Design of Semantic Information Systems using a Model-based Approach

Hans-Georg Fill
Department of Knowledge and Business Engineering, University of Vienna, Austria
1210 Vienna, Bruennerstrasse 72, Austria

Abstract

The use of social and semantic technologies in business demands an optimal balance between business requirements and technological opportunities. Therefore, the usage of model-based approaches to pre-assess the added value of such semantic information systems is of high importance. In this paper we extend an e-business modeling framework to integrate business aspects with social interaction and semantic technologies. In particular we introduce two graphical model types for describing the interaction of users with semantic-enabled services and for visually representing ontologies. The paper is concluded with a concrete use case where the framework has been successfully applied.

Introduction

The area of social computing is gaining practical importance for businesses according to recent reports by Gartner and Forrester (Bradley 2008; Li, Owyang, and Kim 2008). From the perspective of enterprises the role of *social web applications* and *explicit semantics* is therefore not anymore a technical one. It is one that may provide new answers to business needs and may lead to new business models (Hoegg et al. 2006). The potential targets are all areas of electronic commerce from collaboration, communication, and commerce to connection and computation (Zwass 2003). However, the currently available approaches for introducing social computing and semantics into the business world either focus primarily on technical aspects e.g. (IBM Corporation 2008) or only on parts of business requirements, e.g. strategy formulation (Wijaya, Spruit, and Scheper 2008) or revenue models (Enders et al. 2008).

To align business objectives and technical opportunities the use of modeling frameworks has been shown to be a successful approach (Winter 2001; Karagiannis 1995). In contrast to modeling approaches that focus on technical aspects such as the unified modeling language (UML), specialized modeling frameworks such as E-BPMS or e3value explicitly consider the linkage between strategic, operational, and technical aspects of e-business information systems (Karagiannis, Ronaghi, and Fill 2007; Pijpers, Gordijn, and Akkermans 2008).

In the paper at hand we focus on the extension of an e-business modeling framework by integrating explicit semantics and social interaction aspects with the goal to represent the *semantic information systems* of users and machines in an e-business setting. For this purpose it can be referred to a number of modeling languages for representing explicit semantics such as the RDFS/OWL languages, the knowledge interchange format or the XML topic maps ISO standard. These approaches allow to explicitly define the meaning of objects and the relationships between those objects. Thereby a full and automated interpretation of the entered information becomes possible. It has to be taken into account however that these languages have neither been primarily designed for the direct interaction with human users nor that they provide direct links to social computing. The linkage can be established on the basis of a model-based design of web applications where several approaches have been proposed e.g. (Jin, Decker, and Wiederhold 2001).

The task of putting together business models, formal semantic models, and human interaction in the style of social computing may easily lead to complex and inscrutable solutions. Therefore one of the lessons of the Social Web's success is taken as the guiding principle by focusing on *simplicity and efficiency* (Mikroyannidis 2007) without sacrificing academic rigour. To achieve this goal we propose a meta model-based approach that allows for an easy adaptation to user needs and relies on the visualization of the used concepts. In the following, we outline the basic concepts of meta modeling and will then present our approach for modeling semantic information systems by extending the E-BPMS modeling framework with ontologies based on OWL and semantically defined user-machine interaction. We will conclude the paper with findings from a practical deployment of the extended framework in a business setting.

Basic Concepts

In this section we would like to give a brief introduction on our view on meta models and semantic information systems. This will provide the basis for describing our approach to extend the meta models of an existing modeling framework with the concepts of semantic information systems.

Meta Modeling

Both in literature as well as in practice the concept of *meta models* is today widely used (Karagiannis and Hoefferer 2006). For our view we build upon the components of modeling methods by Karagiannis et al. (Karagiannis and Kuehn 2002) that divide a modeling technique into a modeling language and a modeling procedure (see figure 1). The modeling procedure defines the way how to apply the modeling language. The modeling language is used to describe the models and is itself split into syntax, semantics, and notation. Thereby the aspect of the visualization of the models is separated from the syntactic description and thus offers a greater flexibility for the adaptation of the graphical representation (Fill 2006).

