Chapter I
Reference Model Management

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ABSTRACT

Reference modeling is located in a field of conflict between research and practice. Despite the array of theoretical concepts, there is still a deficit in knowledge about the use and problems inherent in the implementation of reference models. Accordingly, in the past years the supply-sided development of reference models predominant in the science world has distanced itself from their demand-sided use in business and administration. This contribution will analyze the causes of these problems and present a solution in the form of an integrative approach to computer-supported management of reference models. The task to be carried out with this solution approach will be concretized using data structures and a system architecture and then prototypically implemented in the form of a reference model management system.

INTRODUCTION

Business Process Modeling and Reference Modeling

The central idea in reference modeling is the re-utilization of the business knowledge contained in reference models for the construction of specific information models (Hars, 1994; Scheer, 1994b; Schütte, 1998; vom Brocke, 2003; Becker & Schütte, 2004; Fettke & Loos, 2004; Thomas, 2006a). Reference models provide companies with an initial solution for the design of organization and application systems. The possibility of orienting oneself with the specialized content in a reference model can, on the one hand, decisively save time and costs for the model user and, on the other, can increase a model’s quality because reference models present general recommendations for the subject area under analysis.

Towards the end of the 1990s, a certain “reference modeling euphoria” could be detected which could be attributed to the strong influence of process-oriented paradigms, such as business
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process reengineering (Hammer & Champy, 1993) or continuous process improvement (Robson, 1991). However, while process consulting and, especially, software tools for business process modeling established themselves as a separate market segment (Gartner Inc., 1996), a development in the opposite direction can be observed for reference modeling—despite the often mentioned close connection to business process modeling.

Today, the systematic development of reference models is seldom seen in practice. Reference models are rarely oriented towards customer segments or enterprise processes. The potential for improvements which result from the enterprise-specific adaptation of reference models is usually not consequently integrated into them. Modeling tool providers are discontinuing modeling projects due to restrictions in time, personnel and finances. Few reference models exist on the basis of a modeling method which offers comprehensive support for model adaptation—the few exceptions here are the reference models from some providers of ERP systems.

Reference modeling as a field of research in the information systems discipline finds itself conflicted between theory and practice. This field of conflict is characterized by the fact that the theoretic foundation of reference modeling propagated by researchers is rarely consistent with the pragmatic simplicity of reference models and the manageability of their enterprise-specific adaptation called for in business practice. This discrepancy can, for the most part, be ascribed to the problems discussed below.

**PROBLEMS IN REFERENCE MODELING**

**Research Diversity**

The number of scientific contributions on the topic of reference modeling has multiplied in the last few years. From the contextual perspective, works come to the fore which support the development of reference models for branches of trade not considered up to now, such as public administration, health care systems or credit and insurance business (Fettke & Loos, 2003). Today’s literature also provides a multitude of different suggestions from the methodological perspective for the construction and usage of reference models. The number of modeling methods and techniques applied with the corresponding approaches is so diverse, that even their classification has become a subject of reference modeling research (Fettke & Loos, 2002b). Up to now, few recommendations for the case-specific selection of classes of methods or individual techniques of reutilization have been made. The question also remains open, as to whether the technologies examined can be integrated into construction processes. The fact that most of the examined technologies are geared to a certain modeling language (Fettke et al., 2002b, pp. 18 ff.) should at least make an integrated usage difficult. Reference model developers and users are therefore hardly in the position of deciding which of the methods, techniques and languages suggested in literature are adequate for their use cases. In this connection, it becomes clear why so few “unique” languages in reference modeling (e.g., Lang, 1997; vom Brocke, 2003) or reference modeling-specific extensions of established languages in information modeling (e.g., Remme, 1997; Schütte, 1998; Schwegmann, 1999; Becker, Delfmann, Knackstedt, & Kuroeka, 2002) have so far not found great acceptance in practice.

**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 modeling” are documented. The only German-language empirical study on the creation and usage of reference models was carried out in the spring of 1997 at the University of Muenster (Schütte, 1998, pp. 75 ff.).
A survey of 390 reference model users in business practice was planned for the questionnaire campaign (planned random sample). The actual sample size (final sample size) however, with only 22 questionnaires filled out (rate of return approx. 5.6%) (Schütte, 1998, p. 371), was so low that no statistically significant statements could be made. Thus, a deficit still exists regarding the benefits and problems inherent in the use of reference models.

