Business Process Modeling and Implementation in Collaborating Environments

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Abstract- **The objective of this paper is to present a general methodology for the modeling of business processes and achieving the automatic implementation of workflow processes in supporting software architecture. The model has been tested in a reference web architecture, where we have accomplished to create a general workflow management system based on generated processes. The methodology is the outcome of the eBEST project, which deals with equipping SMEs and SME associations with state-of-the-art software tools for ecosystem-wide business collaboration. The architecture serves as a shared environment for the cluster members, where member companies can cooperate on collective activity of common interest. In order to fulfill this requirement, the ecosystems need a workflow management solution that can be freely customized for their specific needs. We have developed a general model of transformation from business requirements to executable process definition and the actual software implementation for automated generation and management of collaborative workflow instances.**

Keywords- Business Process Modeling; Semantic Business Process Management; Ontology; Model Driven Transformation; Workflow

I. INTRODUCTION

The objective of this paper is to present a general methodology for the modeling of business processes and achieving the automatic implementation of workflow processes in supporting software architecture. The model has been tested in a reference web architecture, where we have accomplished to create a general workflow management system based on generated processes. The methodology is the outcome of the eBEST project, which deals with equipping SMEs and SME associations with state-of-the-art software tools for ecosystem-wide business collaboration [4]. The architecture serves as a shared environment for the cluster members, where member companies can cooperate on collective activity of common interest. In order to fulfill this requirement, the ecosystems need a workflow management solution that can be freely customized for their specific needs. We have developed a general model of transformation from business requirements to executable process definition and the actual software

implementation for automated generation and management of collaborative workflow instances.

The paper first presents a theoretical overview and the scope of the paper. Then we present a general idea for modeling and transforming business requirements into supporting software. The research approach for ontology based business process development is presented in the following section. Then we present the basic requirements for supporting collaboration software frameworks and the actual application scenario of the approach in the reference research project. Finally, conclusion and future work are shown.

In our days collaborating organizations face many challenges. Technological development is advancing dynamically, product lifecycles are shortening, businesses are becoming global and new markets are developing rapidly. Business requirements change frequently, companies have to survive in a dynamic environment. The success of a company is increasingly determined by how quickly it can react to changing market conditions with appropriate products and services. Furthermore, new business models mean greater source of competitive advantage than new products or services.

A competitive enterprise has to adapt core value-added processes with unprecedented speed, to act appropriately regardless of the situation. For these continuously improved process models must be implemented in real integration platforms. Modern BPM suites are evolving to automate the modeling, monitoring and redesign of complex, collaborative processes to achieve these goals. By managing processes with continuous improvements, the organization can reduce costs, increase efficiency, and strengthen the ability to respond to change.

Business driven application development has a new approach for integrated application building based partly on BPM methods. As the business is in constant transformation, the IT systems implementing transformations have to be agile enough to respond quickly and cost effectively while seamlessly performing current business functions. By deriving technical executable processes from business process structures, the technical models correspond to the

programmed reality and thus lead to a high level of user acceptance. At the same time, companies are able to implement innovative business strategies and the underlying processes quickly and flexibly.

Our model transformation based approach is close to the Model-driven engineering (MDE). To develop an information system it is necessary and sufficient to define its conceptual schema [9]. In spite of the fact that MDE is a popular approach in software development, several challenges are detailed in the Literature [10]. One of the most frequently cited issues is associated to a modelling language; lack of adequacy for the specific application domain that is to be modelled is mentioned. Sometimes the model is valid during the earlier stages of development but it loses value as iteration proceeds and the specification is done. During the further stages of the development, the modelling language is unable to represent certain characteristics of the application, so the model can be abandoned. We involved end users from the beginning to the application development in order to avoid the above mentioned difficulties.

Another important issue is the imprecise semantics usually associated to modelling languages. Most existing object-oriented modelling languages share only a small set of common elements with precise semantics, such as class, attribute and relationship. We avoided this situation, with applying ontology-based development approach. In some cases specification languages represent the problem at an improper level of abstraction. Frequent issue with modelling is the over specification and redundant specifications. Insufficient transformations can lead to two types of situations: no code is generated for some model elements, or code for model elements is only partially generated. In eBest project as it is detailed below code is generated for all model elements (ontology elements).

Quick and cost effective solution can be provided for a new business challenge with the use of model transformations, that suits both the strategic and high abstraction level business models and on the implementation level suits the business integration architecture [9].