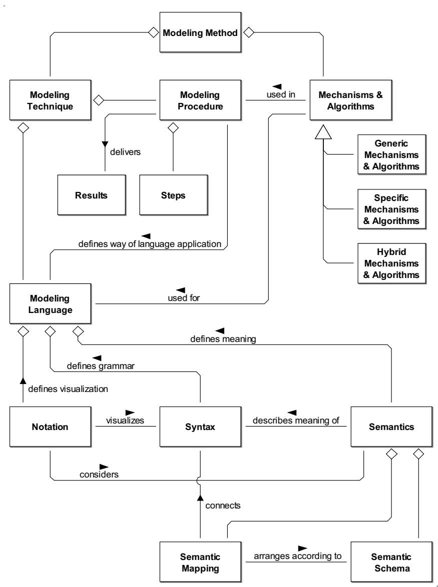

Figure 1: Components of modeling methods (Karagiannis and Kuehn 2002)

Based on these relationships a meta model can now be viewed as a model of a modeling language (Favre 2005). In comparison to other approaches for describing modeling languages such as graph grammars or logic formalisms meta models offer an intuitive way of specifying modeling languages and are therefore also suitable for discussion with non-technical users.

Semantic Information Systems

Information systems in general are used to represent, mirror or simulate phenomena in the real world (Weber 1997). In a business setting these phenomena comprise business, technology, and human aspects with concrete activities such as supply chain management, customer relationship management, enterprise resource planning, etc. When focusing on the interaction of humans and computers, the classic approach from Human-Computer-Interaction would be to regard the syntactic, semantic, and pragmatic levels of the interaction. Thereby the pragmatic level may include aspects such as the user's mental models as well as actual technical devices for accomplishing the interaction cf. (Foley and Wallace 1974; Shneiderman 1993).

With the advent of social computing and semantic technologies the interaction goes beyond this view. The focus has to be extended to phenomena where humans interact with humans and technology is only the mediator. Examples are applications such as wikipedia where humans interact with humans by using a common technology work platform. As with all types of interactions it is essential to be clear about the semantic level that describes the meaning conveyed with input and output (Shneiderman 1993).

The common availability of semantic technologies especially in the form of international technical standards has led to numerous applications in industry that make use of explicit semantic schemata. Thereby new types of interactions between humans and machines become possible. Machines receive the possibility to automatically or semi-automatically infer relationships from pre-encoded semantic content. This is in contrast to the approach of social computing where semantics are at best post-encoded through "collaborative ant intelligence" (Auer and Ives 2008).

With the concept of *semantic information systems* it is envisaged to provide an integrated approach for information systems that make use of both pre- and post-encoding of semantics (Fill 2006). The goal is that the processing of semantics is equally conducted by humans and machines instead of aiming either for a complete machine-based representation of semantics or a primary human-interpretable representation. The notion of the different combinations of human - machine interactions plays an important role to determine the suitable way of encoding semantics. Furthermore, it is intended to abstract from technical aspects of semantic technologies. It shall be focused on their application and value for business. The challenge is to balance business objectives and technological opportunities.

Designing Semantic Information Systems

As Weber states "representation is the essence of the things we call information systems" as it is often cheaper to observe the representations of things rather than observing the things directly (Weber 1997). The use of models during the phase of requirements analysis of information systems development helps to early detect and correct errors and thus may lead to better implementation results (Wand and Weber 2002).

Especially for the area of semantic information systems modeling can bring about advantages. It offers a solution to deal with the complexity that is inherent to these systems. Interactions of humans, machines, and explicit semantics are often hard to balance with business goals, particularly in large organizations. An additional challenge presents the integration of domain experts who are not familiar with technical aspects. Nevertheless, their knowledge is essential to meet the requirements of the users.

For the purpose of this paper we will follow a design science research approach. Design science in general deals with the creation and evaluation of IT artifacts intended to solve organizational problems (Hevner et al. 2004). The *conceptual models* for designing semantic information systems that we will present in the following will be described using the concept of meta modeling. This will permit to show the applied approach and allows for a direct implementation.

A Modeling Framework for Semantic Information Systems

For the purpose of modeling semantic information systems we have chosen the E-BPMS framework as a basis (Karagiannis, Ronaghi, and Fill 2007). The framework allows to define business models and scorecards on a strategic level which are then turned into business processes and products. The processes are detailed by technical product data, IT processes and the corresponding IT infrastructure. Finally, audit data that is generated at run time is evaluated and serves as feedback for the strategic level and the configuration of the business processes. Several meta models are described for E-BPMS that allow to model business models, business processes, IT processes and so on. The meta models are linked to each other in order to model dependencies e.g. between a business model, its corresponding products and business processes, the IT-infrastructure used for the processes, and the actual audit data generated by the executed processes.

