Designing Infrastructures for Reusing Conceptional Models – A General Framework and its Application for Collaborative Reference Modelling

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Abstract

Reference modelling offers numerous potentials for business engineering. These potentials lie essentially in providing means for reusing knowledge about the design of business processes considering both the potentials of application systems and business needs. However, reference modelling is as yet a rather young field of research and hardly ready for widespread operational use in business engineering praxis. Preliminary work focusing on the methodological aspects of model design may in particular be insufficient in supporting business engineers properly.

The article at hand addresses this problem from a pragmatic perspective focussing on the designers' needs in specific modelling situations. Our work has revealed that comprehensive infrastructures are needed which provide various kinds of design support. Apart from methodological contributions, it is especially work in the fields of organisational and technological infrastructure design that is needed.

In order to illustrate and evaluate the approach, we will present a study which applies the findings for the set-up of an infrastructure which makes use of collaborative techniques. The infrastructure is presented with respect to each building block including the presentation of a prototype. The pragmatic approach thus, gives way to collaborative reference modelling. This appears promising for making use of reference modelling in business engineering.

1 The Challenge of Building Infrastructures for Reference Modelling as a Means of Business Engineering

1.1 The Potentials of Reference Modelling for Business Engineering

The field of 'business engineering' emerged at the start of the 1990ies as a management trend. It aims at enriching existing approaches with respect to both the development of operational information systems and business strategies for process design [Cornes 1990; Kruse et al. 1993; Österle 1995; Scheer 1994]. From today's perspective, business engineering can be seen as a method and model-based design theory for businesses in the information age [Österle et al. 2003]. Using those methods and models made available by business engineering, business information systems can be designed, implemented, and adapted according to specific business needs. At the same time, improvements to business operations made possible by innovations in information technology (IT) are also aimed at. Thus, business engineering intends to systematically align business applications and operations with the help of engineering principles.

Business processes have established themselves as the organisational objects of design for business engineering [Davenport 1993; Hammer et al. 1993]. Thus, with regard to corporate strategy, both the design of business processes and the analysis of the demands for their IT-support are of importance in business engineering projects. The design of business processes must follow a comprehensive approach encompassing the planning and the control, as well as the management of the operational workflows.

Information modelling has proved to be useful in supporting the systematic procedure in process design [Fowler 1997; Hay 2003; Kilov 2002; Wand et al. 2002]. Modelling techniques such as, for example, the unified modelling language (UML) [Rumbaugh et al. 2004] or the event-driven process chain (EPC) [Keller et al. 1992], serve as methodological approaches for the construction of models. Software tools for business process modelling, such as IBM Rational or the ARIS-Toolset, can support the business engineer by way of system components for the collection, design, analysis, and simulation of business process models.

The extensive demand for information models in business engineering warrants the need for reference modelling concepts. The intention of reference modelling is to systematically reuse information models in systems reengineering [Thomas 2005; vom Brocke 2003]. The approach is based on the finding that, despite various differences between design processes, general design patterns can be identified, which can solve design problems for a wide range of applications. Thus, the goal of reference models is to cover these general patterns in order to raise the efficiency and effectiveness of specific modelling processes [Becker et al. 2004a; Fettke et al. 2003; Mertins et al. 2006; Scheer et al. 2000].

To give a definition, a reference model is a special information model that can be reused in the design process of other business process models [vom Brocke 2003]. Well-known examples of reference models in the scientific field are the reference model for industrial enterprises (Y-CIM-Model) from Scheer [Scheer 1994] as well as the SAP R/3-reference model resulting from commercial practice [Curran et al. 1998].

The potential in reusing the content of such reference models seems to be promising for both saving time and costs for those carrying out business engineering projects. Moreover, the quality of the models can increase due to the fact that reference models represent established knowledge about specific business areas.

