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Requirements Definition for Enterprise Information Portals: An Integrated Method for Specifying Quantitative and Qualitative Information Needs

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REQUIREMENTS DEFINITION FOR ENTERPRISE INFORMATION PORTALS: AN INTEGRATED METHOD FOR SPECIFYING QUANTITATIVE AND QUALITATIVE INFORMATION NEEDS

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Abstract

Rational and funded management decisions require both quantitative and qualitative information from internal and external resources. New information system architectures like enterprise information portals provide a personalized single gateway to quantitative information, which is mainly provided by data warehouse and OLAP systems for analysis purposes, as well as to qualitative information, which can be administered by content management systems. As the engineering of enterprise information portals meeting managers' special information needs is a complex process, there is a need for suitable approaches to support in particular the requirements definition.

While graphical models like ER models, flow-chart-diagrams etc. are wide spread and accepted by executives as well as system developers for system requirements specification, an adequate modeling language for the domain of enterprise information portals is missing. This contribution proposes such a modeling language. Its specification is formalized in terms of a model: a meta-model. Therefore, we fall back on another approach for requirements specification of Management Information Systems, extending and adapting this for EIP's special requirements.

Keywords: Information portals, data warehousing, content management, management decision support, requirements definition, method engineering, meta-modeling, meta-data integration

The Way to Enterprise Information Portals

Well-founded management decisions require highly integrated information from both quantitative and qualitative as well as internal and external sources. Efforts to integrate the needed information are currently subsumed by the term e*nterprise information portals* (EIP) (Eckerson 1999). According to Shilakes and Tylman (1998, p. 13) EIPs "enable companies to unlock internally and externally stored information and provide users a single gateway to personalized information needed to make informed business decisions." The need for highly integrated management information leads to the development of physical integrated architectures comprising quantitative as well as qualitative information. Being at the beginning of this ongoing development, some approaches aim to allow access to quantitative information—mostly administered by data warehouse systems (DWS) (e.g. Devlin 1997, Chaudhuri and Daval 1997)—and qualitative information—which can be administered by content management systems (CMS) (e.g. Nakano 2001, Lerner 2000, Duffy 2000)—through a sole portal.

DWS and CMS as important basis systems of EIPs have in common to align administered information according to a meta-data structure, which can be used to navigate through and scan the whole set of information. Following the research of Riebel (1979) in the field of cost accounting, for data warehouses this meta-data can be generally divided into *reference objects*, which are the objects of decision-making (e.g. single products, suppliers or regions), and *ratios* (e.g. “Return on investment”); the content, the *facts*, arise from the fact definition in terms of the combination of a reference object and a ratio as well as the assignment of the corresponding value. Hierarchical structures of reference objects (*dimensions*) and ratios (ratio systems) are used to navigate through the data on different cuttings and different levels of granularity (Codd et al. 1993). As one part of the meta-data information administered by CMS can be enriched by descriptive attributes like keywords and abstracts, facilitating structuring and searching of information (Curtis et al. 1999). Besides the descriptive meta-data, technical and structural meta-data like author, version, and date can be defined for each information object.

Current approaches to implement enterprise information portals build a sole portal granting access to the still separated, specialized management systems for quantitative and qualitative information. For example, they take advantage of the fact that an URL can invoke OLAP reports: The URLs are added to the CMS and indexed with meta-data to make them available for search and retrieval functions. But these approaches are not capable to ensure consistency of the CMS meta-data according to the meta-data of the DWS.

Approaches to overcome the system boundaries and realize an enhanced integration by incorporating the meta-data of both systems are proposed e.g. by Rieger et al. (2000), Meier (2000 and 2001) and Becker et al. (2002). The basic suggestion of these approaches is the attempt to transfer the navigation structures implemented in DWS to qualitative information and therefore provide the basis of an integrated EIP architecture.

Implementation of an enterprise information portal within an enterprise does not only mean the overcoming of technical problems resulting from the system boundaries of data warehouse and content management systems. In fact, it is also necessary to enable the sharing of domain knowledge between business and IT executives (Reich and Benbasat 2000). Therefore, a methodically well-founded system engineering method is needed.

In the following, we present a meta-model based approach for requirements specification for enterprise information portals. The relevance of meta-models for method engineering is discussed with respect to methodical and practical aspects. The system engineering method MetaMIS (Holten 2000) is extended to integrate quantitative and qualitative information seamlessly by introducing new elements into the MetaMIS language. This leads to an extended data model, which was implemented using a meta-CASE-tool. A proceeding based on the application of the proposed meta-language for requirements definition for EIPs is concluded.

The Relevance of Meta-Models for Method Engineering

Methodical Aspect

The development of information systems in general implies a structured approach and the use of engineering-like methods. An approach that divides the whole development process into several phases is needed to keep the efforts (number of persons involved, duration of the project, costs) under control. A widespread structure discerns at least the phases of requirements definition, design specification and implementation. Common approaches that fulfill this standard are the OMG's Model Driven Architecture (Soley 2000) or the Architecture of Integrated Information Systems (ARIS) (Scheer 2000).

Especially during the requirements definition phase, a close cooperation between the business and the IT staff is indispensable to generate first class results. As the business requirements are to be identified and modeled from the business perspective, they need to be aligned with the IT objectives. Domain knowledge shared between business and IT executives can support this alignment and, therefore, boost the quality of IT solutions (Reich and Benbasat 2000). A corporate information modeling method that can be collaboratively used by both parties for the specification of the information system provides a fundamental basis for this. In the following, we will examine the feasibility of meta-model based methods for requirements definition for EIPs.