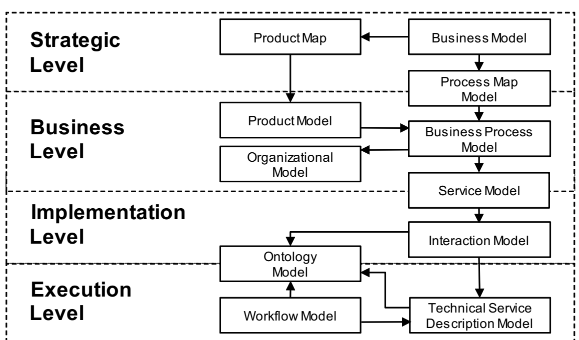

Figure 2: Four layers of the Modeling Framework for Semantic Information Systems

For the requirements of semantic information systems the E-BPMS framework has been adapted in the following way (see figure 2). The levels that are regarded are: the *strategic*, the *business*, the *implementation*, and the *execution* level. To take into account aspects of service orientation, a *service model* has been added on the business level that allows business users to specify requirements for IT services. This is done in a semi-formal way where requirements for the content of the input and the output of the services are specified in natural language. Furthermore, on the execution level, model types for the representation of *technical service descriptions* and *workflows* for the choreography of services are available. This permits to configure service choreographies and use them for the deployment on a technical service platform.

To close the gap between business processes on one hand and semantic technologies and social computing on the other hand another model type has been created. The addition of *interaction models* and *ontology models* enables to represent both the human-machine interaction aspects as well as machine-processable semantics.

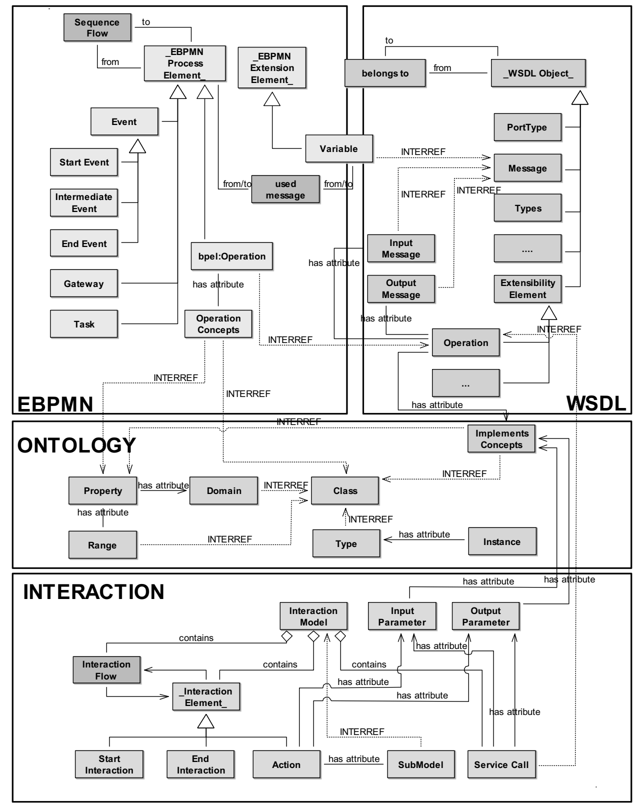

Figure 3: Excerpt of the Meta Models

All model types included in the framework have been described using the abovely outlined meta model approach. Figure 3 shows an excerpt of the meta models for the model types: *Extended BPMN* for the service choreographies, *WSDL* for the technical service descriptions, *ONTOLOGY* for the definition of explicit semantics, and *INTERACTION* for the human-machine interactions. The parts of the interaction and the ontology model type shall be discussed in more detail in the following.

Integrating Social Interaction

The interaction model type addresses the challenge of different types of interactions. This is seen as an essential part of social computing. The basic assumption underlying this meta model is that technology is always required for any kind of social interaction. Non-technology-based human-human interactions are not covered by this approach.

In detail the interaction model type allows to define sequences of interactions that may be influenced by control constructs (see the example in figure 4). Each action can be linked to a concrete webpage in any kind of format (e.g. pure HTML, JSP, PHP etc.) together with parameters for triggering specific actions. The actions can be further detailed by input and output parameters that are linked to the webpage parameters. As shown in figure 4 the actions are visualized as rounded rectangles. If input or output parameters are specified for an action, the visualizations of the actions are changed. If only an output parameter is specified (see e.g. action A in figure 4) only the end of an arrow is attached to the action. If both input and output parameters are specified, the beginning and the end of an arrow are attached (see e.g. action C in figure 4). In case a concrete webpage is specified, a www-symbol is shown (as e.g. for action C in figure 4). Thus it can be specified, if and which information the concrete webpage is able to receive and which information to generate. To better structure the models the actions can be defined as sub-action elements (S-symbol) that link to another interaction model.

