Reference Modeling for Inter-organizational Systems

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Abstract. Inter-organizational business process models are created and used by different partner networks. Often, those models are similar but differ in certain business needs. Due to the lack of methods and tools, companies are required to start from scratch to create their specific models instead of taking advantage of and re-using already existing models. Therefore, we first analyze reference modeling design techniques and their applicability on inter-organizational models and second create a prototype implementation of inter-organizational reference modeling. By creating models out of reference models we expect to gain efficiency in the modeling process and a higher quality of inter-organizational solutions.

1 Introduction and Motivation

Nowadays, the use of business models and business process models often concentrates on intra-organizational systems. However, companies also take part in inter-organizational systems, but they are mostly limited to their implementation such as Web Services by following a bottom-up approach. To overcome these limitations, we developed a model-driven approach towards inter-organizational systems named *Business Semantics on top of Process Technology (BSopt)*.

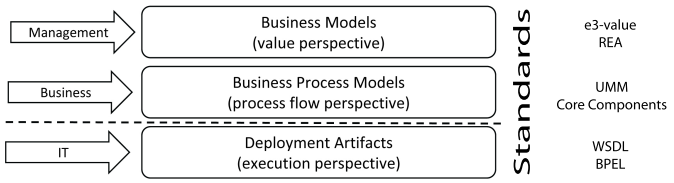

Fig. 1. Layers in inter-organizational systems

The *BSopt* approach [1] builds upon three layers, as shown in Figure 1. The first layer, the *value perspective*, captures the rational as well as the economic resources being exchanged with business partners. To model these aspects, we use two well established business modeling languages, *e3-value* [2] and the *Resource-Event-Agent ontology (REA)* [3], which will be explained later.

The second layer, the *process flow perspective*, is partly derived from the first layer and uses business process models. It describes the flow of business activities and their dependencies in accordance with the business goals to be reached. For this purpose we use *UN/CEFACT's Modeling Methodology (UMM)* [4]. Another important part of this layer are the messages being exchanged between the business partners. To describe these messages we use *Core Components*, which define messages on a conceptual level. In order to get a deployable system, the models defined on the second layer are translated into deployable artifacts covered by the IT layer (the execution perspective). The IT layer implements the business processes by means of tools, frameworks, API's, Web Services, etc. In *BSopt*, the deployable artifacts covered and generated out of the business process models of the second layer are the *Business Process Execution Language (BPEL)* and the *Web Services Definition Language (WSDL)*. We developed a tool for *BSopt* that provides a sophisticated solution to create inter-organizational systems based on models. It allows the user with the help of wizards to model the top two layers mentioned before and generate the artifacts for deployment.

Although the *BSopt* tool proved to seamlessly create inter-organizational systems, we encountered the following problem concerning the re-use of models during evaluation: *If a company wants to use existing business and business process models and wants to change them slightly, it generally has to reinvent the wheel and start again from scratch.*

Therefore, we propose the following solution: *Using various design techniques from reference modeling on the inter-organizational models will foster the re-use of models. Due to less recreation of already existing models which only need to be slightly changed, we expect faster model creation time as well as better quality of models by incorporating best practice into reference models. We anticipate that the design techniques can generally be applied on a variety of model languages.*

The remainder of this paper is structured as follows: Section 2 briefly discusses the models considered for reference modeling and the design techniques in question. Additionally, we introduce existing work in the field. In Section 3 we define the contributions concerning re-using business models and business process models. Section 4 describes the research methods being used in order to create reference models and a prototype implementation. In Section 5 we conclude the paper by showing the advantages we expect from reference modeling used on the inter-organizational models.

2 Background and Related Work

In this section we elaborate on the models used in *BSopt* and on the design techniques of reference modeling. These two areas will serve as the base of the thesis. At the end of the section we discuss additional related work.