As the term suggests, a meta-model itself is a model. Whereas a model represents real-world objects, a meta-model describes the elements and rules whereby a model of real-world objects can be constructed (Holten 2000; Nissen et al. 1996). The dependencies between the objects, the model and the meta-model can be depicted by three layers (Holten 2000): (1) The real world is part of the *instance level*. (2) At the *type-level*, the *model M1* represents an image of the observed part of the problem. As representation of the imagined relations between the observed objects, the model always is the result of a modeler’s construction act. A *modeling technique*, which comprises the semantic of the used *symbols* as well as the *rules*, in which the symbols can be combined (*modeling language*), is needed to write down the model. A discourse among the “knowing and willing” [orig. “neither malevolent nor feeble-minded"] (Kamlah and Lorenzen 1984, pp. 102 et seqq.) requires a unique understanding of the modeling technique. (3) Therefore, the modeling language is explicated by a formal model of the language (*meta-model*) in the third layer (*meta layer*). The semantic of the symbols can be explicated using pre-scientific natural language.

An example for a meta-model based method for the modeling of decision support systems is the MetaMIS approach by Holten (2000 and 2003). It defines a language for the specification of management views on business processes, i.e. the information an executive needs to perform a specific management task. Thus, it enables the modeling process in the requirements definition phase and helps to align business and IT objectives (Reich and Benbasat 2000).

> *"Researchers should be explicit about their approach, clarifying their research aim, theory, and method at the outset and all the way through its application, as well as at the time of its publication." (Avison et al. 1999, p. 96).*

This contribution focuses on providing the basis for discourse about meta-model based methods for requirements specification of enterprise information systems, which is necessary for scientific research/work. The meta-model developed for this purpose describes the developed modeling method. The discourse among the "knowing and willing" forces to reach a consensus. Influence of and reflecting on different point of views will extend applicability of the method right before its practical use. Nonetheless, reviewing and extending in practice is desirable and will have to follow. Additionally, the meta-model can be regarded as requirements specification for a modeling tool implementing the proposed modeling method.

Practical Aspect

Modeling, i.e. the derivation of models from a meta-model, is a time-consuming task. Therefore, it is to strive for support by CASE tools. Providing a free definition of problem-specific meta-models (Karagiannis and Kühn 2002) and the transformation of models between different meta-models (Agrawal et al. 2003), meta-CASE-tools provide adequate support for the requirements definition within meta-model based software engineering (e.g. Hofstede and Verhoef 1996, Nordstrom 1998). In case the problem cannot be mapped adequately using the modeling language, meta-CASE-tools provide the opportunity firstly, to adapt the modeling language (meta-model) to the new requirements and secondly, to create a problem adequate model using the possibilities of the new modeling language.

Several meta-CASE-tools are available; both commercial and non-commercial systems like the *Generic Modeling Environment* (Ledeczi et al. 2001) and *MetaView* (2003). The research this paper is based on deploys a meta-CASE-tool developed at the Dresden University of Technology (Greiffenberg 2002, Greiffenberg and Esswein 2000).

Language for EIP Requirements Definition

As the real-world can be described from different points of view and for different purposes, several approaches have been developed to model and formalize information needs adequately (for data warehousing cf. e.g. Bulos 1996, Golfarelli et al. 1998, and Sapia et al. 1998; for web application development respective content management cf. e.g. Halasz and Schwartz 1990, Garzotto et al. 1993, and Ceri et al. 2000). Frameworks aim to integrate the resulting specialized models (cf. e.g. Zachman 1997, ESPRIT 1989, Frank 2002). They have in common to provide different views on their models to structure information for different purposes. For the intention to specify requirements for enterprise information portals these views can be derived from the question "Which information is needed by whom for a certain task?" The resulting views are: data, organization, and function. The ARIS concept (Scheer 2000) integrates these three views (and the output view) by a fifth view, the process view, in order to map the chronological and logical order of tasks. This contribution bases on the ARIS concept and focuses on the data view as critical point EIP requirements definition.

Therefore, this section enhances the MetaMIS modeling language for requirements specification of management information systems (Holten 2000 and 2003) and introduces new elements and their representation as well as it gives examples for their application. For each of the following sections a grey cluster emphasizes the corresponding parts of the enhanced ERM (Scheer 2000, p. 74 f.), which is in conceptual description of the modeling language (The two hatched clusters correspond to section Scoping. The cluster about the thesaurus is needed by the sections Objects of Interest System and Valuation System). Additionally, this method can be applied to formalize the requirements specification in terms of process models answering the question named-above. As conclusion, an *Event-driven Process Chain* (EPC) will show this exemplarily.

