A Development Method for Ontology Based Business Processes

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Abstract: In this paper we show our development method for executable ontology based business processes. The main goal is the reusable, automatic generation of workflows based on ontologies derived from business process models. In our methodology the focus is given to the mapping the conceptual models to ontology models by using meta-modeling approach. In our proposed approach we establish the links between business model elements and ontology concepts. The „conceptual models - ontology models” converter maps the Adonis model elements of a business process to the appropriate ontology elements in meta-level. The key ambition in our methodology is to capitalize the synergy between the collaborative use of modern application development paradigms and methods in order to generate automated workflow software.

1. Introduction

The business process design based software development paradigm means a promising trend in application development. Application development methodologies have traditionally been driven by programming and not organizational concepts, leading to a semantic gap between the software system and its operational environment. Business process modeling aligns the business goals and incentives with the IT software design process. Ontologies play decisive role in turning process models into working software, providing a visual and textual representation of the processes, data, information, resources, collaborations and other measurements. In our approach the focus is on the automatic generation of workflow systems based on ontologies derived from business process models.

The main challenge in Business Process Management (BPM) is the continuous translation between the business requirements view and the IT systems and resources. Semantic Business Process Management (SBPM) is a new approach of increasing the level of automation in the translation between these two levels, and is currently driven by major players from the BPM, and Semantic Web Services area. The core paradigm of Semantic Business Process Management is to represent the distinct levels using ontology languages and to employ automated translation. [8]

It has been common sense to first determine business requirements and then to derive IT implementations, to develop software according to ideal processes as determined by business logic. Business processes have to perform well within the dynamic organizational environments. Business Process Management comes closer to its promises if it allows for a better automation of the translation between the business level and the software systems. [8]

During the phases of development and implementation, conceptual models are used to support the requirements engineering process. Conceptual models also facilitate tasks such as the exploration, documentation, and validation of requirements. This allows discovering and
correcting possible errors at an early stage. [13] [12] Conceptual modeling captures the semantics of an application through the use of a formal notation, but the descriptions are intended to be used by humans and not machines. The semantics contained in these models are especially implicit and cannot be processed. With semantic schema the creation and the use of the conceptual models can be improved, furthermore the implicit semantics having been contained in the models can be – partly - articulated and used for further processing.

Conceptual business process models are particularly convenient for discussion with non-technical users. Conceptual modeling captures the semantics of an application through the use of a formal notation, while the descriptions resulting from conceptual modeling are intended to be used by business process modelers and decision makers. [7]

Ontologies basically provide the semantics and they describe both the semantics of the modeling language constructs, as well as the semantics of model instances. With utilizing an annotation scheme over the ontology language the automatic creation of workflow processes can be achieved.

The key ambition in our methodology is to capitalize the synergy between the collaborative use of the modern application development paradigms and methods in order to generate automated workflow software.

The paper will be structured as follows: First, theoretical overview about ontologies and semantic business process management (SBPM) is described. The research approach for ontology-based workflow development is presented in the following section. We present an application of the approach in eBest (Empowering Business Ecosystems of Small Service Enterprises to Face the Economic Crisis) research [3] project. Finally, conclusion and future work are shown.

2. Theoretical Overview

2.1 Ontologies

The concept of ontology is used in many different senses and in a contradictory way. The word has a Greek origin – it was originally composed of the words being + discipline. It became public as philosophical tendency, where ontology is a nature and organization of being. Naturally it is interpreted from the viewpoint of information systems in another way. In this area our first goal is to give a formal description of a specific domain, a task or an application. Several definition are available in the literature, one of the most commonly used is Gruber’s definition for ontology.

“An ontology is an explicit specification of a conceptual model (conceptualisation)” [6]. The conceptual model or the conceptualisation is a kind of ideology in the wider sense; it reflects the mind of the specific domain. The ontology may appear in different forms but it has to contain the terms, terminology and semantics of the domain. It always is the appearance of collective specific domain interpretations that helps communication between the parties concerned. This common base enables the correct and successful information exchange that provides possibilities for reusability, public use and operation. Wielinga and his colleagues connected ontologies to agents: “The ontology is a theory of what entities can exist in the mind of a knowledgeable agent” [14]. Schreiber and his colleagues definition is based on the ontology building process in KACTUS project [10]:

“Ontology provides the means for describing explicitly the conceptualisation behind the knowledge represented in a knowledge base.” Another approach for ontology building is to reuse parts of large ontologies [11]:

“An ontology is a hierarchically structured set of terms, for describing a domain that can be used as a skeletal foundation for a knowledge base”. In this way the same ontology can be used for creating several knowledge bases, which can share the same taxonomy.
According to another approach, the role of ontology is to express the knowledge of a specific field with the aid of a vocabulary, using general expressions out. In this case the ontology defines the facts of the domain with the expressions retrieved from a vocabulary. In this explanation the ontology is a collection containing general facts that we would like to share for using it on wider area. We can distinguish the next three categories of ontologies application:

- Communication: between humans - informal, unambiguous ontology can be used for these purposes.
- Cooperation: between systems - it means translation among different tools, paradigms, languages and software instruments. In this case the ontology is the basis of the data change.
- System design and analysis - the ontology can support the analysis and design of software systems with submitting a conceptual description.

These approaches have several advantages:

- Reusability: the ontology is the root of the formal description and coding of the most important entities, attributes, process and its internal relations. This formal description provides (maybe through automated translation procedure) the reusability and the common or shared use inside the given software.
- Knowledge acquisition: speed and reliability of knowledge acquisition can be accelerated, if ontology can be used for analysis or knowledge base creation.
- Reliability: automatic verification of consistency can be assured by the formal description.
- Specification: ontology enables the analysis of requirements and the determination of information systems specification.
- Standardization: top-level ontologies can be used well in different situations. New types of task and application ontologies can be derived from these top-level models with specialization.

Ontologies have key role in semantic web [1] as well. More authors draw parallels between the ontologies and the role of XML in data representation. Ontology describes not only data, but also the regularity of connection among data. Probably the most important description language of semantic web will be the OWL (Web Ontology Language) preferred by W3C.

2.2 Semantic Business Process Management

Business process management has gained significant attention by both research and industry, however, the degree of mechanization in BPM is still very limited and BPM does not provide a uniform representation of an organization’s process space on a semantic level, which would be accessible to semantic functions, like intelligent queries.

The simplified, workflow-centric view on business processes are reduced to the sequencing of activities and the languages, like BPEL and tools for modelling business processes focus on control flow patterns. Lack of machine-readable representation of business process space as a whole on a semantic level is one of the major obstacle towards mechanization of BPM. Semantic Web and Semantic Web services (SWS) technology provide suitable large-scale, standardized knowledge representation techniques to overcome this barrier. Fensel and his colleagues propose to combine SWS and BPM and yield one consolidated technology, which they call Semantic Business Process Management (SBPM) [4].

Semantic Business Process Management is a new approach of increasing the level of automation of BPM by representing the various spheres of an enterprise using ontology languages and Semantic Web Services frameworks. The goal is to be able to apply machine
reasoning for the translation between these two spheres, in particular for the discovery of processes, process fragments and for process composition. [8] The use of ontologies is a key concept that distinguishes SBPM from conventional BPM. Within SBPM two types of ontologies are utilized: domain ontologies and SBPM specific ontologies. Domain ontologies support process modeling in terms of describing the actual data that is processed during process execution. Via this semantic description of the data, business process analysis can be semantically enhanced since the semantic meaning of the data is preserved during all phases of the process lifecycle.[9]

3. Our Development Methodology for Workflow Generation using Ontologies

In our methodology the focus is given to the extension and mapping the conceptual models to ontology models by using meta-modeling approach. The usage of semantic technologies doesn’t affect the main phases of the BPM lifecycle, but increases the automation degree within the phases and enhances the BPMS functionalities. Meta-models offer intuitive way of specifying modeling languages and are suitable for discussion with non-technical users. Meta-models are particularly convenient for the definition of conceptual models. In our proposed approach we establish the links between model elements and ontology concepts.

3.1 Conceptual Modeling

Business Process Modeling is the first phase of the BPM lifecycle. In the case study discussed in the paper the business process models have been implemented using the BOC ADONIS modeling platform. [2] The main application area of ADONIS is Business Process Management. We selected this modeling platform because of its popularity in modeling practice. However, our approach is principally transferable to other semi-formal modeling languages. ADONIS is a graph-structured Business Process Management language. The integral model element is the activity.

![ADONIS Model types](image)

The ADONIS modeling platform is a business meta-modeling tool with components such as modeling, analysis, simulation, evaluation, process costing, documentation, staff management, and import-export. Its main feature is its method independence.
In the implementation phase the business process model is transformed to an executable process model, which can be deployed to a process engine for execution.

