

# Semantic Business Process Modeling – Benefits and Capability

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## Abstract

Models describing business processes in a company nowadays have the drawback that they are not machine-processable for two reasons: First the terminology is not formalized. Second the dynamic semantics of the process model is not formally defined. Thus, many discussions and human work is necessary in order to create and maintain process models. However, with a semantic annotation of process models and the usage of ontologies, tasks can be automatized and the workload of the user can be reduced to a minimum. In this paper we discuss different possibilities and the added value of annotating a business process model with semantic information.

## Introduction

Business process management and its realization through a service-oriented architecture seems to be a very promising approach. However, the gap between business view and IT is still difficult to close. Business process models in many companies are still used mostly for documentation of the designed processes, but in reality the processes are sometimes completely different than the modeled processes (van der Aalst 2007).

With the advent of the model-driven engineering approach models can not only be used for documentation purposes but also for an automatic model transformation and code generation. The model-driven architecture (MDA™) by the Object Management Group (OMG) is a specialization of this approach towards the analysis, design and implementation of systems. But most of the time MDA is only performed top-down – changes to the code or to actual processes in a company do not necessarily lead to an adaptation of the models. Very often the platform-specific models can be automatically adapted, but higher levels of abstraction normally are not reached.

Business process models describe the structure and flow of tasks on a very abstract level. They include the description of organization structures in an enterprise, responsibilities of organization units for different tasks as well as task dependencies. Several notations for modeling a business

process are available: some use OMG's business process modeling notation (BPMN, OMG 2007) which is related to the business process definition meta-model (BPDM, OMG 2006), others event-driven process chains (EPCs, Scheer and Nüttgens 2000), simple Petri nets (Brockmans et al. 2006), UML activity diagrams (OMG 2005) or even introduce proprietary notations (Bauer, Lautenbacher and Roser 2007). These languages cover different aspects of a business process like the functional, behavioural, informational, organizational or operational perspective (Jablonski and Bussler 1996).

But an automated processing or querying of these process models is hampered due to terminologies used in the names of process actions, for the roles and organization units, etc. which are added in natural language by the modeler. These identifiers are often unclear or ambiguous and allow much room for interpretation even for humans. This especially becomes a problem when different process models from various companies or departments are combined, searched, validated or translated (Thomas and Fellmann 2007). For a process model there are two dimensions that need to be considered:

- the **semantics** of the **metamodel** elements when different representations are used,
- the **terms** that describe the **model** elements.

Therefore, an ontological grounding is necessary; i.e. the semantics of each element in a business process model must be defined in a "machine-understandable" fashion to support the whole business process management lifecycle. There are several phases in such a lifecycle; the most important ones are business process modeling, business process configuration, business process execution and business process analysis. The vision of semantic business process management (SBPM, Hepp et al. 2005) describes how to combine business processes with semantic web services in order to query and manipulate the process space. This requires a machine-accessible representation of all terms in an enterprise and of all queries. Additionally, a semantic annotation also fosters reuse, adaptation, a goal-oriented design, etc. In (Wetzstein et al. 2007) the vision of SBPM is linked with the lifecycle of business processes. This lifecycle contains semantic business process modeling, implementation, execution and analysis.

In this paper we focus on the first part of this lifecycle called semantic business process modeling.

**Definition:** A *Semantic Business Process Model* describes a set of activities including their functional, behavioral, organizational, operational as well as non-functional aspects. These aspects are not only machine-readable, but also “machine-understandable” which means that they are either semantically annotated or already in a form which allows a computer to infer new facts using an underlying ontology.

The contributions of this paper are

- A description of the current issues in business process modeling
- How process models can be semantically annotated
- The benefits of this semantic annotation

Therefore, this paper is structured as follows: in the next section we show the issues within current business process models, before we describe the semantic annotation possibilities, the elements that might be annotated and how this annotation can be done in practice. In section 4 we show the overall advantages of using semantic annotation for business process models and describe a short example in section 5, before we conclude.