Implementation Deficit

The deficit in findings in reference modeling mentioned above is also reflected in the lack of IT implementations. Despite the diversity of the theoretical solutions for sub-problems in reference modeling, only a few of these concepts were implemented technically or tested in practice. Thus, in connection with his approach for using reference process building blocks, Lang (1997, p. 8) explicitly points out the fact that modeling tools are circumstantial, because one can fall back on existing tools. He does not, however, explain how this is to be done. Schwegmann (1999, p. 2) completely differentiates his approach to object-oriented reference modeling from implementation-technical problems, although he sees the information systems represented by reference models in a more or less technical light through the use of the object-oriented paradigm.

One reason for the lack of IT implementations is the low “degree of formalization” in the respective approaches—usually, it is a consequent transfer of the requirements definition to a data-processing concept that is lacking. This would, for example, allow the integration into a professional modeling tool and, in doing so, allow many users to be reached and practical experiences made.

REFERENCE MODEL MANAGEMENT

Objective and Subject Area

In light of the problems shown in reference modeling, the author is of the opinion that the current significance of reference modeling in research does not so much result from the necessity of methodically analyzing it, but is rather much more the realization in operational practice that, in times of dynamic markets, knowledge about application system and organization design has become a critical factor for business success.

The current occupation with reference models focuses on a central question in business information systems: “How can application systems and organizations be designed so that they meet the demands of their environment as best possible?” The analysis of this problem pertains to many interdisciplinary fields of work, such as organizational theory, systems theory, enterprise modeling, business process management, knowledge management, innovation management and software engineering. However, respective theoretical concepts often neglect the competition-relevant role of knowledge about the design of application systems and organizations. Therefore, based upon the theoretical concepts, the following modified question should also be asked regarding the problem discussed above: “How is the knowledge concerning the design of application systems and organizations planned and controlled?” Moreover, if one understands reference models as memories for explicit domain knowledge, then one must interpret reference modeling as an instrument, which aims at the transfer of business and IT knowledge (Scheer, Habermann, Thomas, & Seel, 2002, pp. 209 ff.; Fettke et al., 2003, pp. 35 ff.), and if one summarizes the terms planning and control in the term “management,” then the resulting question can be none other than: “How can reference models be managed?” The author
will do his part in answering this question, as expressed in the title of this contribution, in the following.

As touched upon in the previous paragraph, this article understands reference model management (RMM) as the planning and control of the development and usage of reference models. The terms “management of reference models” and “reference model management” will be used here as synonyms.

Core Functions

The management of reference models can be conceived as a process. This process is characterized by creativity and is highly complex due to its multifariousness and dependency on human judgment. Procedure models have established themselves in reference modeling—in analogy to software engineering—as being useful in making this complexity controllable. These procedure models which are presented by, among others, Schütte (1998, pp. 184 ff.), Schwegmann (1999, pp. 165 ff.), Schlagheck (2000, pp. 77-91), Fettke and Loos (2002a, pp. 9 ff.) and vom Brocke (2003, pp. 320-344), emphasize the developmental phase of a reference model on the one hand and, on the other, the phase of creation of enterprise-specific models based on a reference model (i.e., the usage of a reference model). In both cases, a process of construction must be gone through and this process can be supported by operationalizable approaches to the creation of models. The processes of development and usage of a reference model are, however, usually chronologically, as well as contextually and organizationally separated from one another (Thomas & Scheer, 2006):

- **Chronological separation:** The chronological separation of the construction process results directly from the definition of a reference model. A model can be referred to as a reference model when used to support the construction of other information models.

Thus, the construction of a reference model always precedes the construction of specific models.

- **Contextual separation:** Usually, the reference model constructor does not know the demands regarding the content of future reference model adaptations. He must therefore try to foresee them. This problem occurs especially when construction techniques, such as the configuration (e.g., Rosemann & van der Aalst, 2003) are used, whereas in dependence of specific conditions, construction results from the reference model are selectively adopted.

- **Organizational separation:** The model provider and customer, respectively constructor and user, are usually different people, departments or companies. An enterprise is, for example, either the provider of the knowledge in the reference model or—through the enterprise-wide introduction of a modeling tool—a customer for the reference model. This organizational separation can lead to the fact that, on the one hand, the customer requirements on the reference model are not adequately fulfilled by the supplier and on the other, that the customer’s experiences using the reference model are not used continuously for the improvement of the model.