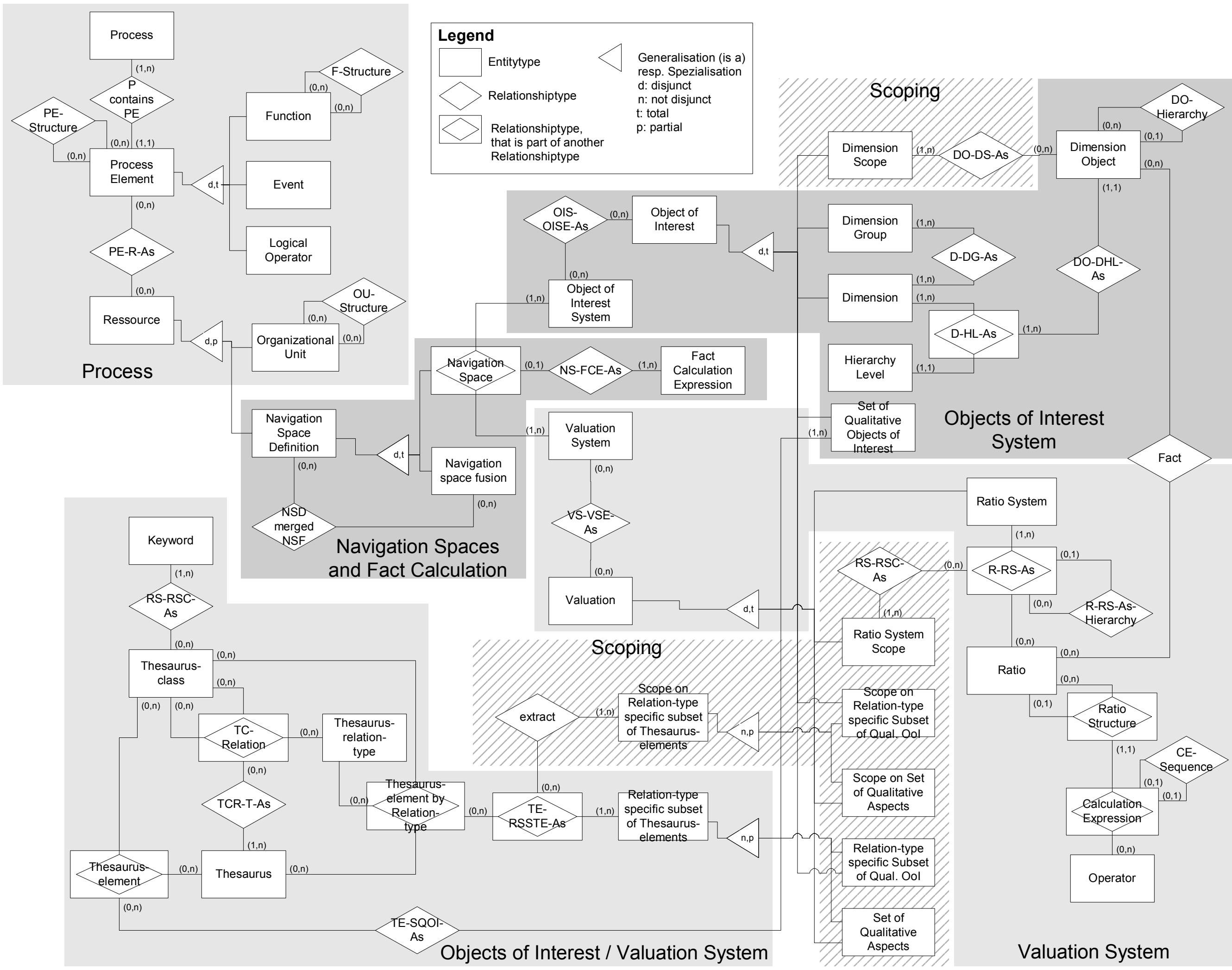

Figure 1. Meta-Model of the Approach Comprising All Views

The data modeling language for EIP requirement analysis and specification has to take the characteristics of quantitative and qualitative information into account. Based on Riebel's differentiation of quantitative information into reference objects and ratios, the MetaMIS approach proposes a modeling technique for quantitative information and is to be enhanced to cover qualitative information, too. Therefore, the dichotomy into reference objects and ratios is generalized. The resulting dimensions of *objects of interest* and *aspects* can be restricted to the essential quantum of evaluated information by the concept of scopes. Fusing the independent dimensions defined by (scoped) objects of interest and aspects to a navigation space provides the user with the relevant information. After all, a third navigation dimension and hierarchical orders to join separate spaces, which allow a more flexible definition of relevant information, are introduced to enrich the navigation space.

Objects of Interest System

According to Riebel, *reference objects* are "measures, processes and states of affairs which can be object to arrangements or examinations on their own" (Riebel 1979, p. 869). In the context of enterprise information portals—which integrate quantitative and qualitative information—this definition must not be restricted to objects which are used for quantitative analysis purposes but has to comprise all objects that can be valued or that managers base their decisions on. Considering the fact, that the term "reference object" is already occupied in the context of data warehousing, "*objects of interest*" is used to refere to Riebel's reference objects in the context of EIP. Consequently, objects of interest generalize quantitative reference objects and qualitative objects of interests. Visualization of these (and the following) elements is presented in Figure 2.

Reference objects can be organized hierarchically in *dimensions*, whereas a superior reference object comprises all its subordinated reference objects. Independently, sub-trees can be imploded to reduce the complexity or exploded to give a more detailed view. Within a dimension, the number of hierarchy levels in every branch is fixed. That means for every branch of the same level, there exist identical numbers of subordinate levels. Examples for dimensions are “Product by type”, “Product by acquisition type” and “Store by geography”. Every dimension object is associated to exactly one *hierarchy level* (e.g. “Continent”, “Country”, “Part” and “Product”), whereas one hierarchy level can be used by more than one dimension. For consistency reasons, a dimension group aggregates dimensions focusing the same objects from different angles (i.e. having the same set of leaves). In the previous example “Product by type” and “Product by acquisition type” are dimensions of the dimension group “Product”.

