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BPM4SOA Business Process Models for Semantic Service-Oriented Infrastructures

Dimitris KARAGIANNIS[1], Wilfrid UTZ[2], Robert WOITSCH[2], Hannes EICHNER[2]
[1]*University of Vienna, Department of Business and Knowledge Engineering, Brünnerstaße 72, Vienna, 1210, Austria*
Tel: +43-1-427738481, Fax: +43-1-427738484 , Email: dk@dke.univie.ac.at
[2]*BOC Asset Management GmbH, Bäckerstraße 5, Vienna, 1010, Austria*
Tel: +43-1-5120534, Fax: +43-1-5120534-5,
Email: {Wilfrid.Utz, Robert.Woitsch, Hannes.Eichner}@boc-eu.com

Abstract: The paper introduces a modelling framework that was developed in the BREIN project to integrate all project related modelling efforts. Based on the project requirements and a state of the art analysis the BREIN related modelling challenges were identified on three levels: syntactical, semantical and contextual. As there are different tools, formats and languages available for the different modelling areas, the key challenge is the integration of the related modelling languages. The paper shows how these challenges are addressed und discusses how business process models can be used for semantic service oriented infrastructures. The implemented modelling framework considers existing standards and establishes a formal integration and transformation among them by realizing a semantic integration service including the syntactical, semantical and contextual level.

Keywords: Business Process Management, Ontology, Service Oriented Architecture

1. Introduction

The following position paper discusses a modelling framework for semantic service-oriented infrastructures that is developed in the IST project BREIN [1], co-funded by the European Commission under the Sixth Framework Programme (2002-2006).

The aim of BREIN is to develop an intelligent grid infrastructure to significantly reduce the complexity of current business-to-business collaborations with a specific focus on SMEs. BREIN will demonstrate its capabilities with two scenarios, the Virtual Engineering scenario and the Airport scenario. Both scenarios involve complex relations between service-providers that need to interact with each other in order to deliver specific services to the customer. The aim of BREIN is to transfer these business collaborations onto grid technology. This means taking the existing business and its services and changing the underlying technology by transferring it to grid technology. In order to succeed in doing this transfer business processes have been selected to perform an analysis of the virtualisation within grid technology. To transfer the business knowledge, ontologies were generated from these business processes as a base of common understanding.

An observation made during the analysis is that business processes are commodity today. Business processes exist in every business field and they need consideration in the related IT-systems. The creation of software is more and more related to the configuration of systems and services using a model-based approach rather than actually implementing it. This paper presents the approach taken to realize the BREIN Modelling Framework covering the observations mentioned above, identifies related challenges and discusses how they are addressed.

The paper at hand is structured as follows: chapter 2 introduces in more detail the objectives of this paper by stating the requirements for the modelling framework and identifying the related challenges. In the third chapter the methodology is presented and chapter 4 presents a case study on the ontology generation approach. Chapter 5 discusses the benefits obtained while chapter 6 provides insight in upcoming research challenges of this approach and gives an outlook on further activities.

2. Integration Objectives and Challenges

As already introduced, business processes are omni-present in business and modelling is continuously gaining importance for the development and the configuration of software systems. A series of national and EU funded projects (e.g. BIG (AUT) [2], FinGrid (GER) [3], BREIN (EU) [1], BEinGRID (EU) [4]) reflect that business aspects need consideration in service-oriented architectures (SOA) and infrastructures (SOI). Within BREIN business related models as well as various technical models have been analysed and discussed aiming to integrate these models into a common modelling framework.

The objective of the BREIN Modelling Framework [5] is to bridge the gap between the demands of the business-oriented end user and the technology-oriented developer. Business experts and developers have the possibility to use the modelling language applicable for specific tasks, which are then integrated by providing a multi-modelling language framework. The semi-formal domain models are transformed into formal and executable ontologies and workflows.

Various modelling services are offered through the BREIN Modelling Framework to support application scenarios such as process-oriented requirements analysis of applications, the specification of the software architecture and the externalisation of expert know-how (knowledge management aspects). In general, the modelling framework separates two levels of abstraction, the business modelling level and the IT modelling level. In addition to these two levels, a "Best Practise Roadmap" deals with knowledge management aspects [6]. The roadmap provides new or external developers that do not belong to the core project team with a model-driven guidance system for system development and extension. Various knowledge services are made available to the developers for collaborative development tasks.