This separation of the processes “reference model development” and “reference model usage” as regards time, context and organization is seen here as a problem of integration. In general language use, integration is understood as the recreation of a whole. From the system theoretic perspective, integration means the linking of elements and components to form a complete system. This integration can take place by merging or connecting elements and components which logically belong together. One can refer to integration as either the process of recreating a whole or the result of such a process. For the field of information systems, integration means connecting man, task
and technology—the components of an information system—to form a whole.

If we transfer this understanding of the term to the topic dealt with here, then we can identify the development, usage and integration of reference models as the core functions of reference model management (cf. Figure 1):

- **Reference model development**: The planning and realization of reference model construction. The development of reference models encompasses the acquisition of and search for relevant information sources and content, as well as the explication and documentation of an employee’s application system knowledge and organizational knowledge. The development of reference models refers to the development of new reference models, as well as the modification and continual improvement of existing ones.

- **Reference model usage**: The planning and realization of the construction of information models using reference models. The usage of reference models comprises the search and navigation of the reference models relevant for the use-case, their selection and distribution to the persons concerned, the presentation of knowledge content, as well as the support of the reference model adaptation. It also comprises the retroactive evaluation of the reference models used and associated information.

- **Reference model integration**: The fusion of the separated processes in the development of reference models and the use of reference models for the construction of enterprise-specific models in the sense of the (re)creation of a whole.

**IT-Support**

The usage of reference models for the construction of enterprise-specific information models is a fundamental idea resulting from paperless, tool-supported data-processing consulting (Scheer, 1994a). Thus, this contribution will not deal with the question as to whether it makes sense to economically develop a computer-aided information system for the management of reference models from the research perspective, as well as from the practice perspective. This question has long been “answered” by the economic success of modeling and analysis-tool providers (Sinur, 2004). On the contrary, we must investigate the question of how an information system should be designed so that it can support reference model management adequately.

Because it is the design-objective of information systems in the sense of the planning, construction and modification of operational reality and supportive information systems that is emphasized in this contribution, the goal to be achieved cannot be found in design alone but rather, also in the creation of an information system which can

*Figure 1. Core functions of the management of reference models*
support the management of reference models. This information system will be referred to as a reference model management system (RMMS).

**Concretion of the Challenge**

The framework shown in Figure 2 will be used as a guideline for the challenge to be carried out. Due to its system-theory character, it illustrates the most important components of an RMMS, as well as their functional interaction.

The graphic is oriented on the contextual and technical interface-concepts for modeling tools which allow the retention of various IT-platforms (Scheer, 1994a). This allows the consideration of the underlying networking of conceptual research results, prototypes and professional software developments. The RMMS-framework is also oriented on studies concerning instruments and processes for the access to and usage of information models which, among other things, lead to the conception of a model library (Mili, Mili, & Mittermeir, 1998). In addition, results from the prototypical development of an integrated information system for the documentation, networking and design of operational measures for business process improvement have been used for its construction (Scheer et al., 2002).

The framework consists of seven components, which are arranged in five layers. The components are represented by rectangles, the relations existing between them by shaded grey connecting lines and the system limits by a rectangle with rounded corners (cf. Figure 2).

In addition to the support in the development and usage of reference models, a third main function was identified for the management of reference models: reference model integration. These functions also form the core functionalities of the information system for the support of reference model management on the tool layer. The link between the elements “reference model development” and “reference model usage” is created by the element “reference model integration.” This “bracket” is illustrated by the arrangement of the components, as well as by the connections representing the relations between the components in Figure 2.

The information model for reference model management, derived from the conceptual layer,

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**Figure 2. Framework for a reference model management system**
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can be seen as the core component for the organizational framework. It identifies and links the most important information objects of the reference model management as well as associated information objects and, at the same time, forms a basis for its physical management. It is a semantic data-model, which—against the background of the research diversity discussed in the first section—is used to clarify relevant terms, as well as to define a uniform terminology.

The RMM-information model forms the technical basis for the functionality “reference model integration” of the RMMS on the tool layer. It is, however, also the basis for the logical database structure of the RMMS on the physical layer. It is also referred to as a repository. Both relationships are illustrated in Figure 2 by way of the connections plotted between the components.