1.2 The Need for Work on Infrastructures Supporting Reference Modelling in Practice

Despite the considerable potentials of reference models, their operational use in business engineering projects has not yet been established. In fact, reference modelling, as a field of research in the information systems discipline, especially finds itself in the tug-of-war between research and practice. This field of conflict is characterised by the fact that the theoretical foundation for reference modelling propagated by the research world rarely coincides with the pragmatic simplicity of reference models and the manageability of their enterprise-specific adaptation in practice [Thomas et al. 2004]. This discrepancy can basically be attributed to the following fields of difficulty:

- *Research diversity:* The number of scientific contributions on the topic of reference modelling has multiplied in the past few years. The number of modelling methods and techniques is so diverse that even their classification has become a subject of reference modelling research [Fettke et al. 2003]. Up to now, few recommendations for the case-specific selection of classes of methods or individual techniques for reutilisation have been made.
- *Findings deficit:* There is a considerable degree of unanimity in literature regarding the application possibilities of reference models. Nevertheless, few empirical studies on the topic of ‘reference modelling‘ are documented. Thus, a deficit still exists regarding the benefits and problems inherent in the use of reference models.
- *Implementation deficit:* The deficit in findings mentioned above is also reflected in the lack of IT-implementations. Despite the diversity of the theoretical solutions for sub-problems in reference modelling, only a few of these concepts have been implemented technically or tested in practice.

Findings indicate that one reason for the rare practical use of reference modelling in business engineering may lay in the fact that reference modelling is still in a rather early stage of research. Most contributions focus on methodological aspects which may not suffice to put knowledge engineers in the position of building and using reference models in operational design processes.

In order to increase the practical use of reference modelling, a pragmatic approach appears. This approach is characterised by a focus on the specific context situation of a modelling project from which a more holistic view pertaining to the needs of the interested party involved in the design process is derived. According to these needs, a comprehensive infrastructure should be built comprising helpful settings for the design and use of reference models in business engineering. Within this infrastructure, also methodological aspects may play an important role. At the same time, however, the infrastructure is not only limited to these aspects. Further aspects may be relevant as well and there might even be situations in which limitations in methodology may be compensated by appropriate pragmatic arrangements.

These ideas will be examined in detail in the following section. We will identify essential building blocks of a reference modelling environment which are structured within a comprehensive framework.

1.3 The Building Blocks of an Infrastructure for Reference Modelling

An infrastructure for supporting business engineers in reusing conceptional models must be oriented towards the specific needs of a certain design situation. However, certain fields of action which are relevant for designing the infrastructure can be distinguished. A description of these fields within a framework can serve as a guideline for the implementation of specific infrastructures.

In order to derive relevant fields of action, a framework describing specific aspects for the implementation of design processes in information systems science [vom Brocke 2003] can be applied. Fig. 1 presents an overview of this framework along with the fields of action for building an infrastructure for the reuse of conceptional models in business engineering.

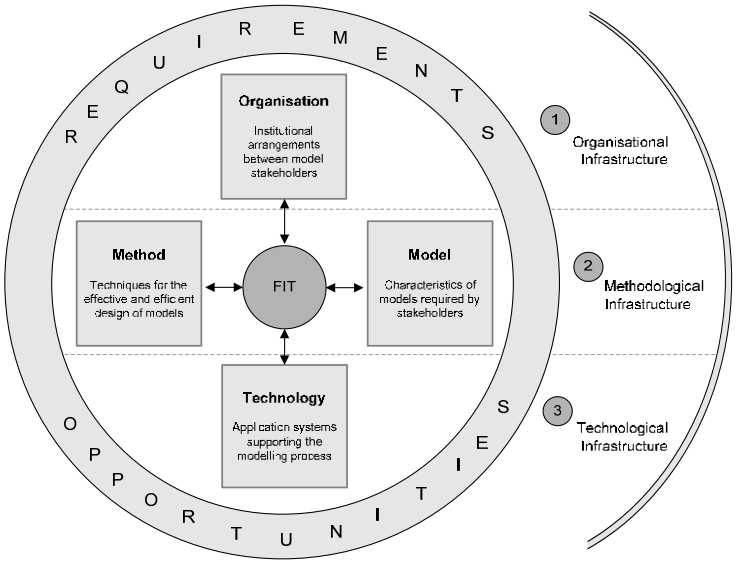

Figure 1. Framework for the Design of Infrastructures for Reference Modelling

The framework emphasizes the fact that the implementation of design processes is an interdisciplinary task. Thus, the work calls for contributions from various perspectives that have to be integrated according to specific requirements and opportunities. The model particularly shows that apart from the methodological aspects of model design focussed on in theory, contributions in the field of technological and organisational infrastructure are needed.