## Problems in business process modeling

Companies that use process models have to encounter several difficulties when using them intra-organizational or when exchanging them with other companies. Within one company there are the following issues:

**Only for documentation purposes:** Process models are often only designed to document the process flows in a company. This is often due to norms for quality management which require that everything is captured in documents to receive a certificate (e.g. ISO 9000, ITIL).

**Not up-to-date:** As process models are not generated automatically they become outdated after a while. In many companies they are only adapted in advance to a recertification. Research in process mining reveals that reality is often quite different from the idealized models.

**Not executable:** Until today process models in most companies are not executable. They could be used as a starting point for model transformation to gain more platform independent and even platform specific models, but as described before they are in the majority of cases only intended to be used for documentation.

**Not all processes modeled:** Most of the time companies model only the most important processes in their company, while others (e.g. based on best practices) are not modeled at all.

Besides these issues within one company, there are several problems when different departments in an enterprise or different enterprises want to exchange process models in order to collaborate:

**Different representations:** As there is no single standard for modeling a business process, different companies will probably use various notations. Since delivered together

with software from SAP, Enterprise Process Chains (EPCs) are a common notation in Europe. But the (primary only the US-market dominating) business process modeling notation (BPMN) is now getting also more promoted in European countries. Other companies utilize UML2 Activity diagrams or simply use Microsoft® Visio or Powerpoint or other graphical drawing suites.

**Different constructs for one real-world entity:** Existing approaches to process modeling lack an adequate specification of the semantics of the terminology of the underlying process models, which leads to inconsistent interpretations and usage of knowledge. People from different departments or companies do not always use the same vocabulary for entities of the real world. Especially between business and IT departments this divergence can often be observed. But also in different companies the identifiers for process actions are different: “Pay an account” in one company might be the same as “Settle a bill” with both addressing an “invoice”.

**Same constructs for different entities:** The other way round is also a problem when two companies want to collaborate and their terminology seems to be the same at first glance, but emerges after a while to be quite different. E.g. the word ‘suit’ can semantically either mean a law suit, a suit of clothes or a suit of playing cards.

The mentioned issues can be divided in two parts: the former describe the metamodel and the terms used there (e.g. different representations), whereas the latter show difficulties with concrete model elements (e.g. different constructs).

## Semantic annotation of process models

### What does semantic annotation mean?

Semantic annotation is mostly proposed in literature to annotate documents and web pages. 'Annotation' in contemporary English has two meanings: (1) *a note added by way of comment or explanation* and (2) *the act of annotating*. Additionally, some use annotation as a *synonym to specification*. In linguistics (and particularly in computational linguistics) an annotation is considered a formal note added to a specific part of the text. The annotation can be about the whole document (*document-level annotations*) or refer just to a specific part of a text (*character-level annotations*) (Ontotext 2007). There are lots of alternative approaches regarding the organization, structuring, and preservation of annotations. As outlined in (Lautenbacher and Bauer 2007) there are many annotation approaches for web services or Grid services and there are first attempts to annotate business process models, too.

There are different levels that can be annotated with semantic information in a process model: on the one hand the constructs which are defined by the meta-model can be annotated (*metamodel-level annotations*) with an ontology that contain constructs describing process actions, control nodes, etc. On the other hand the elements in the model can be annotated themselves, too (then referred to as *model-*

level annotations). Therefore, different ontologies are needed: for metamodel-level annotations ontologies can be utilized such as sBPEL (Nitzsche, Wudke and van Lessen 2007), sBPMN (Abramowicz et al. 2007), an ontology describing BPDm, etc. For model-level annotations one might use domain ontologies defined in the context of the MIT Process handbook (Malone, Crowston and Herman 2003), the TOVE ontologies (Fox 1992), the enterprise ontology (Dietz 2006), etc. Figure 1 shows an example of such meta-model and model annotations for very simplified process models and ontologies.