Because established products exist in the field of information, and especially business process modeling, the complete new development of an RMMS is not necessary, but rather only the extension of existing systems. Thus, on the modeling layer especially, professional tools were used for the design of the component “modeling and analysis.” The functionalities necessary for the development and usage of reference models which, for example, require a model modification, have already been implemented in corresponding systems. Functionalities which, however, serve the documentation of a construction process or a certain procedure in the usage of reference models may require a new implementation. Moreover, the deficit in findings discussed above is met through the implementation of the RMMS as an integrated part of a professional tool for business process modeling.

The user-interface of the RMMS is designed on the interaction layer. In addition to human judgment, the user interface of the RMMS represents a large bottleneck in the implementation of computer-aided information systems. Great importance must therefore be attributed to its design.

In the following, the design target defined by the RMMS-framework, that is, the description of the individual components of the framework, as well as their interactions, will be pursued. In doing so, the conceptual aspects of the RMM-information model, as well as the technical aspects in the form of an RMMS-system architecture, will be discussed.

REFERENCE MODEL MANAGEMENT SYSTEM

Information Model

The RMM-information model pursues two goals. First, the model, as the core component of the RMMS-framework on the conceptual level, builds the foundation for the design of the RMMS-functionality “reference model integration” on the tool level. This was identified as the “link” between the RMMS-functionalities for the development and usage of reference models before. Thus, the RMM-information model must identify and connect the most important information objects for the development and usage of reference models. In addition to the technical analysis of the field of application, the RMM-information model also pursues another goal. It serves as a starting point for the technical implementation of the information system and forms the foundation for the database-structure of the RMMS on a physical layer (RMMS-repository). The modeling language in which the RMM-information model is explained must therefore allow the representation of the relevant business content and be so formalized that a subsequent transfer of this content to information technology can be accomplished. The class diagram from the unified modeling language (UML) (http://www.uml.org/) was selected as a modeling language.

With the help of an object-oriented model, many classes and associations are constructed in the description of the application field “manage-
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Figure 3. Macro-model of the reference model management

Reference models created within the framework of a construction or enterprise-specific information models designed during the adaptation of a reference model by persons, departments or enterprises can generally be interpreted as output. The usefulness of this output can be acknowledged by its recipients (for example, customer or a certain company-internal department). This interrelationship is represented in Figure 3 by the two packages Organizational Unit and Reference Modeling Output, as well as by their relationship to one another.

During the structuring of the macro-model, the idea was pursued that certain processes must be run through for the development and usage of reference models. These processes generally possess project-character due to their chronological and contextual restrictions. The respective reference modeling projects are therefore realized using concrete measures initiated and carried out by organizational units. The reference modeling projects, in turn, aim at creating reference modeling output. Thus, the package Reference Modeling Project is also introduced and is the center of the macro-model in Figure 3. The connection described is illustrated by the relationships between
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Figure 4. Micro-model of the reference model management (section)

Reference modeling projects are instantiated from the homonymous class Reference Modeling Project which refers to the interface of the corresponding package in the macro-model. A reference modeling project is comprised of the concrete project activities with which a target reference modeling output is to be created. A “network” is constructed here as a general procedure structure for project activities. The association class Activity Plan states that an activity can, but must not, have several successors and predecessors. The association class Activity Hierarchy suggests the possibility that an activity can consist of several sub-activities and is an element of a superordinate activity. The data structure for describing

the packages Organizational Unit, Reference Modeling Project and Reference Modeling Output.

Reference models are recorded in electronic form or conventionally on paper. The models stored electronically can be assigned to application systems, such as modeling, and analysis tools as supporting media. The package Application System addresses this point.

Reference Model Controlling also carried out by organizational units, plans and controls the costs resulting from the activities in connection with reference modeling output and in addition, evaluates the reference modeling measures carried out according to their economic aspects.

The application field “Reference Model Management” is characterized in a survey-like manner with the UML-package diagram model. We will concentrate in the following on the classes assigned to the individual packages in this macro-model and the associations existing between them. Due to reasons of space, the description is limited only to the central package Reference Modeling Project (cf. Figure 4).