Inter-organizational models. The Inter-organizational models are implemented using Domain Specific Languages (DSL). Thereby, *e3-value* describes a business model as a value web where multiple actors exchange objects of economic values such as money, goods, or services. Next, *REA* was originally in-

troduced by McCarthy [3] as an accounting model and extended to an ontology by Geerts and McCarthy [5]. In contrast to *e3-value*, *REA* captures the bilateral agreements and commitments between exactly two agents. *REA* stands for the three main concepts *Resource*, *Event*, and *Agent*. After the business models are defined, business process models based on *UMM* can be partly derived to realize the value exchange. *UMM* allows to create a business process model from an observer's perspective in order to depict inter-organizational processes. It builds upon three views: the business requirements view capturing the requirements already gathered from the *REA* and *e3-value* models, the business choreography view defining the business transactions between partners, and the business information view responsible for the messages being exchanged. *UMM* does not require a certain standard for messages. The *BSopt* project makes use of *UN/CEFACT's Core Components Technical Specification (CCTS)* [6] for defining business documents on a conceptual level using a DSL implementation [7]. Once all the models are created, deployment artifacts can be created on the IT layer to be used by the process or workflow engines.

Design Techniques. Reference modeling is mainly driven by the German Information Systems community and has primarily focused on internal business processes [8–10] . The main idea enables faster creation of models by re-using existing ones as well as delivering higher quality models. Vom Brocke [10] introduces five design techniques for reference modeling (cf. Figure 2). *Configuration* allows to configure a model out of a superset of elements of a core model. *Instantiation* provides a framework of a model with placeholders for parts yet to be defined. These placeholders can then be further specified by plugging in models with specific characteristics. *Specialization* relaxes re-use by allowing to take over a complete general model and changing it by adding or changing arbitrary elements. *Aggregation* allows to combine multiple existing reference models to compose a new complete model. Finally, *Analogy* serves as an orientation for the creation of a new model.

Configuration *by selection*	*The technique of configuration is characterised by deriving a configured model c out of a configurative model C by means of making choices from a greater variety of alternatives offered in C.*	*The application domain can be described fully in design time including all relevant adaptations that have to be considered in various applications.*
Instantiation *by embedding*	*The creation of a resulting model "I" by integrating one or multiple original models "e" into generic place holders of the original model "G". The model "I" incorporates the integrated construction results of "e" in "G".*	*The application domain can be covered by a general framework; this framework however, has to be adapted in regard to selected aspects that can not fully be described while building the reference model.*
Specialization *by revising*	*Derivation of a resulting model "S" from a general model "G". That way, all statements in "G" are taken over in "S" and can either be changed or extended (but generally not deleted).*	*The application domain can be covered by a core solution; but this solution has to be extended and modified (without deleting) in an indefinite manner for various applications.*
Aggregation *by combination*	*The combination of one or more original models "p" that build "a" resulting model "T", with the models "p" forming complete parts of "T".*	*The application domain can be described partly; each part can fully be specified whereas their combination for replenishing the entire coverage of an application cannot be foreseen when building the reference model.*
Analogy ~ *by creativity*	*An original model "A" serves as a means of orientation for the construction of a resulting model "a". The relation between the models is based on a perceived similarity of both models regarding a certain aspect.*	*The application domain can be described by certain patterns recurring in each application; the entire solution, however, has to be replenished in an indefinite manner.*

Fig. 2. Design Techniques of Reference Modeling according to [10] and [11]

These design techniques are specified on a general methodological level, independent of special modeling languages. So far, vom Brocke [10] has applied the design techniques to *Entity-Relationship-Diagrams* and *Event-driven Process Chains (EPCs)*. By incorporating the design techniques into inter-organizational models we foster re-use of these models. Hofreiter et al. [11] have already detected an appropriate example for each of the design techniques to be used with *UMM*, but thorough analysis of further re-use possibilities have to be conducted. We have already analyzed first steps towards inter-organizational reference models in [12]. The contributions of this thesis are discussed in the next section.

3 Research Contributions

In our *BSopt* project various modeling languages (i.e., *e3-value, REA, UMM*, and *Core Components*) were used to create an inter-organizational system. These languages include structural and behavioral models, respectively. During the evaluation of these modeling languages we identified a lack of re-use of existing models - except for copying & pasting parts of existing models. Thus, if two business partners want to create a model which is similar to an existing one, they basically have to start from scratch to create a new model and are not able to take advantages of existing ones. To enable and foster re-use of inter-organizational models, we define following research contributions of this thesis.