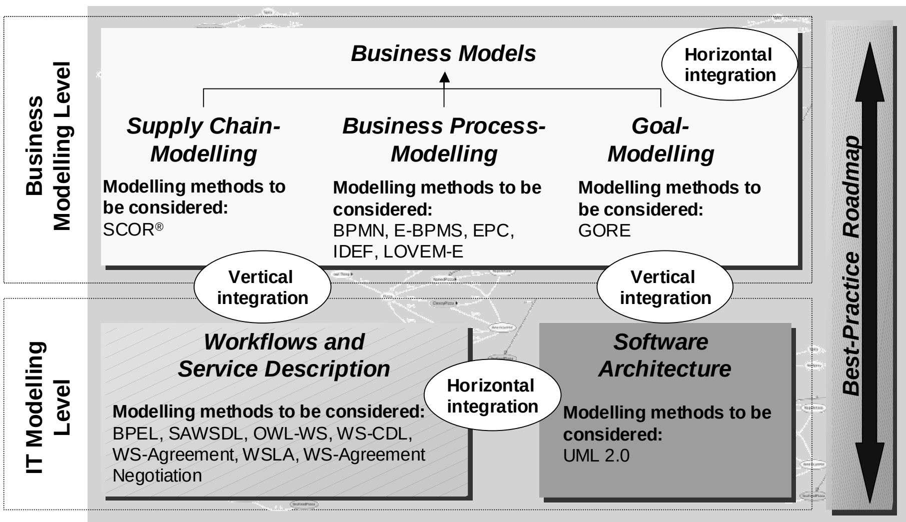

Figure 1: The BREIN Modelling Framework

Considering the BREIN scenarios that are characterized through complex supply chains and inter-organisational collaboration that should be automated, the requirements for the modelling methods used in the business modelling layer and the IT modelling layer, have been derived. As a result the BREIN Modelling Framework has to deal with several modelling languages that have different focus (e.g. business or technical level) and has to consider several languages within one modelling domain. Based on the requirement of the scenarios, the business modelling layer has been instantiated with (see Figure 1):

- Supply chains to model the inter-organisational perspective (SCOR [7]),
- Business processes to represent the intra-organisational view (e.g. BPMN [8], E-BPMS [9], EPC [10]) and
- Goal models to steer the business collaborations (approaches based on GORE (Goal Oriented Requirements Engineering [11])).

The IT modelling layer is split into two building blocks:

- Workflow and Service Description for the discovery and the execution of services and workflows [12] (BPEL [13] and OWL-WS [14]) and
- Software Architecture to document the platform and for the technical specification of services (UML™ [15]).

The integration of all these modelling languages involves several challenges that may be classified according to their level: (1) syntactical, (2) semantical and (3) contextual:

The **syntactical level** concerns models and their representation. The problem here is that modelling languages differ on a syntactical level which means that they are stored in different formats and there is no unified way to access them. Models may be stored as files or in repositories (such as relational or XML databases), and their format may not follow any standard representation. Proprietary formats and different data sources lead to many problems as they require the development of new interfaces for every representation and make the use of models complex.

The **semantical level** deals with modelling languages and raises the question how different modelling languages may be integrated with each other. The integration of two modelling languages usually results in a semantic gap, and the key question is how this gap may be bridged. In particular there are substantial difficulties when it comes to bridge the gap between the business and the IT-view referred to as the "Business-IT Gap". One approach is to use business processes to derive requirements for IT services that will in return automate them. In this case the method used to model the business view has to be integrated with the one representing the technical world (e.g. a business process modelling language for the business view and UML [15] for the modelling of software artefacts).

The third challenge is the **contextual level**, which is concerned with the translation of knowledge from one domain into another domain and the fact that different stakeholders use the same term in different contexts. For instance a business expert might interpret the term "*business process*" referring to a concrete business process in a company e.g. transporting the passengers from the gate to the aircraft at the airport. A technician might understand it as a sequence of web service invocations. The problem is that domain experts have the business expertise but rarely the IT-competence. On the other hand software developers cannot define the business requirements. A common understanding of the domain between all stakeholders is essential and the communication between business people and technician for a successful system implementation.

After setting out the requirements for the modelling framework and the related challenges, the next chapter explains how the framework is realized and how the challenges are addressed. The most challenging objective is the contextual level, which will be explained in more detail.