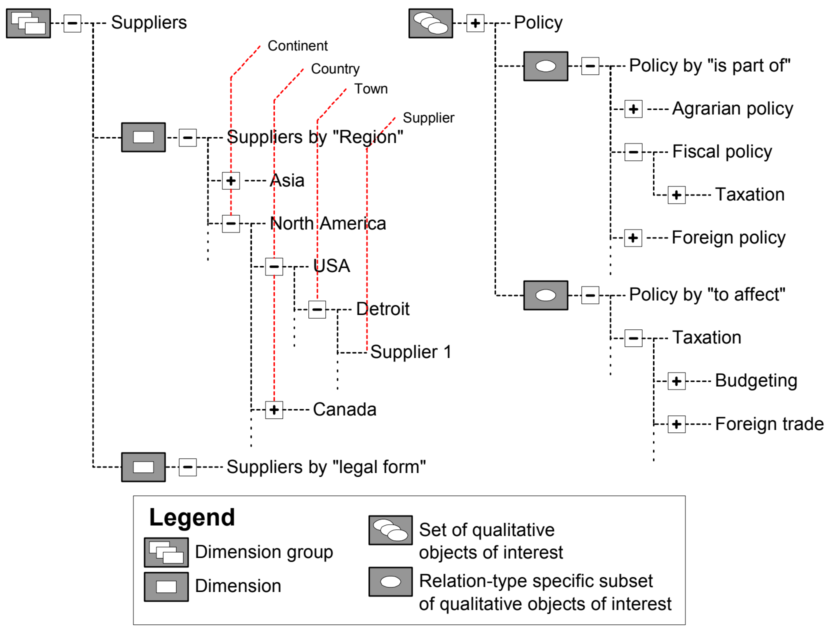

Figure 2. Graphical Representation of Dimension Groups and Sets of Qualitative Objects of Interest

Qualitative information is not restricted to the set of reference objects of a data warehouse. E.g. a web page may concern the economy, taxation policy or competition situation. Therefore, “Economy”, “Taxation policy”, and “Competition situation” represent *qualitative objects of interest* (cf. in the following the right hand side of Figure 2). In content management systems, objects of interest correspond to *keywords* classifying the content elements. Often *thesauri* are used to structure these keywords. Therefore, *thesaurus classes* aggregate keywords with similar or equal meaning. Between thesaurus classes *typed relations*—expressing the meaning of the relation—can be defined to arrange them in meaningful order (for the discussion of thesauri cf. especially Figure 1). The resulting structure forms a thematic grouping of related terms. Mapping the thesaurus concept to qualitative information within EIP, qualitative objects of interest can be organized by thesauri: *sets of qualitative objects of interest*. The restriction of the view on only one type of relation between objects of interest (e.g. “part of”, “to affect”, and “generalization/specialization”) defines relation-type specific subsets of qualitative objects of interest. Relations between thesaurus classes origin in habitual or domain-specific language use and do not fulfill formal requirements of hierarchies. Therefore, objects of interest can appear in different places of one subset.

Qualitative information may also analyze (quantitative) reference objects. For example, a video can document damaged products and therefore focus objects of the dimension “Products”. As this type of qualitative information is already indexed within the EIP using the (quantitative) reference objects, there is no need to model them separately. In this case, the reference object and the qualitative object of interest are identical in naming and hierarchical structure.

Valuation System

Ratios represent quantitative circumstances in a focused manner. Combined with reference objects they build *facts*, the key element of information within data warehouses. Ratios are defined by algebraic expressions, whereas one ratio can be calculated from other ratios. This leads to arithmetic structures within the set of defined ratios. Additionally, ratios can be combined into *ratio systems* when they are complementary and explanatory to each other and are focused on the same subject. This can be used to represent dependencies, which cannot be calculated (e.g. the number of warranty cases will have influence on the number of sold products, but this influence cannot be determined in means of arithmetic expressions). Their visualization can be found in Figure 3. Examples for ratio systems are the DuPont-Pyramid or the Balanced Scorecards (cf. Kaplan and Norton 1996).

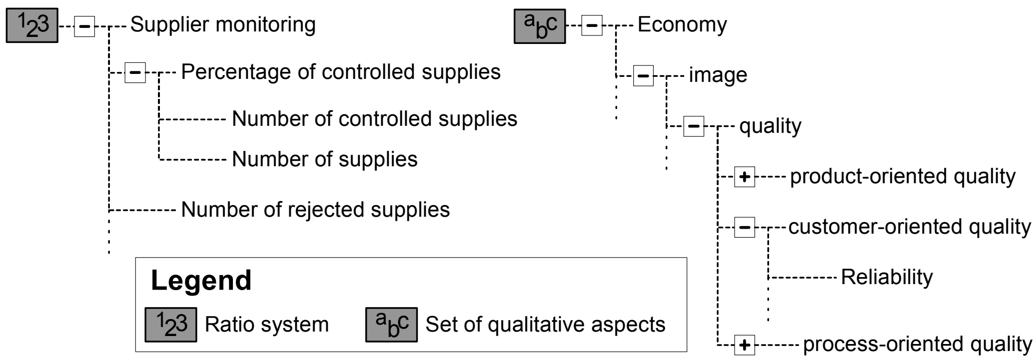

Figure 3. Graphical Representation of Ratio Systems and Sets of Qualitative Aspects

Valuations as part of qualitative information lack algebraic expressions and are characterized by more subjective ratings. Therefore, by introducing the concept of *qualitative aspects*, qualitative valuations are modeled separately from ratios. Qualitative aspects are valuations that specify which qualitative property of an object of interest or a reference object is being analyzed (e.g. for the qualitative object of interest “Competition”: “Competitive pressure” or “Competitive position”; or for the reference object “Product”: “Image” or “Competitive position”). Factual dependencies between qualitative aspects (one aspect is influenced by another) organize qualitative aspects in *sets of qualitative aspects* (Figure 3). In case, a ratio is not figured quantitatively but valued in a subjective way, this ratio can also become a qualitative aspect. For example, the growth of the sales volume can be estimated by a percentage or by an estimation like “better than expected”.