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Procedure models is also illustrated in Figure 4. Procedure models describe standard procedures for certain project types and can be used for the specification of concrete project procedures. Procedure types, instantiated as objects from the class `Procedure Type`, can be assigned to the class `Procedure Model` over the association class `Procedure Type Correlation`. This allows the reutilization and redundancy-free storage of procedure types. The various possibilities for the structural connection of procedure types are expressed by the class `Structure Type`. The contextual relation between the classes `Reference Modeling Project` and `Procedure Model` is created by the association class `Project Procedure Model`. Depending on the complexity of the project, several procedure models can be assigned to a reference modeling project. They are then processed within the framework of the total project as more or less independent sub-projects.

**INFORMATION SYSTEM ARCHITECTURE**

The primary technical aspects of the tool for the management of reference models refer to the definition of the technological platform, the identification of the IT-components and the description of their DP-logical relationships. The main task below consists in selecting individual technologies and integrated technology systems, and arranging these in a network so that the user is supported as best as possible in carrying out his or her tasks within the framework of the reference modeling project. The selected information technologies are illustrated in Figure 5 in the form of a system architecture.

The system architecture of the RMMS is that of a client/server. Due to the multitude of RMMS-system elements, these are “classically” structured in three layers—the data management, application and presentation.

*Figure 5. RMMS-system architecture*
The data management-layer of the RMMS-system architecture is divided up into database and file management. While the structured data (human resource and customer data, as well as as-is and reference models) is managed in relational databases, the weakly-structured data (text documents, spreadsheets, presentation graphics, images, video and audio files, as well as links to further documents), is stored in a file system. The database structure is built upon the logically integrated data models developed on the conceptual level.

The data management-layer differentiates between four databases—an enterprise-wide human resource database, an enterprise-wide customer database, an as-is-model database and a reference model database. The reference model database, in particular, is a systematized collection of reference models (reference model library). It stores the reference model constructs, as well as their structural relationships, model attributes such as name, identification number, type of model (for example, EPC or ERM), description, time of creation, originator and last modification or last processor. The customer model database is also a model database, as is the case with the reference model database. It contains documented as-is-models, that is, sections of the customer’s enterprise-structure interpreted by the creator of the model at the time of modeling.

The external databases in Figure 5 manage the data needed by the RMMS. Together they form the “minimum configuration” of the external RMMS-database. The individual databases in Figure 5 are represented as logical entities for purposes of simplicity, which, as a rule, consist physically of several distributed databases. For example, the reference model database could consist of several external databases. This is the case, for example, when in modeling projects reference models from different modeling tools are used to manage the models in their own databases.

The application layer comprises the server-services and data (RMMS-repository) which are used to carry out the technical tasks. The programs in this layer receive the user’s (client’s) instructions and carry them out on the relevant data. By using a client/server-architecture, several applications and users can access the same database at the same time and process it.

The RMMS-repository, in the center of the application layer, is completely defined by the data model designed above (cf. Figure 6). It structures the information objects necessary for the development and usage of reference models and can be searched. As already mentioned, textual project documents (for example, offers, commissions, specification sheets and bills) and presentation graphics or multimedia files (for example, audio and video recordings) are not stored in the RMMS-repository. They are managed in the file system of the data management layer and processed with external programs. Nevertheless, the search for and in these files is controlled with the help of links to the repository. It is especially the connection of structured and weakly structured documents via the database and file-server that is of importance here. The repository-data is stored in an XML-structure for internal processing. Through this, the integrated application of the structured data (database), as well as the weakly-structured data (files) are guaranteed, because they can be managed independently of their format. Thus, for the user, the database and file system appear to be one.

The project database is at the center of the RMMS-repository. It manages internal and external reference modeling project commissions between organizational units by storing data such as project name, type, objective, time period and status or progress. The data-structure of the project database corresponds to the UML-class-diagram model in Figure 4. Project documents, such as project commissions, structure plans, schedules, minutes and status reports or specification sheets,
are not directly stored in the RMMS-repository. These documents are created by the users locally and managed in an external file directory. The project database also supports project management by managing the number, type and logical order of all activities with which a reference modeling project is to be realized, as well as by storing model histories. With the help of relations to the user database, each reference modeling project is assigned a project leader and a group of project members. Associations to the customer database take reference modeling-specific customer requirements into consideration. The project-related new development, configuration or reengineering of reference models, as well as the documentation of changes in the knowledge basis, require access to the reference model database.

