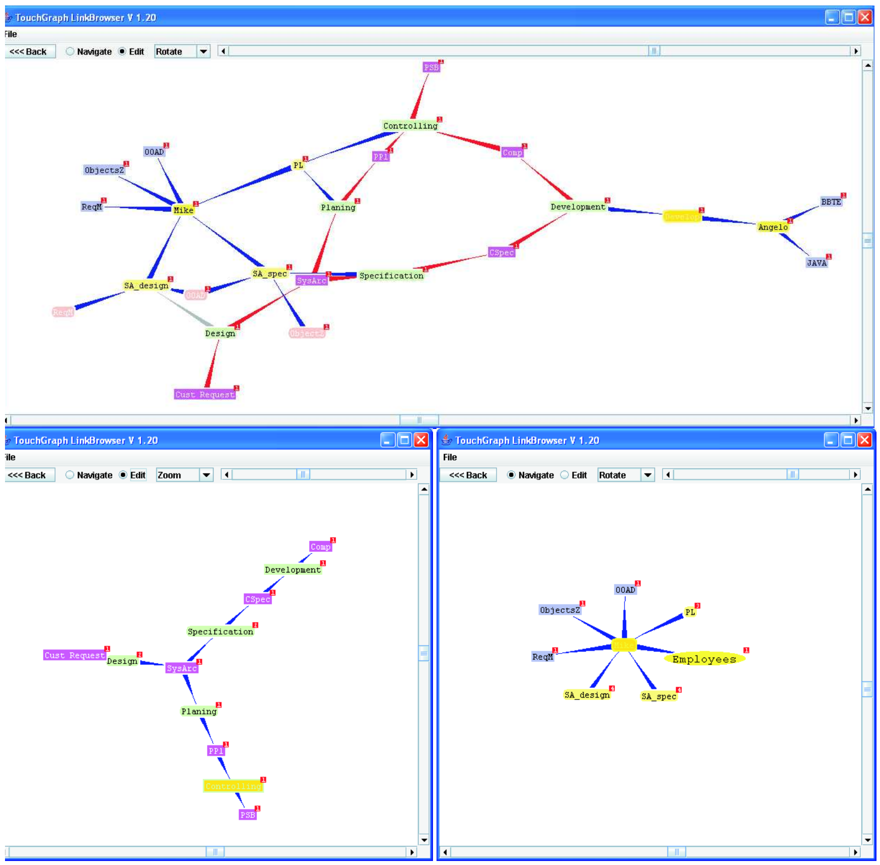

Figure 2: *Process Map* and views derived from KMDL model in fig. 1

or prevent unwanted flows of knowledge or knowledge process designs assuring "wanted" and preventing "unwanted" process evolution. Each of these positive impacts and benefits are essential for dynamic business process management because huge parts on manual model updates could be automatized which has to be done actually by hand.

6 Summary and Outlook

K-Modeler is appropriate for modeling knowledge intensive business processes. The described concept map HCI interfaces KMDL models is appropriate for interactive knowledge work based on models but these features are not very well integrated with the K-modeler. KMDL-N3 is an efficient backend processing tool based on semantic web tools. But as well as the concept map HCI it is not deeply integrated with KMDL and the K-Modeler. Our further mission is to merge these three streams of development into one powerful framework for an integrated, operational and business process oriented knowledge management platform.

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