3. Conceptual Basis of the BREIN Modelling Framework

As already mentioned in BREIN a modelling framework for all project related modelling tasks was defined. Based on the requirements that BREIN and its scenarios impose on modelling, the definition of the modelling framework started by identifying major technologies involved. The modelling approaches of ATHENA [16], EMI (Enterprise Model Integration) [17], MDD/MDA (Model Driven Design/Model Driven Architecture) [18] and concepts of SOA (Service Oriented Architectures) [19] were analysed.

ATHENA has developed a viewpoint-based integration approach to model interoperability which shows the existence of multiple viewpoints comprising the viewpoints of business analysts, product developers, system architects, and software developers. It becomes evident that these viewpoints share some common objects or concepts that need to be integrated in order to sustain modelling integrity. A quite similar attempt of defining a generic modelling framework is the Enterprise Model Integration (EMI) approach. EMI stands for the integration of the different modelling methods used on the design graph. On the one hand, the design graph includes semi-formal business oriented models, which try to explain the business domain independent of the technology to be used. On the other hand, the design graph includes platform independent technical models which, in the case of processes, can be considered as the basis for process execution.

Considering the observations made in the analysis, the following separations of layers with their respective models, which are also defined in the MDD/MDA approach [18] by the OMG, have been derived (see Figure 2):

1. CIM (Computation Independent Model): models capturing the real world business, serving as the requirements.
2. PIM (Platform Independent Model): workflow models on a platform-independent layer that may be derived from the upper layer.
3. PSM (Platform Specific Model): executable models bound to a specific platform, which are a refinement of the PIM layer.

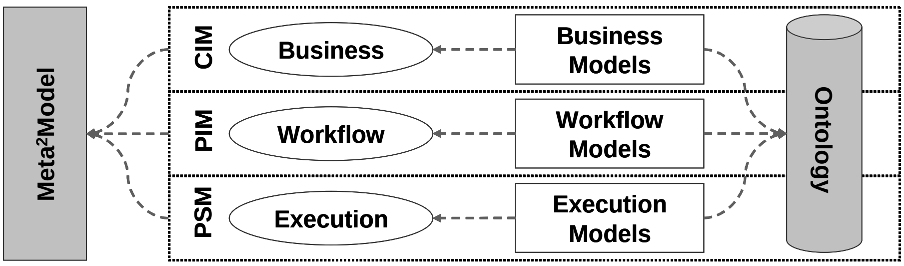

Figure 2: The Concept of the "BREIN Modelling Framework"

3.1 Addressing the BREIN Modelling Challenges

In general shortcomings on a **syntactic level** can be addressed by the use of standards for a specific modelling task. Due to the fact that various modelling languages are made available through the BREIN Modelling Framework a common and generic repository for all models created using different methods is established. BREIN uses a generic model repository that acts as a mediator and allows access to the models through one unified XML format. The functionalities of the generic model repository are exposed through web service interfaces. The framework allows the model interchange with external systems through the implementation of import and export mechanisms with standard formats including EPC, UML/XMI, BPEL and OWL.

On the **semantical level** the BREIN Modelling Framework enables the integration of modelling languages with meta-model integration patterns. The modelling languages are linked using a loose integration pattern. The modelling languages are coupled using a so called transition layer that contains concepts from both methods. Taking the example regarding the "Business-IT Gap" presented before, the language of the business layer (e.g. E-BPMS) and the language of the IT layer (e.g. UML) have been analysed and the common concepts were identified (in the case of E-BPMS and UML, the common concepts are "use-case” related) and may be bridged using the common concept on the transition. There are different types of integration - we consider **vertical and horizontal integration** as well as a **hybrid integration** combining vertical and horizontal approaches:

Vertical integration is a typical top-down or bottom-up approach where different levels of modelling abstraction are integrated. For the top-down-integration the starting point are the elements of the higher level method. Method fragments of the lower layer are selected and integrated based on the requirements from the upper method. Another possibility is the bottom-up integration which is more common in reengineering approaches. To conflate the business modelling layer and the IT modelling layer, vertical integration is needed and, in the case of BREIN that a top down integration approach has been chosen. This means that business goals, strategies and business processes serve as starting points for application development.