Seen against the background of this framework, we can identify three fields of action for the design of an infrastructure for reference modelling :

- *Organisational Infrastructure:* relevant interested parties in a certain reference modelling situation must be identified and efficient ways of coordination between them established. In detail, this indicates the need to take into account the user‘s perspective at an early stage in the modelling process. Further interested parties could be for example, business associations, scientific communities, and shareholders.
- *Methodological Infrastructure:* appropriate guidelines for describing business processes using models are needed. These guidelines should focus on certain characteristics, which the models should have in order to meet the requirements of certain modelling situations. Hence, rules are derived describing ways of building models accordingly.
- *Technological Infrastructure:* in order to make use of reference modelling in practice, application systems which support the settings considered relevant within the other fields are needed. From a

methodological perspective, it is mainly the functionality of case tools that is addressed. Thus, available tools must be examined and used accordingly. In addition, seen from an organisational perspective, systems supporting various ways of cooperation are needed. Hence, functions are relevant typically provided by knowledge management systems, work group systems, or project management systems.

According to the model, the fields of action described above must be designed in view of specific modelling situations. These situations are characterised by certain requirements and opportunities which direct the settings in the fields. In order to meet the situation properly, various interdependencies between the settings in the different fields must be taken into account. For example, the technological conditions have an effect as an enabler or as a restriction for both organisational and technical settings. Thus, the design follows a balanced manner, aiming at a so-called 'fit of design'.

A study will be presented in the following section in order to analyse the impact of the approach of building infrastructures for reference modelling support. The study was chosen in such a way that the special characteristics of the framework are emphasized. Thus, the study particularly shows the impact of work in the field of organisational and technological design on the practicability of reference modelling.

2 A Study on Building an Infrastructure for Reference Modelling Applying Collaborative Techniques for Business Engineering

2.1 The Potentials of Collaborative Techniques for Reference Modelling in Business Engineering

The effects of the approach on reference modelling presented in this paper which aim at building a comprehensive infrastructure for special modelling situations can be illustrated by a concept called "collaborative reference modelling". Within this concept, reference modelling is primarily addressed from an organisational perspective, deriving relevant settings in the field of technological and methodological infrastructure.

The essential idea of collaborative reference modelling is to share models with a greater range of interested parties in order to both continuously check and improve them from various perspectives. Accordingly, the infrastructure should provide efficient ways of transferring and discussing modelling results during the entire life-cycle of certain business areas. Given such an infrastructure, both a division of labour and an increase of model quality could be reached. As a result, an essential contribution to business engineering could be achieved in practice.

In order to design an appropriate infrastructure for collaborative reference modelling, efficient means of collaboration from an organisational perspective must first be analysed. These findings set the main requirements for the design of the technical infrastructure. Finally, findings in the field of methodological infrastructure can also be derived which can facilitate the collaborative design of reference models in practice. The following passage briefly introduces these perspectives.

2.2 Organisational Infrastructure: Networking Interested Parties

For collaborative purposes, mechanisms of network organisations [Håkansson 1989; Klein 1993] can be applied in the organisational infrastructure of reference modelling. In particular, preliminary work in the field of organising reuse-based engineering can be applied [Mili et al. 2002; Ommering 2002; Tracz 1995]]. According to the transaction cost theory, the arrangements may be carried out by hierarchy, market, or hybrid forms of coordination [Coase 1937; Williamson 1985]. A deeper analysis of the alternatives to reference modelling [vom Brocke et al. 2004] shows that the network organisation, as a hybrid mode, is a promising means for reference modelling. On the one hand, it guarantees a certain standardisation necessary for developing shared mental models. On the other hand, it leaves a critical degree of flexibility important for involving a wide range of interested parties. On the basis of the AGIL-scheme [Klein 1993], a brief outline of the underlying mechanisms of the network organisation in reference modelling can be given.