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 process view at the BPM level is limited to the sequencing of activities. The modeling languages like BPEL, and the tools for modeling 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 obstacles towards mechanization of BPM. Semantic Web and Semantic Web services technology provide suitable large-scale, standardized knowledge representation techniques to overcome this barrier. Fensel and his colleagues propose to combine Semantic Web services technology and BPM and yield one consolidated technology, which they call Semantic Business Process Management (SBPM) [5].

Semantic Business Process Management (SBPM) is a new approach of increasing the level of automation in the translation between the business requirements view and the IT systems and resources, and is currently driven by major players from the BPM and Semantic Web Services area [3]. SBPM and MDE together lead to the next phase of business process evolution from merely automating repeatable processes to flexible automation of dynamic processes [10].

The use of ontologies is a key concept that distinguishes SBPM from conventional BPM. 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. Ontologies basically provide the semantics and they describe both the semantics of the modeling language constructs, as well as the semantics of model instances [6]. Ontologies facilitate the unambiguous descriptions of business processes. In more general terms, ontologies facilitate the development and sharing of domain knowledge, incorporating all information required to help the automatic generation of process supporting software. The advantages of modeling the process domain knowledge with ontologies are numerous. It improves the design of programs with better specification and handling of exceptions. It provides the opportunity for the fast deployment of a process instance, and to react and redeploy according to the changing business requirements [7]. With utilizing an annotation scheme over the ontology language, all the implementation details are incorporated into process definition and the automatic creation of workflow processes can be achieved [8].

II. GENERAL MODEL FOR BUSINESS REQUIREMENTS TRANSFORMATION

Our general model for business requirements transformation provides the means to detach the design and modeling activities from software implementation and operation, this way enable businesses for the appropriate and rapid reaction for the changes in business requirements.

The general model for the realization of this transformation is depicted on the following illustration:
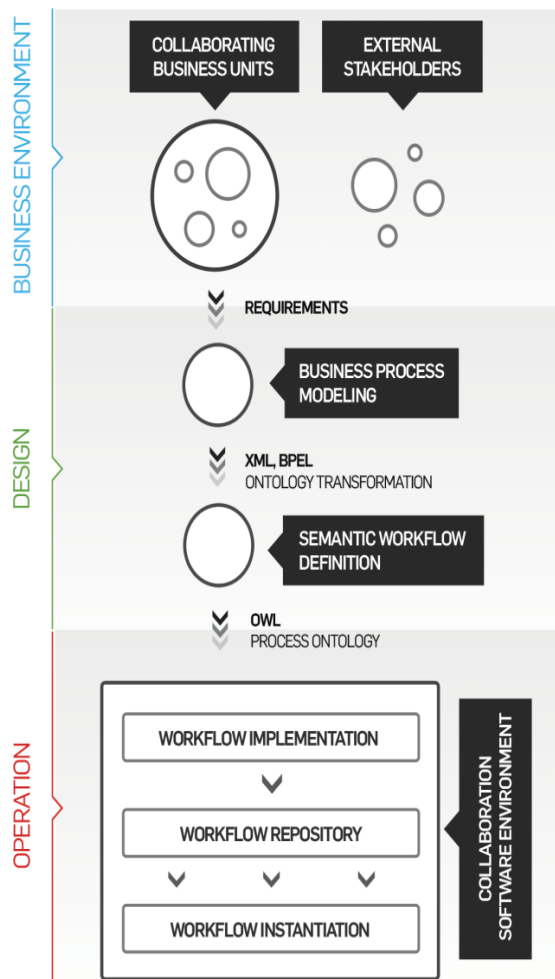
Fig. 1 The General Model

Business requirements are determined and influenced by both the collaborating ecosystem of business partners and the exterior stakeholders of the business environment. An important aspect is that requirements change frequently and process models must adapt to these changes in a quick and affordable manner. These requirements – whether coming from the inner ecosystem or as exterior environmental impacts – determine the business process model.

Being able to cope with the requirements, process design is completely detached from the software implementation. In this way it is feasible to automate the creation of workflow instances. Since this automation is a key feature in the successful adaption to real life problems - the designing phase must incorporate each and every aspect of the implementation - has to contain all the information that is inevitable for the creation of the supporting software environment.