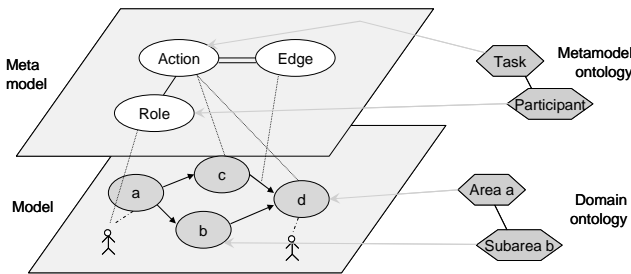


Figure 1: Meta-model and model annotations

### What exactly can be annotated in a model?

On the one side all **identifiers** (such as ‘invoice’) of the model elements like process actions, roles, data, etc. can be annotated to specify what they exactly mean in a “machine-understandable” manner. On the other side the **modeling elements** such as categories and functions where the used process actions can be classified as well as the inputs and outputs (resp. preconditions and effects) of these process actions in order to facilitate for instance a (semi-) automatic composition. Additionally, non-functional aspects such as author, maximal costs, quality of service, etc. could be used for the annotation, too, to compute a process model or validate one considering these aspects.

### How can the annotation be done in practice?

**Use metadata to bridge models and ontologies:** (Thomas and Fellmann 2007) proposed to use metadata to annotate EPC models with semantic information. Therefore, the ontology contains all EPC constructs on class level and domain information on instance level.

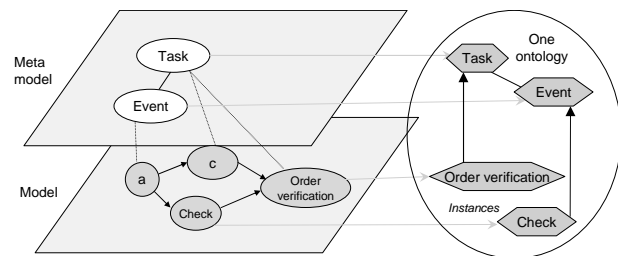


Figure 2: One ontology for domain and metamodel information

But using this approach it is not possible to utilize existing domain ontologies, but one is always bound to the

generated ontology. Figure 2 shows a short overview about that approach.

**Using transformations between different technological spaces:** However, we are using different technological spaces (Gasevic et al. 2004): The technological space for models (*MDA TS*) and the ontology technological space (*Ontology TS*). Therefore, a transformation between these two spaces seems to be necessary at the beginning. Figure 3 shows these different technological spaces in our context. To annotate the process model, the model as well as the metamodel might be transformed into an ontology first and then this ontology can be connected to existing other ontologies.

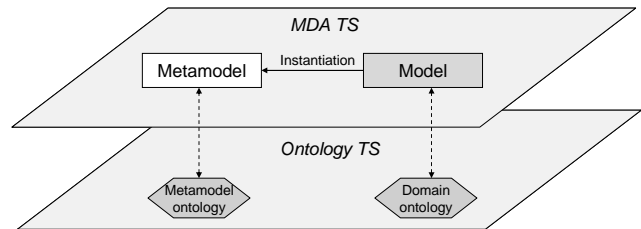


Figure 3: Transform model and metamodel to an ontology

### Annotation as a property included in the meta-model:

One could also extend the metamodel with additional properties such as `ModelElement.Annotation` and include the information about each construct of the domain ontology and the metamodel element there.

### Benefits of semantic business process models

Bringing semantic information into current process models shows a lot of potential. Some of the benefits of semantic business process models are listed below:

#### Advanced search in process models

Right now it is only possible to make a keyword search. If you are interested in the term web services, then you won’t find any resources that describe distributed systems in general. This is also the case for process models. However, most of the times you just don’t know which terms have been used by the modeler. Therefore, reasoning on the relationships and equalities between different terms assists a search to find all relevant process models and not only the ones containing exactly the same word.

#### Enhanced validation of process models

It is currently not possible to automatically validate all modeling guidelines / regulations or accomplish a verification of specific guidelines. These guidelines are in most companies written in plain text and are therefore not machine-interpretable. When these are instead written in ontologies, these ontologies can be used for a validation of semantic business process models.

## Automatic process execution

Process models are currently realized by software developers who use their knowledge to find the web service or other software system that fits the given requirements best. However, with the advent of semantic web services, semantic annotated process models can be used to automatically find the needed web service which also conforms to the given non-functional requirements and execute these services then automatically (Hepp and Roman 2007). Henceforth, no user interaction is necessary anymore.