A strong impact on coordination comes from the individual return each participant expects from his or her participation in the network. In particular, suppliers of reference models face a wide range of customers whereas customers profit from transparency over a greater range of models. The design of reference models can focus on highly specialised solutions, which significantly contributes to model quality. Being connected in networks, people tend to establish a common understanding of concepts describing their business. In reference modelling, this gives way to the establishment of shared mental models about the semantic context of an application domain. Whereas the information system infrastructure provides a methodology for describing the semantic context, its design and application is carried out on the organisational level. Because the understanding of models is strongly influenced by personal perception, this shared context is vital for efficient collaboration.

Due to the history of shared experiences, social relations evolve in networks. In reference modelling, these relations are helpful in order to reduce the risks in modelling projects. Assets like the reputation of the participants give ground for vague requirements specifications which facilitate flexible responses in a dynamically changing environment. This way, both the quality and the efficiency of the design, are supported.

In addition, governing structures are also evident in networks. In software development for example, open source-communities are an example for rather liberal and self-regulatory governing structures. In these arrangements the influence of single participants results from their contribution to the network. In the practice of reference modelling however, collaboration might also be meaningful in projects with a restricted audience. Take, for example, development projects carried out by ERP-System providers involving various experts worldwide and a selected group of customers. In these applications, a more centralised governing structure could be established.

2.3 Technological Infrastructure: Collaborative Platforms

In order to start collaboration, information systems which support model sharing are needed [Gomaa 1995]. In particular, this means the support of processes for both exchanging and discussing models within a shared semantic context. The essential functionality is illustrated in Fig. 2 by an example for a prototype implementation (see: www.herbie-group.de).

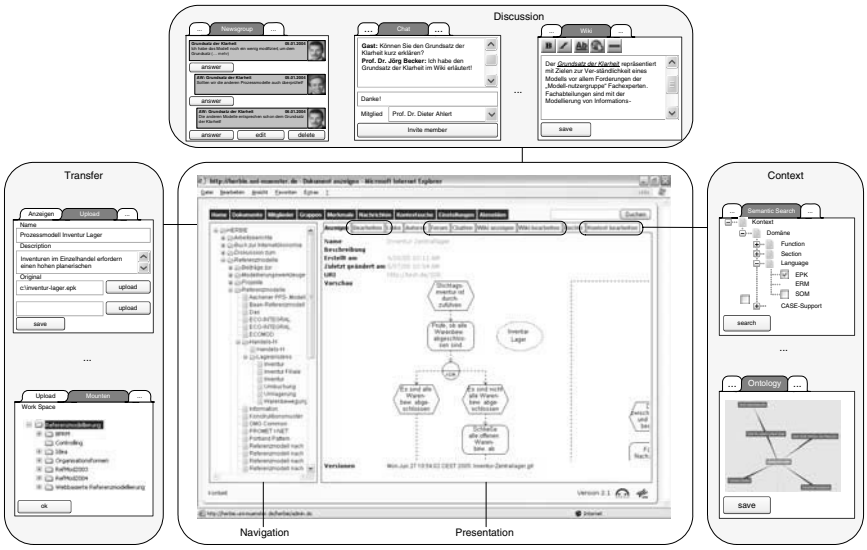

Fig. 2: Elements of a Collaborative Platform for Reference Modelling

Features for exchanging models, i.e. the up and downloading of models on a shared repository, build the foundation for the collaborative design. Internet-technology offers promising means for accessing the repository in a flexible manner via a web-browser. On the basis of standard exchange-formats like XML, higher level formats complying with the syntax of modelling languages mark future trends. For the language of EPC for example, the format EPML is, for example, provided for the language of EPC [Mendling et al. 2004]. Standards

like WebDAV make it possible to integrate the platform with local file-servers which facilitate the processes of model exchange.