Business Process Modeling tools provide the means to describe the process structure, the process flow and embed the roles and responsibilities of the different stakeholders into the process definition. This activity is managed by higher level process planning. The outcome is adequate for making managerial decisions, and on the other hand,

provides the basic process information in a standardized form for further refinement and specification.

The next step towards the realization of automatic software generation is to design a process model containing every implementation detail of the processes. We have accomplished this definition with process ontologies. Process ontologies are created from the process models by a simple model transformation. Process ontologies are "equipped" with detailed semantic information by extensions based on an annotation scheme. The resulting ontology is ready to be imported into supporting collaboration frameworks.

The operating software framework provides a repository for the processes. The process ontology import is fully automated, it requires no IT contribution. An updated ontology can be imported upon changes in the process model. Process models are in part or as a whole reusable, they can be used with different levels of granularity. Similar to the object-oriented software design paradigm, instantiation of a semantic process model means the creation of a real instance of a particular process model within a given collaboration setup assisted by a collaboration software framework. The opportunity for re-instantiation realizes the ability to update a business process model with process alterations originated by changing business requirements. Collaborating partners operating the software framework access the implemented processes, and instantiate them from the process repository according to their needs.

III. ONTOLOGY BASED BUSINESS PROCESS DEVELOPMENT METHOD

In this part of the paper 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, providing facilities for the automation of workflow software instance generation.

A. Business Process 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 [1]. 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. 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 [13].

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 ontology outside the workflow. Ontology for ontology-based process modeling has to reflect also the semantics of the processes.

For the extension and mapping the conceptual models to ontology models, the ADONIS models are exported in the structure of ADONIS XML format.

B. Mapping the Conceptual Models to Ontology

The "conceptual models—ontology models" converter maps the BPM model elements to the appropriate ontology elements in meta-level. 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 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) [11].

The general rule we follow is to express each BPM 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.

In order to specify the semantics of BPM model elements through relations to ontology concepts, the BPM business model 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 model language constructs and a representation of model elements. Modeling language constructs such as "activity", as well as the control flow are created in the ontology as classes and properties. Subsequently, the model elements can be represented through the instantiation of these classes and properties in the ontology. The linkage of the ontology and the model element instances is accomplished by the usage of properties. These properties specify the semantics of amodel element through a relation to an ontology instance with formal semantics defined by the ontology.

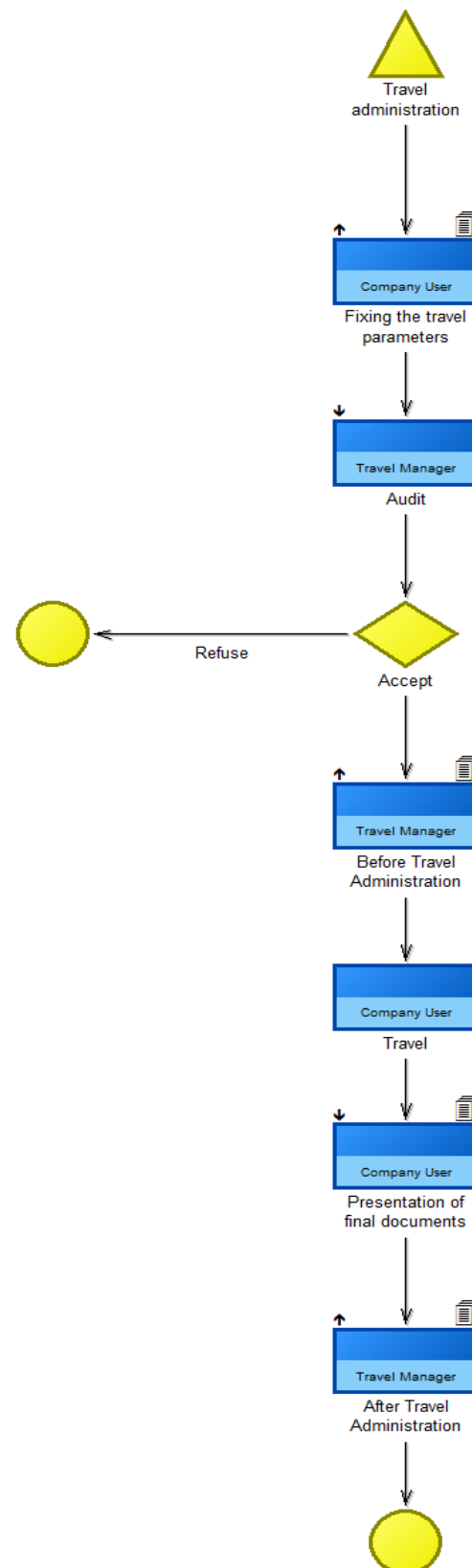By means of a concrete process we show the applicability of the method.