In our approach the next step after the modeling phase is the semantic annotation to explicitly specify the semantics of the tasks and decisions in the process flow. The semantic annotation can either be embedded in the workflow itself or can exist as an ontology outside the workflow. An ontology for ontology-based process modeling has to reflect also the semantics of the processes.

3.2 Conceptual Model – Ontology Converter

For the extension and mapping the conceptual models to ontology models by using meta modeling approach the models are exported in the structure of ADONIS XML format. The „conceptual models – ontology models” converter maps the Adonis model elements to the appropriate ontology elements in meta-level. The meta-level mapping is described in the following table:

<table>
<thead>
<tr>
<th>Adonis model elements</th>
<th>Ontologies concepts</th>
</tr>
</thead>
<tbody>
<tr>
<td>activity</td>
<td>class</td>
</tr>
<tr>
<td>process</td>
<td>class</td>
</tr>
<tr>
<td>subprocess</td>
<td>class</td>
</tr>
<tr>
<td>actor</td>
<td>class</td>
</tr>
<tr>
<td>task</td>
<td>class</td>
</tr>
<tr>
<td>event</td>
<td>class</td>
</tr>
<tr>
<td>start event</td>
<td>class (subclass of event class)</td>
</tr>
<tr>
<td>intermediate event</td>
<td>class (subclass of event class)</td>
</tr>
<tr>
<td>end event</td>
<td>class (subclass of event class)</td>
</tr>
<tr>
<td>resource</td>
<td>class</td>
</tr>
</tbody>
</table>
The model transformation aims at preserving the semantics of the business model. To avoid loss of information during the transformation inserting information into annotation attributes of the target elements is needed. The model elements must be annotated to get properly processed by the transformation, model and code generator tools.

There are various languages for the explicit and formal representation of an ontology. OWL is a standard from the World Wide Web Consortium. OWL will be used as the language for representing ontologies due to its increased acceptance. The Portégé-OWL application supports building ontologies based on the Web Ontology Language (OWL).

The general rule we follow is to express each ADONIS model element as a class in the ontology and its corresponding attributes as attributes of the class. This transformation is done by means of XSL translation which performs the conversion.

To specify the semantics of ADONIS model elements through relations to ontology concepts, the ADONIS business model first must be represented within the ontology. In regard to the representation of the business model in the ontology, one can differentiate between a representation of ADONIS model language constructs and a representation of ADONIS model elements. ADONIS model language constructs such as “activity”, as well as the control flow are created in the ontology as classes and properties. Subsequently, the ADONIS model elements can be represented through the instantiation of these classes and properties in the ontology. The linkage of the ontology and the ADONIS model element instances is accomplished by the usage of properties. These properties specify the semantics of an ADONIS model element through a relation to an ontology instance with formal semantics defined by the ontology.

A mapped ontology should define all the entities involved in the business process including how they relate to each other and what properties they have.

### 3.3 The annotation scheme

The OWL standard ontology is extended by the implementation of the semantic annotation scheme. The annotation scheme defines the following information in details:
• The structure of the process model, process steps, precedence schemes, joints, parallel steps.
• The process step data definition, attribute instances, attribute properties, together with localization and internationalization options.
• Special framework interaction types, such as linking of framework documents, personal and organizational stakeholders, contents, and non-generic functionality.

The resulting annotation scheme is an OWL-restriction ready one to be automatically processed by supporting software infrastructures. Annotations include information for handling special cases e.g.: how to connect ontology classes into the existing database schema or in which order the class properties need to shows up when we are presenting it on a form to the stakeholders of the processes, etc.

From the ontology document appropriate database schema files and web forms can be automatically created. By generating application parts this way, we can easily integrate changes made on ontology any time.

4. Conclusions

In this paper an ontology based business process development methodology was presented and our most essential experiences were explained. The main goal was the reusable, automatic generation of workflows based on ontologies derived from business process models. In the outlined approach the focus was given to the extension and mapping the conceptual models to ontology models by using meta-modeling approach. The method has been tested in a reference web architecture, where we have accomplished to create a general workflow management system based on generated processes.[3] We strive to further enhance the „conceptual models - ontology models” converter and the ontology annotation scheme, focusing on creating a standardized interoperable workflow definition for modern information architectures.

References