Beyond the technical aspects, it is essential to describe the semantics of the models to be shared on the platform [Mili et al. 1995]. For this purpose, feature-based techniques can be applied. Apart from the area of domain engineering [Kang et al. 1998], these techniques are subject to the field of knowledge management, especially information retrieval. In this field, quite a number of appropriate techniques are being developed, ranging from simple taxonomies to more complex anthologies [Daconta et al. 2003; Whitman et al. 2001]. However, the appropriate application of these methods in practice still seems to be challenging. In reference modelling, one major requirement is to use the same context for both models and people in order to match the supply and demand of the models to be reused.

Services for discussing models are needed in order to support the continuous improvement of the reference models disseminated on the platform. In contrast to conventional community platforms, these services should be made available in relation to each single model. In reference modelling, such a close connection is essential for directing the discussion towards special contributions and thereby, raising the efficiency of the collaboration. Because the preferences for the topics of discussion differ from case to case, various channels of communication should be offered for each model, including newsgroups for asynchronous communication and chat rooms for synchronous communication. Innovative possibilities are provided by the WIKI technology. In a great number of cases, WIKIs turn out as an efficient means for discussing reference models.

2.4 Methodological Infrastructure: The Encapsulation of Models

In the study described in this paper, considering the organisational field of infrastructure gave way to a new approach in reference modelling. This approach is characterised by collaboration. As a technological basis to the approach, collaborative systems can be applied which offer special functionalities for sharing knowledge on the basis of conceptional models. Thus, the study mainly gives an example of the impact of the organisational and technological infrastructure, yet it also illustrates the fact that new methodological findings can also be derived. In the study, for example, special requirements for the design of models can be gained in order to then easily share them in a collaborative manner.

Throughout the network of stakeholders, models represented in various modelling languages can be shared. For example, UML and EPC models can be distributed one by one. However, the efficiency of sharing the models could be fostered by encapsulating them according to certain standards [vom Brocke 2003]. An example of such a standard is shown in Fig. 3. In the example, models for accounting in the procurement and distribution process of retail information

systems [Becker et al. 2004b] are encapsulated in one component for ‘accounts payable‘.

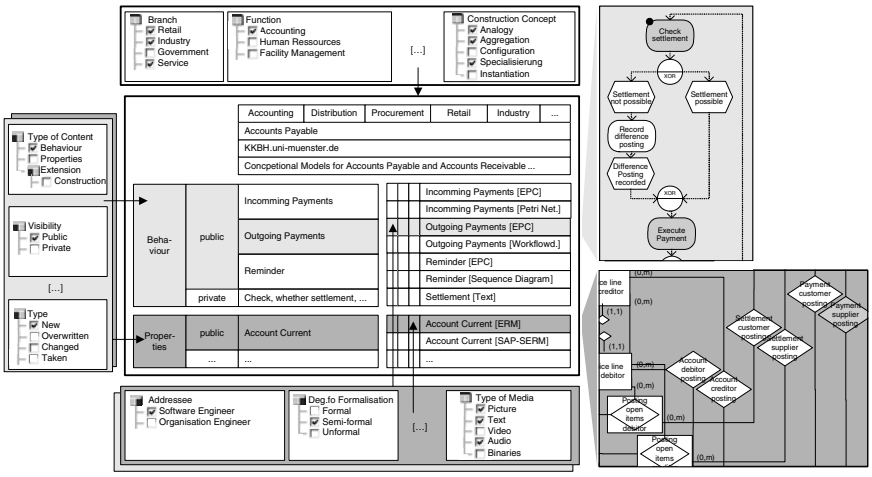

Figure 3. Encapsulating Reference Models as Components

The framework incorporates principles from component-based software engineering [Mili et al. 2002; Szyperski 1998]. This essentially means that multiple models should be structured in such a way that a combination of them fulfils a certain modelling purpose. In addition, a description is given which serves to hide details of implementation. Thus, models are identified with respect to their essential semantic contribution. For this purpose, the framework provides interfaces on multiple layers: in detail, there are interfaces which specify the overall subject, the content provided and the representations available.