Scoping

Dimensions, sets of qualitative objects, ratio systems and sets of qualitative aspects tend to quickly become quite large. For a specific management task, however, in general not all assigned elements (objects and valuations) are needed. It is the obligation of information systems to avoid an information overflow and to expose only the relevant part of information needed by the user. Therefore, the concept of *scopes* is introduced.

Dimension scopes select sub-trees of a dimension. Navigation within these sub-trees is still possible and can give either a more detailed or more aggregate view. An object of interest system combines any number of dimension scopes. Only information related to at least one object of interest of each dimension scope is selected (i.e. the objects of interest system implies a conjunction). For example, scopes from the dimension groups “Suppliers”, “Part”, and “Time” define an object of interest system “National suppliers for tires, current month”. The concept of scopes can be applied to sets of qualitative objects of interest, ratio systems and sets of qualitative aspects respectively (Figure 4).

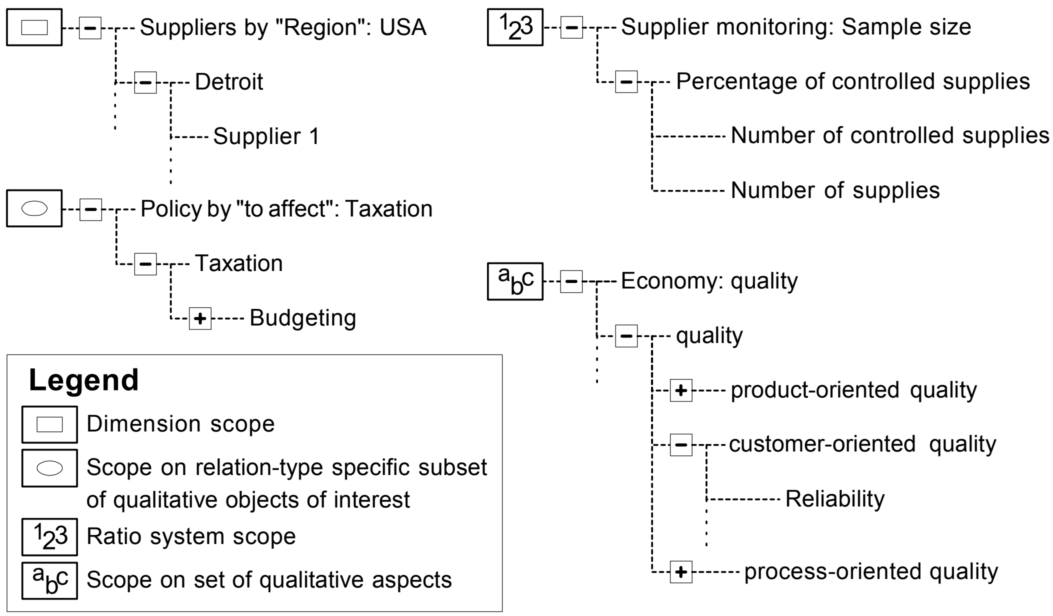

Figure 4. Graphical Representation of Scopes

Navigation Space and Fact Calculation

Task-adequate navigation structures are needed to ease access to decision-relevant information. Therefore, a *navigation space* combines objects of interest and their valuations. The objects of interest aggregate quantitative reference objects and qualitative objects of interest to an *object of interest system* (Figure 5). This can be compared to a set of dimensions in a multi-dimensional space. Users can explode the branches of each dimension they are interested in. By navigation through the different (hierarchy) levels they can specify the set of objects relevant for their management task. Valuations define the second class of dimensions of the navigation space. The ratio system and the set of qualitative aspects are aggregated to a *valuation system*. The navigation within valuations works in the same way as for objects of interest.

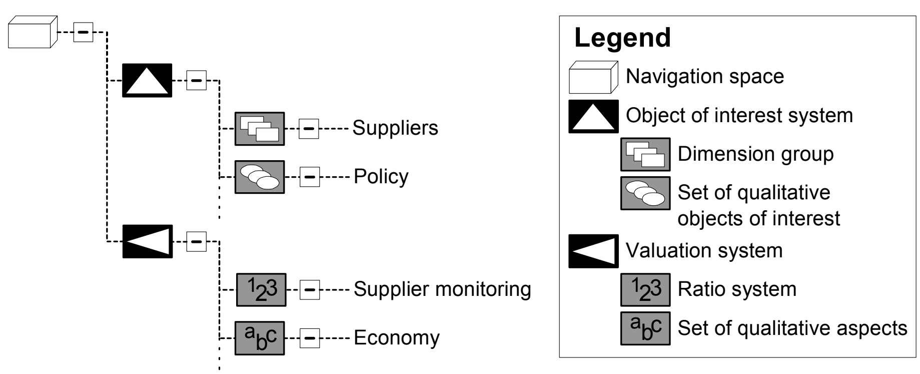

Figure 5. Graphical Representation of Concept Navigation Space and Relation to Other Concepts

Navigation space fusions aggregate navigation spaces to allow the user to define more complex sets of information needed for management decision-making. For example, the “Growth rate analysis for suppliers for tires” can be combined with an additional suppliers analysis as shown in Figure 6.