## Better reuse of process fragments

A semantic annotation would also lead to enhanced reuse of existing process models and therefore to customization of old process models to new requirements. Currently the existing knowledge is often neglected and new processes are created from scratch without considering the best practices that exist in the processes of the company.

## Replacement of process fragments

Very often small parts of a business process have to be replaced by an updated version that is more efficient or uses new technologies. By using semantically enriched business processes, an automatic verification is possible whether the replacement of an old process fragment with a new one is possible.

## Integration of different departments or companies

Interaction between different companies or even departments of one company is hindered due to the used terms, standards, etc. Annotating the process models with semantic information (using a domain ontology which captures the domain of interest and a modeling language ontology that includes a description of the concepts in the process model) offers the possibility to interact across company or department borders.

## Auto-creation, adaptation and auto-completion of process models

SBPM also assists the user when creating a model: The user starts modeling a process and the system can make a recommendation how the process model could be finished. Therefore, several autocompletion mechanisms (such as Brockmans et al. 2006 or Betz et al. 2006) are discussed right now. But even the modeling of first steps of a process is not necessary in our opinion if a user simply specifies goals. Then the machine can automatically plan a process model based on given process actions (e.g. from a process repository) which finally lead to the goals. Therefore, the process actions need to be semantically described (at least) according to their inputs and outputs to make reasoning on these data. In the project SEMPRO (Henneberger et al. 2008) an approach is proposed that consists of three steps: finding dependencies between existing process actions, generate an action-state-graph using an innovative

planning algorithm and add control structures at the end. The result is a set of feasible process models which can be approved by the modeler.

## Modeling of B2B scenarios

If public processes of several business partners have to be integrated, a collaborative business process (CBP) including the message exchange has to be developed. Using semantically enriched process descriptions an automatic generation of message mappings as well as the automatic integration of partner process steps is possible.

## Example of a semantic business process model

We consider the typical example of an order process as a short use case for semantic business process models: when an order arrives in a company, the sales assistant checks the given prices and forwards the order to the customer service who enters the positions in the ERP software and automatically forwards the order to the warehouse department. There, the availability of the articles is checked and feedback is given to the customer, if some parts are available or not. Otherwise, everything is packed and labelled and all documents are finalized for the express agent to deliver them. The resulting process model looks like in Figure 4.

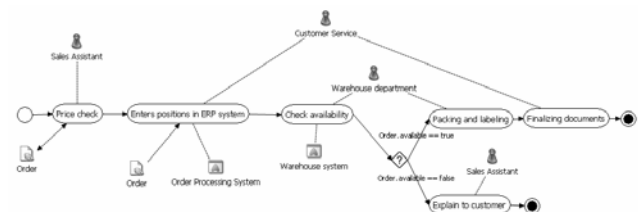


Figure 4: Order process in one company modeled with AgilPro<sup>1</sup>

What exactly does this process model describe? A machine can only find that there are six process actions with different responsibilities, but cannot recognize what these process actions are about. On the other side how are this process model and its process actions related to the process model of another company (Figure 5 shows a small example)?

A human can understand that 'Enter positions in ERP system' is in this context the same as 'Insert order into software', but a machine can only reason on this using semantic information. Therefore, we annotate both process models with the ontologies eClassOWL (Hepp 2006) as domain ontology and an ontology based upon BPDM for the metamodel elements. eClassOWL is an OWL DLP ontology for products and services and based on the categorization standard eCI@ss 5.1. There, terms like an 'Order' or an 'Article number' are ontologically defined and can be used to annotate the process actions.

<sup>1</sup> [www.agilpro.eu](http://www.agilpro.eu)

Additionally, the ‘Actions’ in AgilPro and the ‘Activities’ in BPMN are defined as ‘Tasks’ in BPDM, which enables a reasoning engine to compare these elements.