In the interface which specifies the subject, the overall contribution of the model is described on a pragmatic level. In addition to identifiers, the purpose of the collected models is characterised so that the component may be easily found by its contribution. For this purpose, both a textual and a taxonomy-based description is considered. The taxonomy-based description is especially helpful in large-scale networks because it builds the foundation for mechanisms of information retrieval [Mili et al. 2002]. In particular, work on semantic descriptions carried out in the field of knowledge management can be applied for collaborative reference modelling. According to this type of specification, the component shown in Fig x is characterised by the framework to provide ‘Conceptional Models for Accounts Payable and Accounts Receivable…‘ which address companies in the branches of ‘Retail‘ and ‘Industry‘ as well as in ‘Service‘.

The content that is necessary for fulfilling the overall purpose of the component is specified by an additional interface on a more detailed layer. In this interface, items of the taxonomy serve to differentiate content regarding various different views in information modelling. On the basis of systems-thinking,

models can be differentiated by focussing on either the behaviour or the properties of a described system. Further differentiations can be implemented by the taxonomy, including either a wider or a more detailed set of views. The component describing ‘accounts payable‘, for example, needs descriptions of processing ‘Incoming Payments‘ and ‘Outgoing Payments‘ as well as conducting the ‘Reminder‘ process. As a basis, properties described in the model ‘Account Current‘ are needed.

In a collaborative environment, the content of each type can be represented in various modelling languages because interested parties have different preferences. Therefore, a special interface should be created which specifies the representations available. The semantic description here serves to characterise the interested party‘s perspective for which a representation is made. The Entity Relationship Model representing the ‘Account Current‘, for example, addresses ‘Software Engineers‘. Additional rules are required which support the integration of models in order to ensure a consistency in construction. A relationship type named ‘Payment Supplier Posting‘ must be available corresponding to the function ‘Post-Payment Supplier‘ as part of the behavioural design.

For combining various sets of reference models encapsulated in the framework, special construction concepts can be applied [vom Brocke 2003] such as configuration, instantiation, aggregation, specialisation, and analogy. That way, systems of reference model components interlinked by the interfaces can be built.

3 Conclusion and Further Research

Reference modelling has not yet established itself in business practice. This is due to the early stage of research in the field of reference modelling. Most of the contributions function on a rather theoretical basis, whereas little research has been done on the practicability of using reference models in business engineering. Accordingly, in the past years, the development of supply-sided reference models predominant in the science world, has distanced itself from their demand-sided use in business and administration. This article is devoted to this problem.

In the article, an approach to reference modelling from a pragmatic perspective is presented. Apart from focusing on methodological aspects, the recommendation is made to start considering the type of modelling situation relevant. Thus, the overall aim is to provide knowledge engineers with an infrastructure which facilitates the reuse of models in their daily work. Following this approach, a framework was introduced which illustrates major building blocks of such an infrastructure. The findings show that apart from methodological aspects, it is particularly organisational and technological aspects which play a major role.

In order to illustrate and evaluate the approach, a study was presented applying the theoretical framework. In this study, a design for an infrastructure

for reference modelling is described which facilitates the collaboration of various interested parties in business engineering. It is argued that such a collaborative setting, derived from organisational theory, strongly contributes to the use of reference modelling in practice. For each building block of the infrastructure, a detailed description of relevant contributions is given. According to this study, which focuses on the potential for collaboration, further modelling situations must be analysed. That way, a kind of reference guide for the infrastructure design can be given.

The findings gained in this analysis can be used as a starting point for further research work. Thus, for example, empirical studies be carried out to investigate the engineer‘s behaviour and to learn about his further demands. In addition, monitoring the efficiency of modelling projects can give further insight. The findings described in this paper may give way to these studies.

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