Fig. 2 The Travel Management ADONIS Process Model

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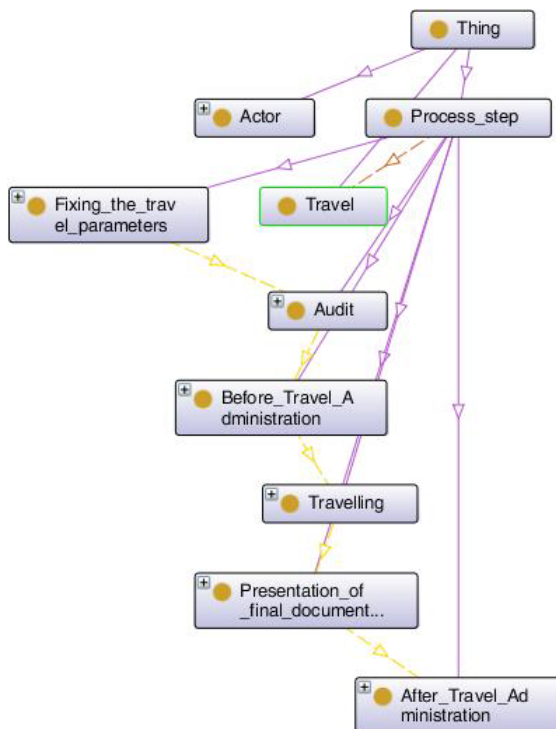

Fig. 3 The Ontology From Process Definition

The converted OWL ontology in the structure of Protege/OWL XML format is imported into the editor of Protege 4.1, where we have extended it also with domain ontology.

The process consist of process steps (ontology class: Process_step), each step belongs to a specific process (ontology class: Travel). All process steps are extending the base Process_step class, and also it defines a relation with the connected process steps.
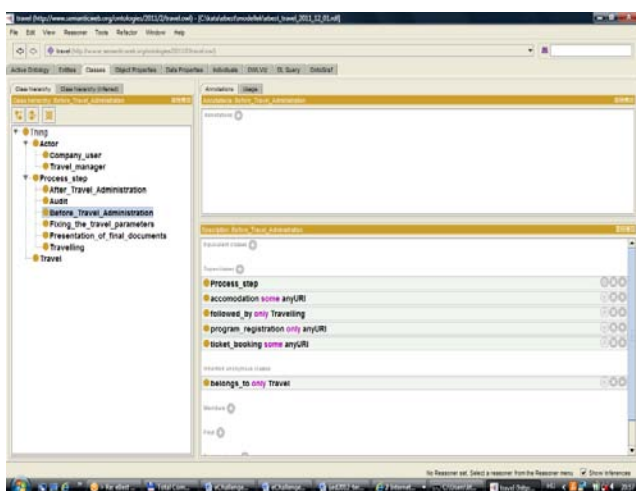

Fig. 4 Workflow Ontology – Owl Structure

C. OWL Ontology Extension

After the ontology notation with the basic business level process definition has been prepared, the next step is the

semantic annotation to explicitly specify the semantics of the tasks and decisions in the process flow. The model elements must be annotated to get properly processed by the transformation, model and code generator tools. 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 show up when we are presenting it on a form to the stakeholders of the processes, etc. The semantic annotation can either be embedded in the workflow itself or can exist as ontology outside the workflow. Ontology for ontology-based process modeling has to reflect also the semantics of the processes. OWL is the most common language for representing ontologies.

The OWL standard ontology definition is extended by the implementation of our 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 roles of the different stakeholders distributed to process steps, the access and authorization to perform the desired task at process step level;
- 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 document covering all aspects of the workflow process and is ready to be deployed by supporting application frameworks.

IV. COLLABORATION SOFTWARE ENVIRONMENT

We have developed reference architecture able to implement the general process design rules an incorporate the process repository, and the provision of workflow instances through instance generation.