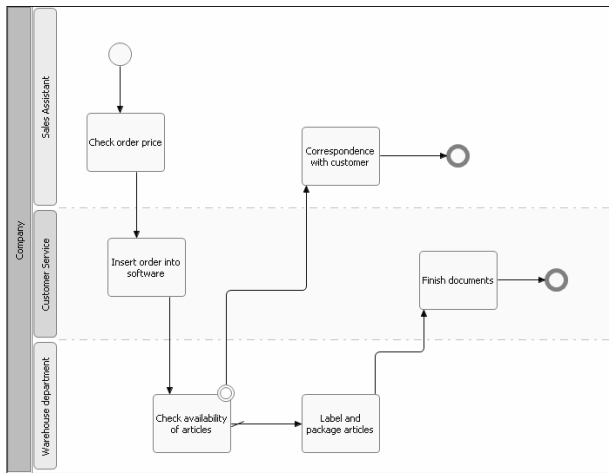


Figure 5: Order process of another company modeled using BPMN

### When does semantic annotation make sense?

Of course, not all companies will describe their processes with semantic information in the future. The annotation of process actions initially requires a huge amount of work. Sometimes the semantic information might already come with a (semantic) requirements specification for a new product, but most of the time the semantics needs to be created for business process models from scratch. Process mining techniques maybe could also be used to get some of the semantics of business process models. The following shows a list with indicators that a semantic annotation of the process models in a specific company will create an added-value:

- Many processes: A semantic annotation of process models does not pay off for SMEs with only a dozen process models.
- Ever-changing standards: When standards, regulations, laws, etc. in a specific sector change very often, the process models need to be adapted frequently. The manual work could be reduced to a minimum using semantic annotations.
- Many collaborations with other departments or companies: Especially in a huge supply chain network, where many collaborations with other companies are necessary, assisting the users by reasoning on semantic data to create the CBPs reduces the human work to the verification of the generated process models.

### Related Work

There are a lot of research projects that cover SBPM and the semantic annotation of process models right now: In the European-funded project FUSION<sup>2</sup> an innovative approach, methodology and integration mechanism for the semantic integration of a heterogenous set of business applications, platforms and languages within SMEs is developed (Alazei et al. 2007). The objectives of the SUPER<sup>3</sup>-project are the development of a technological SBPM framework, new generic languages for process or goal descriptions, automated annotation techniques, process query tools, mediation procedures and the adjustment of existing reasoners (Filipowska et al. 2007). Additionally, there are several other projects like SemBiz<sup>4</sup>, FIT<sup>5</sup> or OntoGov<sup>6</sup> that cover aspects like the semantic annotation of process models, too. A lot of projects demonstrate that even without semantic annotations business process management can be improved: process mining techniques (e.g. van der Aalst 2007), validation of process models (cp. Weske 2007) or process execution based on BPEL. However, these approaches have limitations as described above.

### Conclusions and further research

This paper showed that current business process modeling approaches show a lot of drawbacks. With a semantic annotation of process models the creation, reuse, search, validation and execution of process models can be widely extended. We described what could be annotated in a process model and how this annotation might be done in practice. Additionally, we showed a small example.

There are many areas where our future research will focus:

- A fully-fledged planning of process models including non-functional aspects such as costs, time, quality of service, etc.
- Implementing a validation of semantic business process models based on given modeling guidelines.
- Using the semantic annotation not only in process models, but already in the first software engineering documents as created during requirements engineering. These could then be refined and reused for business process models.
- Realizing process models by semantic web services either by finding the web services that fit to the requirements or by using model transformations from a semantic business process metamodel to a semantic web service metamodel.

<sup>2</sup> [www.fusionweb.org/Fusion](http://www.fusionweb.org/Fusion), as at 2008-01-22

<sup>3</sup> [www.ip-super.org](http://www.ip-super.org), as at 2008-01-22

<sup>4</sup> [www.sembiz.org](http://www.sembiz.org), as at 2007-11-15

<sup>5</sup> [www.fit-project.org](http://www.fit-project.org), as at 2007-11-15

<sup>6</sup> [www.ontogov.com](http://www.ontogov.com), as at 2008-01-16

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