While read-access to the weakly-structured data is controlled via the FTP-server, the SQL-server controls the read and write-access to the external databases and the data transfer to the repository (cf. Figure 5). The application server gives the RMMS-users access to the modeling and analysis tools. The application-server allows the flexible modification and extension of the RMMS-system architecture. When, for example, a new modeling and analysis tool is added, all that must be done is to adjust the respective software on the application-server.

The components of the RMMS with which the user has contact are assigned to the presentation layer (cf. Figure 5). They make the input and output user-friendlier and are represented by a graphic interface. The operational concept of the RMMS and its graphic user interface should be adapted to the interface design of established modeling and analysis tools. This way, the separate systems appear to be a logical entity for the user—from the technological point of view. This also makes access to the RMMS easier for users familiar with modeling tools.

The central element of the presentation layer is the RMMS-client. This term refers to the graphic user interface for the reference model management system in Figure 5. The access to the repository data, as well as the control of the SQL and FTPervers, takes place over the interface of the RMMS. In addition, the requirements to the modeling and analysis tool are routed to the

Figure 6. RMMS-repository and databases
application-server and, when necessary, data are transferred to the XML-processor.

While the RMMS-components are used for processing information which is important for the development and usage of reference models, the creation, processing and deletion of information models remains the task of the modeling and analysis tools. Several different modeling and analysis tools may be used here. This is illustrated by the rectangles arranged one after another in Figure 5. In order to not focus on the integration capability of modeling tools (Mendling & Nüttgens, 2004) the use of only one modeling and analysis tool will be assumed. Not the interactions between several modeling tools, but rather the general exposure to reference models and associated information objects are the subject here. It is important, thereby, to secure the compatibility of the database of the modeling tool with the model databases in the data management-layer.

A decisive difference exists between the components “modeling and analysis tool” and “application system” (cf. Figure 5) on the technical side. While the modifications of the modeling and analysis tools flow back into the database of the RMMS, the information from the RMMS is only transferred to the application systems. This means that the knowledge won from these systems does not flow back into the RMMS-repository.

The repository-data is stored as XML-documents. Due to the independence of these documents from logical and physical structures, the integration of other application programs which use these documents is facilitated in the RMMS-system architecture. Applied RMMS-interfaces are conceivable in the software categories of office information (for example, word processing, spreadsheets and presentation graphics), computer-aided software engineering, computer-supported cooperative work, document management, enterprise resource planning, knowledge management, organizational memory and project management or workflow management. A simple implementation would be, for example, the integration of components which help to generate and output HTML-descriptions of process models. This can be especially useful in international reference modeling projects, where separate project groups operate. It allows the discussion of modeling results via Internet and Intranet. Some manufacturers of modeling tools already offer such components.

Prototype

The graphic user interface of the RMMS is illustrated in Figure 7. The prototype, implemented in the platform independent programming language Java (http://java.sun.com/), differentiates between a project and a model view of the tasks associated with the development and usage of reference models.

The project view has been selected in the screenshot in Figure 7. The RMMS workspace is divided up into an explorer and a viewer. These are connected logically with each other—a project selected in the explorer is displayed in detail in the viewer and can be manipulated there. The project active in Figure 7 is called “Reference Model for Event Management” and is used for the development of a reference model for the application domain “event management.”

The title, the project’s customer segment and information concerning the project period, progress and type were selected by the project manager while setting up the project with the help of the assistant (project wizard). This information can, in addition, be modified using the buttons “Project” and “Subject.” A detailed representation of the customer assigned to the activated reference modeling project (i.e., his or her address, branch of business, turnover, number of employees, range of products, etc., can be reached using the button “Customer”). This functionality also allows the user to call up information such as customer description, goals or requirements. While this assignment in the use of reference models pertains more to individual customers, projects in refer-
ence model development are usually assigned an entire customer segment, as reference models are constructed for a whole class of use cases.

The Viewer is divided up into index cards, which can be selected using their respective tabs. The index card “Overview” (cf. Figure 7) basically characterizes the modeling projects. The elements in this card form important criteria according to which the projects stored can be sorted or searched.

The index card “Activities” contains the tasks or activities necessary for the realization of the targeted reference modeling project. Furthermore, descriptions of the above, activity plans and hierarchies are also stored here. These tasks are individually assigned to project members (via a link to the index card “Members”), as well as to project documents, such as meeting minutes or the presentation of results (linked to the index card “History”).

The creation of the team, which will work together in realizing the reference modeling project, takes place using the index card “Members.” This card also contains the name, position, location, organizational unit and contact information for each member of the team, as well as the respective tasks assigned to them.