Horizontal integration is used for the integration of method fragments on the same layer of modelling abstraction, which means that meta-models on the same level of detail can be integrated. This integration approach is used to integrate the methods within the business modelling layer as well as the methods in the IT modelling layer, respectively.

The modelling challenge on the **contextual level** will be tackled through the integration of meta-models and ontologies to map different modelling languages. A bootstrapping approach [20] where models serve as basis for the creation of ontologies and vice versa has been selected for ontology evolution based upon available content. The main idea is to use business process models for the generation of ontologies, thus also reflecting business aspects. On the other hand a uniform terminology defined as ontology will be used to assist the user when creating models. This issue is treated in chapter 4, presenting two related modelling services that try to overcome the limitations currently existing in this area.

4. BREIN Semantic Modelling Services

From an implementation perspective a service-oriented modelling framework has been established for development and deployment of semantic modelling services supporting the BREIN integration challenges described above. In the following two representative modelling services within this framework have been selected, both dealing with the semantic integration between modelling languages. These services will be described in detail focusing on the Airport Scenario use-case also describing roles involved in using the services.

4.1 Model Mapping Service for Semi-automatic Ontology Generation

The model mapping service allows the semi-automatic generation of an ontology using already existing business process models as a basis. The derived ontology is the basis for refinement and evolution steps and continuous improvements of the system. From the literature of meta-models and their relation to ontologies described in [21], [22] it was reasonable to use business process models, filtering them according to relevant concepts and transforming the relevant ones into formalized ontologies.

As the ontology language (e.g. OWL) and the business process modelling language may be interpreted as meta-models, the meta-modelling reference pattern according to [15] can be applied. For the model integration two dimensions have to be considered, first the direction of integration (vertical, horizontal or hybrid) and second the level of integration (loose, intermediate, and strong). BREIN implements a vertical integration between business process models and ontologies. The integration can be also considered as loose as we consider the business process models and the ontology almost independent.

For the development of the modelling service there are two ontologies that can be applied: an upper ontology on a meta-model layer comprising of a list of concepts for business process modelling as well as derived from the high-level ontology on a model layer comprising of a list of concepts of the scenarios.

The meta-model concepts have been analysed according their usability and the service translates modelling concepts from the business layer to modelling concepts to the ICT layer by applying mapping rules, defined in a language mapping file. As input the modelling constructs of the modelling languages used have been considered and mapped accordingly. For this task the knowledge engineer works in conjunction with the business user to derive and build up a common understanding of the modelling language.

The second approach deals with the transformation of concrete business process models into ontologies. The semi-formal description of business process models using E-BPMS [9] and related business process management languages (e.g. [10]) derived directly from the use-case partner of the Airport scenario and Virtual Engineering scenario (about 100 semi-formal business process models in different iteration for the specific services) were used as the basis to define scenario specific concepts. Again, mapping rules have been established to allow automatic transformation of these models into scenario ontologies.

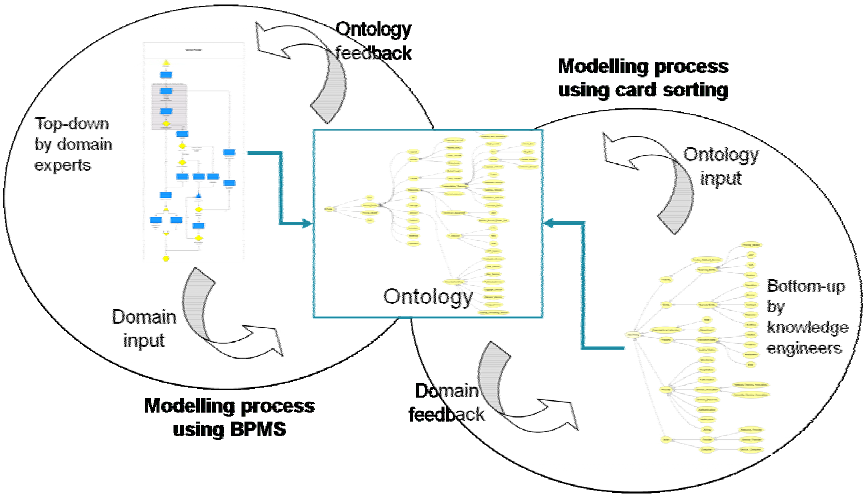

Figure 3: Ontology Generation Approach

In parallel to this top down approach (from the semi-formal models to formalized ontologies), a continuous evaluation and improvement step by knowledge engineers and ontology experts capturing and refining the derived ontologies has been established. The combination of these approaches led to the definition of the ontologies in an iterative way (see Figure 3) leading to a complete domain conceptualisation for the two scenarios.