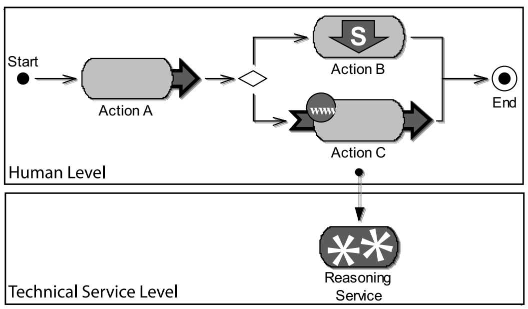

Figure 4: Sample of Interaction Model Type with Service Call

Actions can be linked to web service calls in addition, e.g. to a semantic reasoning service as shown in figure 4. This allows to specify which technical services are required for the accomplishment of the action. Also, for the webservice calls input and output parameters can be specified and references to technical service descriptions defined. The references to the technical services are realized via the WSDL model type and the contained *operation* elements. This linkage between actions and service calls allows a domain user to specify which services should be used for a particular action without requiring knowledge of the concrete implementation.

With the elements and attributes of the interaction model described the structure of interactions on a *human level* and on a *technical service level* can be depicted. This corresponds to a syntactic specification with the semantics of the interactions being implicitly defined. However, it permits to represent the social aspect of web based applications, e.g. as offered by wikipedia. The advantage gained so far is that the interaction models can be related to concrete business processes via the service model type and to the technical services via the technical service description model. Thus, an alignment between business objectives, socio-technical interaction and IT systems can be established and formally analyzed.

What has not been considered so far are the semantics of the actions and services. To capture the meaning of the input and output parameters of the actions references to an ontology model have been created. This is shown in the meta model excerpt in figure 3 via the *implements concepts* element. In the same way the input and output parameters of the web service calls have been linked to the ontology model. By using the semantic references of input and output parameters it can be defined which semantic information is exchanged between actions, e.g. for assessing which information is available in a social software application.

Integrating Ontologies

The ontology model type as it is positioned between the implementation and the execution level of the modeling framework in figure 2 satisfies two purposes: first, to support the process of *modeling* semantic information systems and second, to support the *implementation* of semantic applications.

For the support of modeling, the ontology model type (see figure 5) can be used to annotate model elements with semantic concepts. This opens the possibility to search for similar model elements based on their semantic content and not only based on syntactic comparisons of element labels or attributes. An example would be to search all interaction models for actions dealing with customers. A traditional search would only return actions that contain the string ”customer” or parts of it in their descriptions but not elements labelled with ”client”. In case the elements are annotated with the ontology concepts ”customer” or ”client” that are defined as equal in an ontology a semantic search can correctly return all potential results.

For the implementation aspect, the annotation documents the use of ontology concepts. By using the interaction models together with the ontology models as a kind of *building plan* a programmer can derive how to implement a social-semantic application. However, in contrast to pure implementation approaches the dependencies between semantic concepts, social interactions and business aspects are explicitly taken into account and can be analyzed.

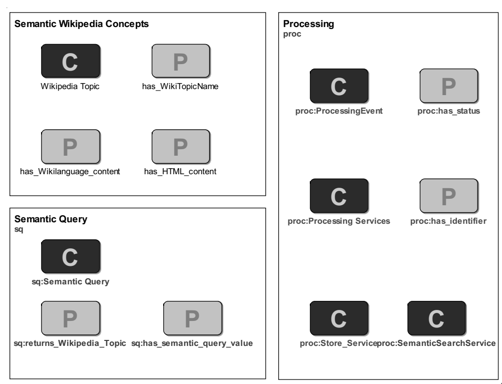

Figure 5: Sample of an Ontology Model showing Classes, Properties and Namespaces

Use Case: The SCG Semantic Portal for Culture Events

The approach of the modeling framework for semantic information systems has been applied to a concrete use case