In addition to the project activities and employees involved in business engineering projects, one should also document information about the progress of the tasks and the problems met, as well as possible and ultimately selected measures for solving these problems. The history of the reference modeling project is therefore documented in a project history (“History”). This can be used by the project members as a source of information.

Figure 7. Graphic user interface of the RMMS
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regarding the project history and can support the user in planning future projects.

The collaboration between employees in different departments and at different locations is also customary in the development and usage of reference models (vom Brocke, 2003). The RMMS thus has functionalities which support collaboration during reference modeling projects. To this purpose, an asynchronous communication medium (discussion) is offered on the “Collaboration”-card. One is also given the possibility of reviewing project documents.

The workspace in the RMMS-model view is also divided up into an explorer and a Viewer (cf. Figure 8, screenshot in the background). In the model explorer, all of the information models managed by the RMMS are displayed. This pertains to reference models constructed in development projects, as well as enterprise-specific models created in application projects.

The index card system in the “Model Viewer” is used to manage the most important model-related information for the management of reference models.

The information models managed by the RMMS are characterized on the index card “Overview” of the model view. This is similar to the corresponding card in the project view. The elements of the card “Overview” provide criteria similar to the corresponding information in the project view, according to which the information models stored can be sorted or searched. Potential sorting criteria, which can be selected in the corresponding pulldown menu in the upper part of the “Model Explorer” are: branch-of-trade, model name, application domain, model developer, period of development, modeling progress and modeling language. In the screenshot in Figure 8, the criteria “Economic Activity” is selected,

Figure 8. Interaction-design between the RMMS and the ARIS-Toolset
which differentiates between branches of trade at the top level. The reference model selected, which due to its form is referred to as “Event-E,” is assigned to the branch “Marketing.”

A graphic representation of the model to be constructed in the modeling project is made possible with the card “Graphic.” Figure 8 illustrates the connected requirements clearly, as well as the resulting interactive-design between the RMMS and the modeling tool ARIS-Toolset (IDS Scheer AG, 2003). The example illustrates that the user can make modifications on a version of the reference model organizational framework for event management. To do so, he or she must open the ARIS-Toolset by clicking the “Edit” button. In addition to reading, editing or deleting models and model elements, the user is given further functionalities of the modeling tool.

The subject of the dialogue which can be reached using the “Versions” button on the “Graphic”-card (cf. Figure 8) is the management of the models and model element versions (model history) created in the course of the reference model modeling project. In addition to the most important model data, such as name, type or creation and modification dates, other data such as time, responsibility (link to the card “Members”), description, reason, priority and status of the model modifications, as well as the corresponding project activities (link to the card “Activities”), are recorded. The structure of this dialogue is based upon the findings on the version management of reference models (Thomas, 2006b).

The display of characteristic information, with which certain information models can be recognized, can be viewed on the index card “Attributes.” Similarities and differences between the models are emphasized and used for other activities (for example, similarity analyses and searches).

The RMMS gives you diverse functionalities for the support of distributed reference modeling. In the Project View, these referred to the support of administrative project tasks, complemented by the asynchronous communication medium of the discussion forum. These functionalities have been extended by way of a synchronous communication medium on the index card “Collaboration,” a shared whiteboard for the interactive viewing and annotation of graphic data.

**Related Work**

“Reference model management” is a term rarely used in science and in practice for the description of the management tasks associated with the development and usage of reference models. Therefore, a few examples for the use of this term will be discussed below.

Within the framework of his approach to the computer-aided use of reference data models Hars (1994, p. 11) sees the purpose of meta-models in creating a more favorable structure for the storage and management of models. What he means by this term, however, is not explained.

In a paper within the framework of the research project, “Business Process Design with Integrated Process and Product Models” (GiPP) Klabunde and Wittmann (1998), see the reference character of information models anchored in a “broad” basis of knowledge. This could be guaranteed when instruments and procedures for the access and efficient and flexible use of reference models were developed and would make it possible to fall back on existing models, discuss their content, compare them with other models and continue models development. They see the DP-supported management of reference models in libraries as one of the central challenges here (Klabunde & Wittmann, 1998, p. 16).