Up to the present, calculations—realized with ratios—are related to a single reference object. More complex calculations involving various reference objects and ratios like calculations of growth rates (typically in % of a given base quantity), variances (typically calculated as difference of two base quantities of the same dimension in %) and shares of subordinated quantities in relation to higher quantities (in %) cannot be realized using the concepts introduced so far.

Conceiving the arithmetic term as an additional property of navigation spaces, these *fact calculation expressions* can be executed (Holten et al. 2002). They provide a term applied to the supplied reference objects and ratios defined by the navigation space. Basing on arithmetic expressions, fact calculations can operate on quantitative objects of interest and valuations. An example for a fact calculation is the "Growth rate analysis" in Figure 6.

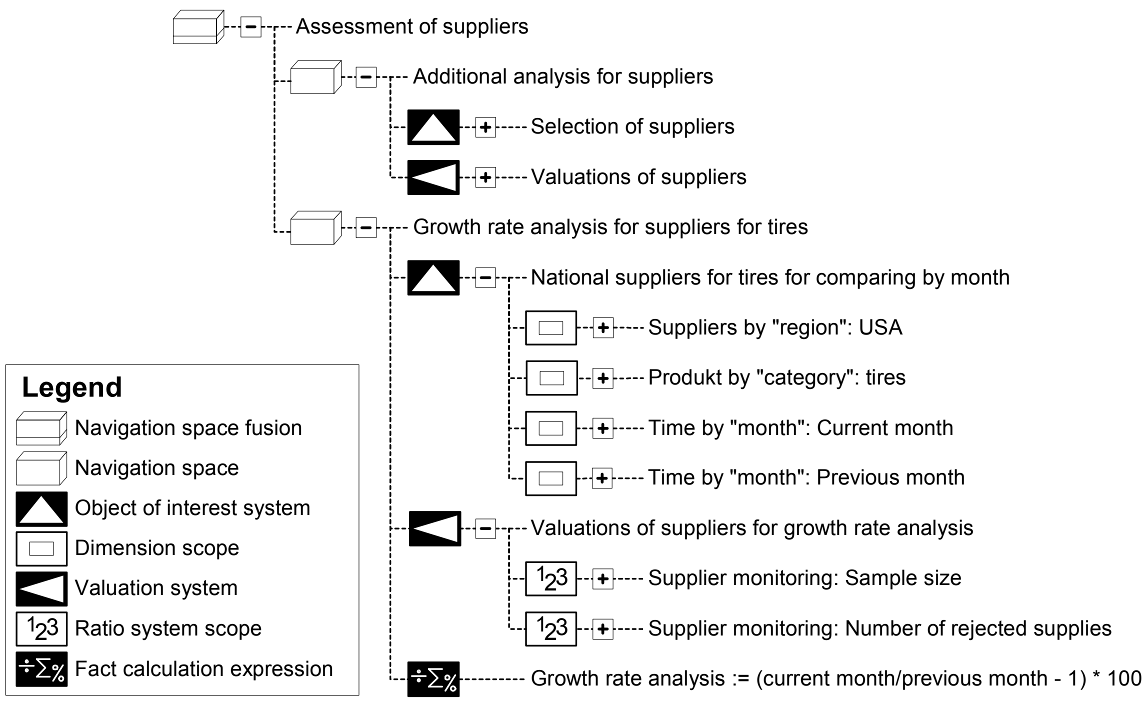

Figure 6. raphical Representation of Navigation Spaces and Their Aggregation

Process

The process view allows the modeling of interdependencies between elements of the different views. In the requirement definition phase, different techniques like Petri-nets (Petri 1962), object-oriented approaches (e.g. Rumbaugh 1991), or Event-driven Process Chains (EPC) (Scheer 2000) can be used. As the EPC is formal enough to be used for conceptual system description and nonetheless easy to understand, the EPC is enhanced by the new elements as described above. (The concept could also be transferred to other methods like the UML activity diagram; cf. Greiffenberg 2002, p. 115).

The basic elements of the EPC are events and functions corresponding to the tasks defined in the task view. The EPC depicts which functions (tasks) are triggered or generated by which events, thus representing a specific business process of the enterprise. With the help of operators like conjunction, disjunction and adjunction, sequences and parallel branches can be executed in a conditional manner. Elements from the organizational (addressee view) and the data view are integrated, enhancing the EPC by organizational units and navigation spaces. As shown in Figure 7, these elements are introduced into the process view and attached to the respective function for which they have been modeled.