The reference framework software is based upon open-source technology. The framework follows the MVC implementation pattern [2]. The development has been conducted in the Symfony PHP framework [12]. It incorporates the Doctrine ORM database abstraction layer. The software architecture complies with the principles of service orientation.

To implement the automatic generation of workflow interfaces based on the semantic workflow notation, the framework must adequately conform to the following criteria:

The process definition import module generates the imported workflow processes. Any OWL following the process annotation scheme can be imported into the framework. The process ontology interpretation is fully automatic and requires no manual interaction.

The framework contains a custom framework module to generate ORM data models and web forms from the

interpreted process ontology. The relational database scheme is also generated automatically. All the defined classes and all of its relations are automatically created at database level. The generation process hides all implementation details.

The automation of the workflow creation is managed by a class, which generates appropriate ORM database schema and the presentation layer from the ontology document.

The presentation layer manages the information received from the annotation scheme, which determines every implementation detail like the form field labels and help texts, how form fields are ordered, what controls to show, which fields the user must fill in, etc. The generated workflow interface can also be further customized if required.
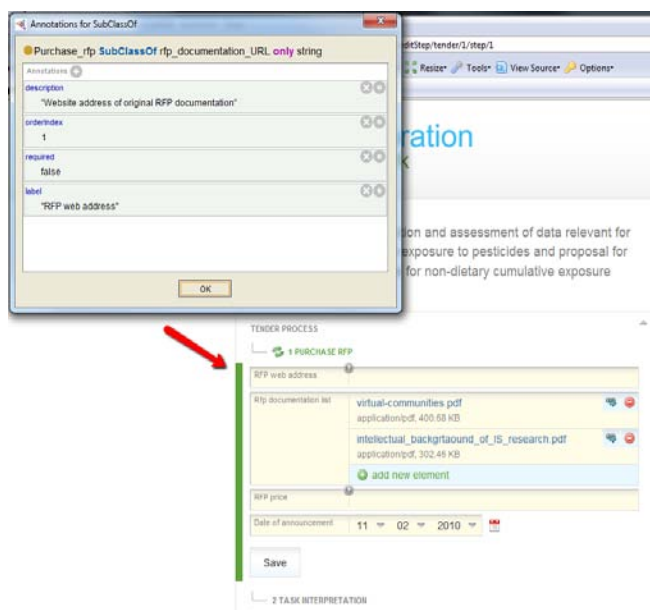

Fig. 5 From Ontology to Webforms

The generated models provide Role Based Access Control for the different stakeholders at process step level. According to our plans future implementations will be able to support the RACI approach (Responsible, Accountable, Cooperation, To inform) extended from the BPM process view.

The process repository manages the semantic process models and realizes the instantiation of the workflow processes. The repository is capable of handling multiple parallel workflows with different sets of stakeholders. Any workflow can be updated upon changes originated at the business process modeling level or at the ontology definition level. The stored workflows are accessible from the frontend interface of the framework. The deployed workflow processes are automatically available. New workflow instances are ready to be initiated by the members of the ecosystem.

The workflow management interface of the framework must control objects and entities outside of the scope of the workflow process domain and has to interact with the other modules of the application. The framework provides the possibility to manage and embed the following framework objects into the processes:

- User access management: Role Based Access Control provision for the different levels of stakeholders of collaborating companies or other business units identified within the framework.

- Content management: The framework provides an interface for collaboration content management. Any content created and managed within the framework can be attached to attributes of the process steps, and content creation is available from the process step view of the workflow interface.

- Document management: Process and role based provision of workflow-related documents

- Task and issue management: Issue tracking module integrated with the workflow management

If any non-workflow specific functionality not covered by the ontology definition is required, further interface customization is feasible by adding functional module extension and modifying the view layer. The inserted modules interact with both the process instances and the framework objects.

V. CONCLUSIONS

In this paper our ontology based business process development methodology was presented and the most essential experiences were explained. In our approach the focus is given to the extension and mapping of the conceptual models to ontology models. 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. The process ontology extension is still limited to simple linear process models, but the main contribution of the project is the practical experience gained from the architecture realization of freely defined business processes taken from real life expectations. We does not claim that the model covers all aspects of real life organizational problems, nor that it is the only way for collaborating organizations to follow, but we have conducted a successful experiment for the modeling and implementation of business ecosystem activities. We strive to further enhance the ontology annotation scheme, focusing on creating a standardized interoperable workflow definition for modern information architectures.

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