Inter-organizational Reference Models. The first research contribution addresses the definition of reference models for inter-organizational systems. We will consider the well elaborated modeling languages used in *BSopt*: *e3-value*, *REA*, *UMM*, and *Core Components*. In order to create reference models we have to identify the potential for re-use of the various original models. Therefore, sets of existing similar models have to be analyzed. Model instances are compared to each other and variating elements are identified. Additionally, we have to find the proper design techniques (i.e., *Analogy, Aggregation, Specialization, Instantiation*, or *Configuration*) for these variations in order to create the corresponding reference model which can be used as a basis to create new models.

Metamodel for Reference Models. The second research contribution concerns the creation of an appropriate metamodel for the reference models by extending the BSopt modeling languages. The metamodel has to cover all elements of the models as well as of the reference models (e.g. an additional element for a placeholder in a reference model, which will be further defined in the derived model). First, we have to study the existing metamodels and second, we have to identify locations in the metamodel to allow for placeholders/extension points for the variating elements on the model level. Furthermore, we have to include those extensions in the metamodel allowing for creation of models as well as of reference models for the various modeling languages.

Change Patterns. The third research question deals with identifying the change patterns to derive a model from a reference model. According to the design technique of reference modeling, special points of extensions for the reference model will be enabled for the modeler. The change patterns have to be

specified on a meaningful level of abstraction covering a set of changes on single nodes and edges. To help the modeler to create the model instances, wizards conforming to the change patterns will be created to guide the modeler and keep him from the modeling details. Additionally, traces between the newly created model and the reference model have to be kept. This will allow future changes of the reference model to be propagated to the derived models and is a prerequisite for proper model evolution.

These research contributions allow us to create reference models as well as provide them to modelers in order to create model instances. We expect a more efficient modeling process since the modeler does not have to start from scratch and a higher quality of the models by building upon best practice.

4 Research Methods

In this thesis we follow a Design Science approach [13], which is commonly used in the discipline of information systems (IS). As the area of IS research is at the "intersection" of people, organizations, and technology, Design Science is not only about designing, but also observing and validating "implemented" changes. Design Science identifies design processes (i.e., build and evaluate) and design artifacts. The latter are constructs (e.g., specific vocabularies and symbols), models, methods, and instantiations (e.g., prototype systems). These artifacts enable researchers to understand and to address the problems in developing, implementing, and validating information systems. The following phases are conducted.

Literature Study Right now we study related work in the area of reference modeling and design techniques to identify existing work. Additionally, we will evaluate existing tools in this area with a focus on the five design techniques. Furthermore, we also consider re-use concepts from software engineering, which reference modeling is related to.

Identifying Re-use of Models Once we have studied the different design techniques we will analyze the models used in *BSopt* (i.e., *e3-value, REA, UMM*, and *Core Components*) for their suitability for reference modeling. Thus, similarities in a set of likewise models have to be detected.

Defining Reference Models and Change Patterns After we detected the variating model elements, proper extension points/placeholders in models have to be defined. The existing metamodels have to be extended to allow for these extension points/placeholders. Additionally, change patterns describing the transformation from a reference model to a model instance have to be defined.

Prototype Implementation This phase will use the reference models from the previous phase and implement a prototype using domain-specific languages. The prototype will be built upon our existing *BSopt* tool, which already proved to be consistent.

Prototype Evaluation To validate our assumptions we will evaluate the reference modeling tool. Therefore, the evaluation builds upon three major pillars: *Experiments* with students building models from scratch and students building models using our reference modeling approach; *Case Study* with an appropriate

company including questionnaire as well as face-to-face interviews; *Collaborative studies* in workshops with experts of the used models.

5 Conclusion

The goal of this thesis is to provide reference modeling for inter-organizational systems. Thus, the five design techniques from reference modeling *Configuration*, *Instantiation*, *Specification*, *Aggregation*, and *Analogy* are incorporated on the models used in the *BSopt* methodology. This requires the extension of the existing metamodels to provide further to be specified placeholders in the models. Additionally, change patterns have to be defined to transform a reference model to a model utilizing wizards. The prototype implementation for *BSopt* reference modeling is expected to lower the complexity and fasten the process of modeling inter-organizational systems as well as to provide higher quality models.

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