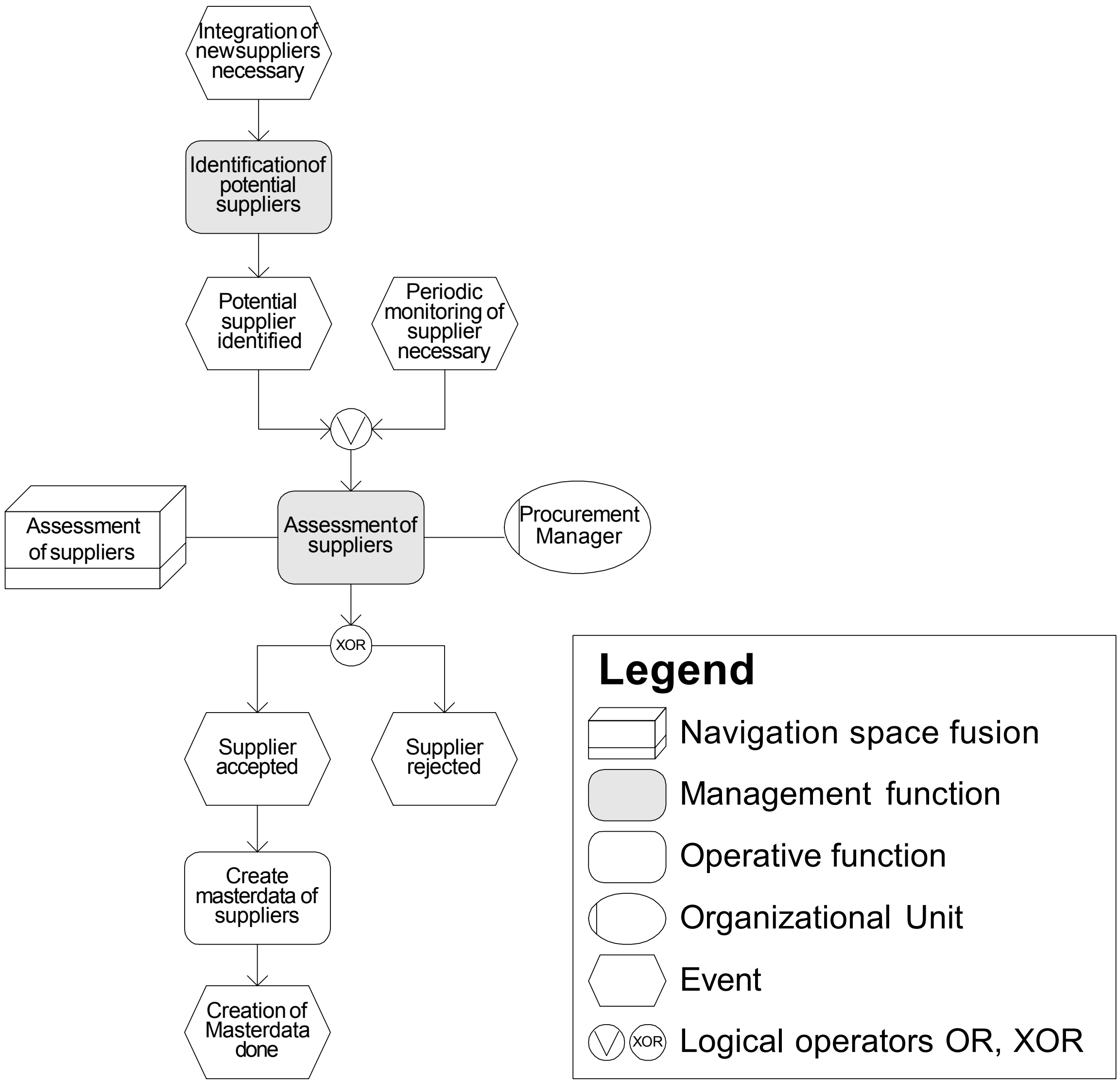

Figure 7. Excerpt of the Process Model "Supplier Management"

Implementation

An exemplary implementation of the approach in a meta-CASE-tool has been realized with the *Generic Model Editor (GME)*, which has been developed at the University of Dresden (Greiffenberg and Esswein 2000). The editor implements a meta-meta-model allowing unified definition of meta-models (Greiffenberg 1998, p. 24) as well as the construction of models derived from a previously defined meta-model. The tool is therefore made up of two core components in order to realize this dual purpose.

The modeling technique has to be implemented into the tool. Therefore, the conceptual specification of the modeling language (cf. Figure 1) had to be adapted to the meta-modeling language of the GME. The resulting meta-model has been implemented using the GME's first component, the "Type editor" (Figure 8, step 1). It allows definition of different views corresponding with the views defined above. Having defined the properties and graphical representation of all elements in each view (Figure 8, step 2), models can be constructed using the second component, the "Scheme editor" (Figure 8, step 3). New elements or elements defined in other views or diagrams can be dragged and dropped from the menu onto the drawing space (Figure 8, step 4). By proceeding this way through all views, the complete model is being constructed.