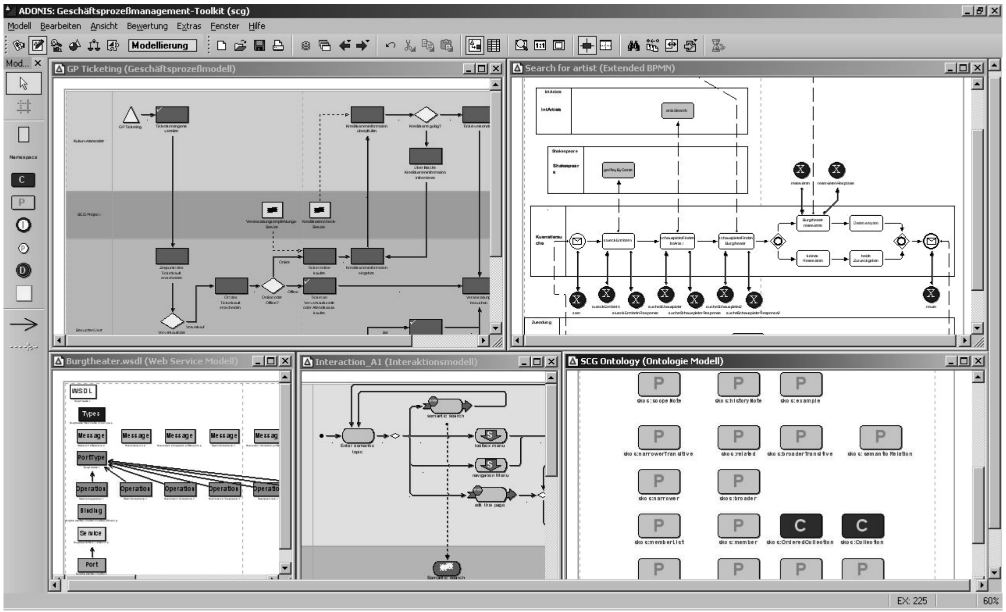

Figure 6: Screenhot of some SCG Models on the ADONIS Platform

and implemented on a meta modeling platform. Both shall be shortly outlined in the following.

The use case is taken from the Semantic Culture Guide Project (SCG). Together with project partners from industry and academia a semantic-enabled web platform for accessing culture events in Austria is realized. As tourism plays an important role in the Austrian economy with a GDP share of around 16 percent [1], the provision and successful management of culture events is of great interest for many stakeholders. The goal of the SCG project is to make culture events easily accessible via a one-stop-shop approach. Already existing IT systems shall be connected to the central platform to increase the accessibility and visibility of the available culture events. Thereby, technical as well as syntactic and semantic varieties have to be made interoperable.

On the user side, the SCG project addresses the different user interests e.g. in regard to preferred genres, artists, locations, etc. by providing a trust-based semantic recommender system. This recommender system uses a community rating service as a basis to give advices to users, such as recommendations for events or help in searching the portal (Vasko et al. 2008). For the definitions of the events and the corresponding ratings ontologies are used to identify similarities between events as well as to give recommendations based on reasoning with information provided by the user and information available in the system.

At the beginning of the project it was decided to use a model-based approach for the analysis of requirements. The modeling framework as shown in figure 2 has been implemented on the ADONIS meta modeling platform[2]. Together with project partners from industry at first business models were designed to evaluate the business impacts of the future platform. In a next step interviews with a range of organizers of culture events were conducted with the goal to assess how they perform their business processes (see figure 6). Based on these processes possible services were identified that could be offered by the platform to support the event management and the users. In parallel, an ontology was created in OWL to provide the semantic definition of events, locations, genres, and auxiliary concepts. From the identified services a subset was selected and further detailed by interaction models. At this stage the interactions of future users with the platform and with each other could be already discussed with domain experts. The interactions were then enriched with semantic concepts from the ontology. This allowed to derive a first draft of potential semantic web service descriptions. Thereby already at an early project stage the idea of semantic technologies and social interaction between the users could be conveyed.

Currently, the services designed with the modelling framework are being detailed and implemented whereby some services are implemented as basic services and some as choreographies of other services. These choreographies will then be depicted with the EBPMN models that can then be exported from the ADONIS platform and deployed on a workflow engine.

Conclusion

With the presented framework for modeling semantic information systems it could be shown how business objectives can be aligned with technological opportunities. The basic idea is to follow a top-down approach from the strategic and

[1] For details see Statistics Austria at http://www.statistik.at

[2] ADONIS is a commercial product and registered trademark of BOC AG. A free community edition is available at http://www.adonis-community.com/

business levels to the implementation and execution level. Thereby the concrete gains from using semantic technologies and social web techniques can be depicted and assessed. Further work will include the evaluation whether the linkage of ontology model types with other model types can bring additional gains. This would for example allow to semantically link different types of business process models independent of their notation. Related work on these aspects can be found in (Hoefferer 2007).

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