Gerber and Müller-Luschnat (1999) describe a method for business process-modeling projects for the “Sparkassenorganisation” (SKO), consisting of three components which serve the “coordination of diverse modeling projects, … the use of synergies in modeling and … the prevention of multiple developments” (Gerber & Müller-Luschnat, 1999, p. 27). In addition to the procedure model, which describes the individual project
phases and the reference process model which serves the reutilization of process templates, they define *process model management* as a third component. This model “describes the processes necessary for the permanent care and further development of a reference model” (Gerber et al., 1999, p. 28). They declare the consistency of the reference process model during the usage of models from different BPR-projects to be the main task in process model management.

The goal of the project “Transformation of Reference Models for Standard Business Software” (TREBES) is the development of a theory for procedure model transformations with special regard to the requirements of business process engineering and reference model-based customizing (Oberweis, 2003). Petri-nets are used as a modeling language. According to existing procedure description methods, business objects are integrated and described using the extensible markup language (XML). The simultaneous transformation of several models during customizing (delta analysis) and the *computer-based management of reference models* are seen as problematic areas.

In addition, the term “model management” is often discussed by consulting firms in connection with the integration of enterprise applications. Model management then refers to the integration and contextual adjustment of models (for example, organization models, process models, data models and object-oriented models) within the same task and is seen as an important medium for increasing quality in software development (Resco GmbH, 2002). While model management deals primarily with instance models with respect to the degree of abstraction from the original, enterprise model management aims at type and cluster models. *Enterprise model management* (EMM) integrates and consolidates models on the project-level and tries to generalize their facts, so that the models can be applied on the department, division or enterprise level. The resulting models are, in turn, adjusted to each other and by adding other areas, further generalized.

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**CRITICAL DISCUSSION OF THE RESULTS AND FURTHER RESEARCH**

The instrument “reference modeling” has not yet established itself extensively in business practice. This is due to the particular field of conflict between research and practice in which reference modeling is at home. Thus, there is still a deficit in knowledge about the use and problems inherent in the implementation of reference models despite the array of theoretical concepts. Accordingly, in the past the supply-sided development of reference models predominant in the science world has distanced itself from their demand-sided use in business and administration. This contribution has been devoted to this problem.

The rationale for the “reference model management” approach selected here is based on an analysis of the state of the art in reference modeling, whereby potentials were seen in two respects. First, we have shown that the contributions at hand comprehensively address the design of construction results but, however, disregard the corresponding construction processes which make the retraceability and, thus the reuse of the results, difficult. On the other hand, results pertaining to the design of the construction processes are available; they concentrate, however, either on the development or the use of the reference models or they do not sufficiently reduce the chronological, contextual and organizational separation between both processes. Reference model management was therefore formulated explicitly with the purpose of recreating the connection between the separated processes in reference model development and usage. Thus, within the framework of a process-oriented interpretation, the integration of both processes has been identified as a third function in reference model management next to the development and usage of reference models. The design and realization of an information system for the management of reference models were concretized as objectives here because, due to the
The magnitude of the models in modeling projects, the economic construction and use of models is only possible with the help of IT-tools. The development of this information system referred to as a reference model management system was structured by a framework.

The knowledge won in this analysis can be used as a starting point for more detailed research work. Thus, for example, empirical studies could be made to investigate whether the insights won more or less deductively coincide with the reality of business practice. One could also investigate how the use of the RMMS affects efficiency in modeling projects. The investigation of the effects of this prototype in operational business reality is seen as a future challenge for the author in his research activities.

The reasons for further research in the field of reference modeling lie in the fact that up to now no uniform reference modeling language has been established in theory or practice. Even the reference modeling-specific extensions of established languages in information modeling created primarily for research are rarely used in practice. Reference modeling research must carefully weigh formal precision against pragmatic manageability when developing such a modeling language: If modeling languages have formal semantics then they are suited to machine processing, but the interpretation of real-world connections can become more difficult. In this case, studies should be carried out to resolve this conflict. Thus, one of the central tasks in the future of reference modeling researchers should be to not only present the consequences of their results for science, but also for modeling practice.

Obviously, more fundamental research is required in order to understand the effects connected with the creation and usage of reference models in science and practice. However, this topic is dealt with in the future in reference modeling research, the compilation of improved knowledge about application system and organization design remains a central task in the field of information systems. With the cognition won within the framework of this study, a concept and a prototypical implementation for the management of this knowledge, which is represented by reference models, are to be available.

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