4.2 Model Assistant Service for Model Consistency Checking

The model assistant service evaluates the derived conceptualisation and makes the formal description usable for the business expert [23]. The ontology is used as input for various checks to be done by the domain user in order to refine and evaluate the models created. The checks/assisting evaluations are available for the user during the modelling tasks performed and makes sure that correct terms are used, suggests synonyms and allows check from a granularity as well as semantic perspective. Apart from this feedback the service also allows to enhance the ontology with new terms or concepts that were not present before. Also other advanced features such as auto-completion or enriched search mechanisms are possible through this integration.

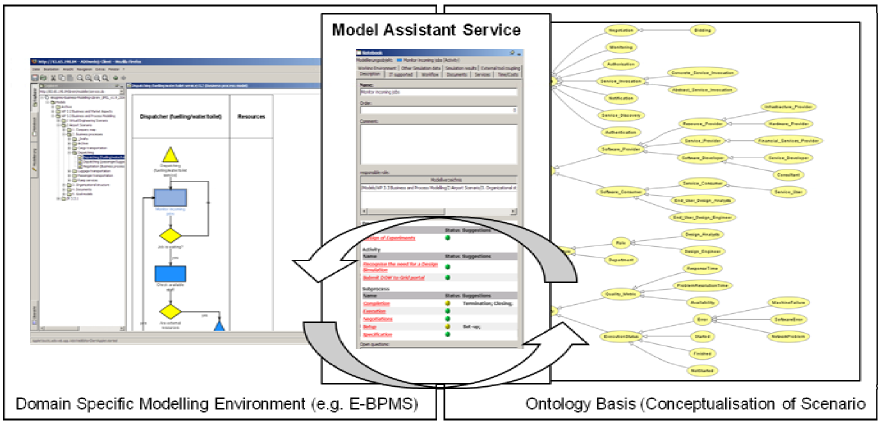

Figure 4: Model Assistant Service for Business Process Modelling

5. BREIN Modelling Framework Business Benefits

Aligning IT with a company's business strategy is critical to its success, and yet, it remains an ongoing challenge. Currently model-based approaches are prominent for this integration. The modelling framework is the first step into this direction providing the integration of different modelling languages to derive IT from business requirements.

The use of business processes to communicate the business needs have been found useful since an early integration of the end user in technical discussions is possible. Business experts can formulate their needs in easy to understand semi-formal models. The first step in modelling was to analyse the scenarios' supply chains to see the interactions between the business actors in the complete end-to-end process. Then business process modelling focused on the intra-organisational perspective.

The modelling activity helped to externalise the dynamic dependencies between participants and processes, increasing the shared understanding of the domain. This semi-formal domain description was the basis to communicate business needs to the systems architects. Based in this common understanding all stakeholders including software developers could take advantage of. An additional aspect is the profit for the knowledge engineer, which is concerned with the ontology building. Through the transformation mechanisms the business processes could be taken as valuable input to complete the rather technology-driven ontology. The integration of the business aspects is a clear enrichment of the system-oriented ontologies.

6. Conclusions

Business processes are commodity today. They exist in every business field and need consideration in the related IT-systems. As there are different tools, formats and languages available a key-challenge is the integration of all these modelling languages into a common and interchangeable framework to ease cooperation and communication efforts.

The presented framework is currently implemented and is used via a prototype by the project consortium and is seen a first step towards the establishment of a common knowledge base in the domain. As the project progresses the BREIN Modelling Framework will evolve including the development of better mappings from business layer towards the ICT layer, more sophisticated modelling services to simplify the handling of ICT models by non-experts and to integrate ontologies into the modelling framework as the underlying model exchange format.

The vision is to evolve the framework to an "IT-socket" that lets business plug-in into IT. Instead of today's IT, which is tightly integrated with the business (i.e. IT is designed for specific business sectors or even applications), in the envisioned future businesses plug into an IT-socket using their business specific plug. To allow this the level of integration has to be lifted from technical to a business level using a model based approach. This is subject to research in a future EU-project.

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