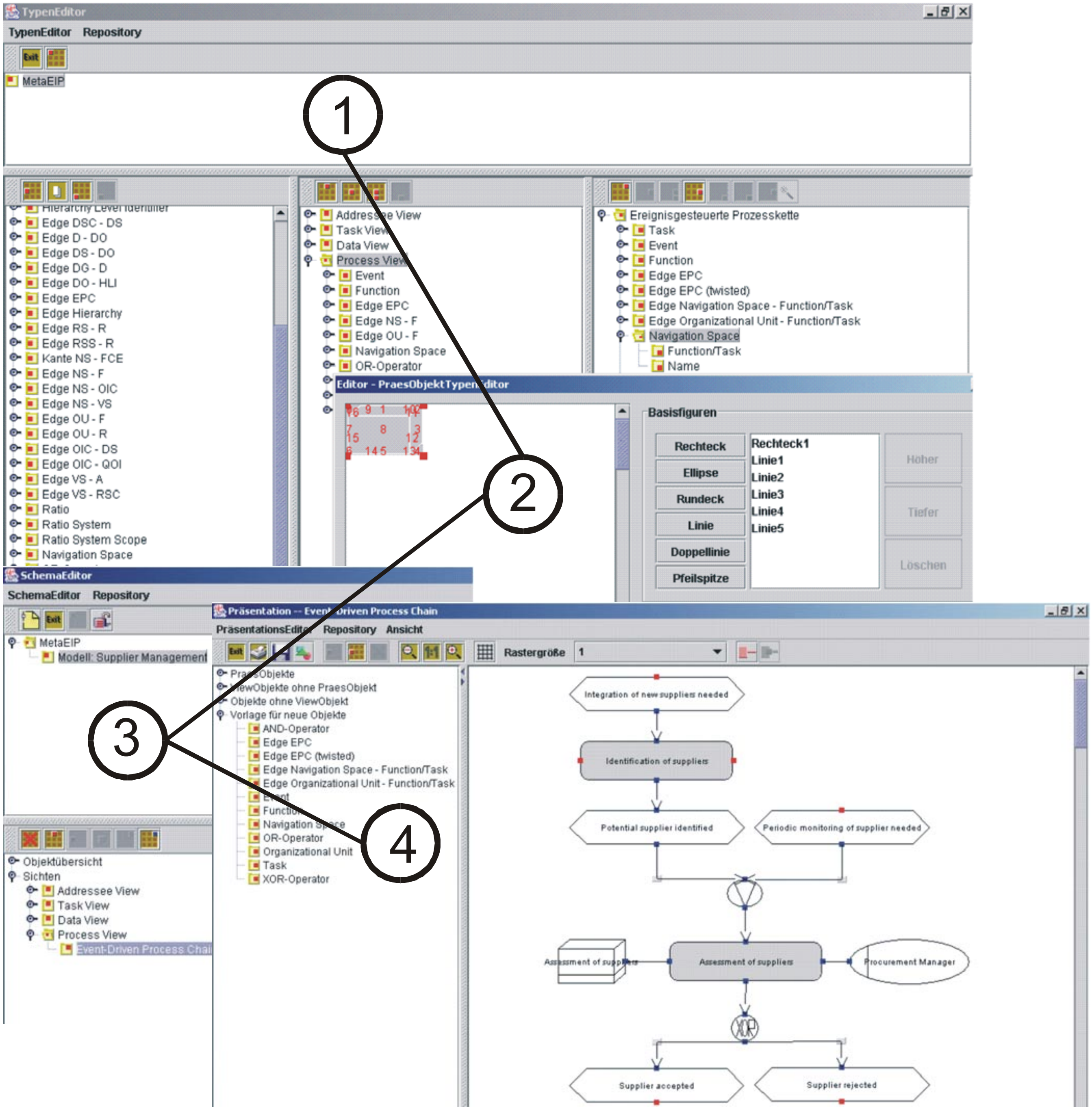

Figure 8. Modeling Steps Within the Meta-CASE-Tool GME

Conclusion and Outlook

This paper extends the meta-model based MetaMIS approach for conceptual specification of executives' information needs to cover and integrate quantitative and qualitative information. Therefore, a contribution to the need for an adequate system engineering method for enterprise information portals is made. The new elements have been specified in more detail by a data model at the level of design specification. This can be employed to build a problem-specific CASE-tool using meta-CASE-tools. Concluding the presented modeling technique a proceeding can be derived:

1. Identification of relevant objects of interest.
   a. Arranging of reference objects according to hierarchical orders and combining to dimensions and dimension groups.
   b. Arranging qualitative objects of interest regarding hierarchies and dependencies.

2. Identification of relevant valuations.
   a. Definition of arithmetic relations between ratios; arrangement into a ratio system.
   b. Structuring aspects regarding hierarchies and relevant dependencies.

3. Identification of tasks and assigned addressees for specification of management processes.

4. Identification of addressee-specific required scopes of dimensions and ratio systems.

5. Definition of addressee-specific navigation spaces covering the information.

6. Integration of different views by depicting a complete process model.

Thus, combining the modeling language and the suggested proceeding leads a meta-model based method for EIP requirements specification.

Our experiences in different branches (reinsurance (Holten et al. 2002) and retail (Holten 2003)) have shown that the MetaMIS approach is a powerful tool for the specification of management information needs on the level of requirements definition. In parallel, we observed that it is necessary to teach laypersons in OLAP/DWH systems in general and the system, which will be implemented, before starting a project. Only if an adequate level of understanding is reached, a correct application and well-funded pointing for necessary adoptions of the method are possible.

Quantitative prove of the adequacy of our approach depends on availability of systems fulfilling the integration requirements as suggested e.g. by Becker et al. (2002). Therefore, data warehouse, content management, and enterprise information portal Systems have at least to provide unified interfaces for seamless meta-data integration. The ongoing demand for highly integrated management information will accelerate the establishment of such interfaces.

The proposed approach may need situation specific adaptation in language elements and the underlying data model. Enhancement and adaptation of the modeling language is made easier by the fact that the approach is base on a meta-language. Additionally, we could recognize that implementation of tools supporting information system development methods can be improved in a wide range (flexibility, speed, costs etc.) by the use of meta-CASE-tools. This improvement eases development of domain-specific methods, which also have valuable impact on system development (Nordstrom et al. 1998).

Acknowledgement

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