CONFIGURING REFERENCE MODELS[1]
An Integrated Approach for Transaction Processing and Decision Support

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Abstract: Reference models are of normative, universal nature and provide a solution schema for specific problems by depicting best or common-practice approaches. The configuration of these reference models has been a field of research in the past. However, the integrative configuration of different reference models or respectively reference models serving multiple purposes lacks of applicable methods. In practice this is a common problem as the simultaneous implementation of an enterprise resource planning system and a management information system shows. We provide a method that allows the integrative configuration of conceptual models for transaction processing and decision support by integrating meta models for modeling languages. In addition, we exemplarily show its application to extend an existing reference model.

1 INTRODUCTION

The conceptualization of business activities into processes is fundamental to Business Process Management. The goal is to identify improvement possibilities and weaknesses of processes to generate propositions for process improvement. Conceptual models have become accepted as instruments to attain this goal. The representation of the "as-is" and "to-be" situations in the form of conceptual models enhances the structuring of the problem and transforms it into a more solvable form. As a support for to-be modeling the application of reference models is discussed alongside other approaches like benchmarking, process simulation and animation, heuristic design principles and checklists (Becker et al., 2006).

Reference models are conceptual models that can be used for designing specific models (Schütte, 1998, Vom Brocke, 2003). The knowledge which is provided by reference models can give valuable contribution to business reengineering and software engineering purposes. Using reference models as template for deriving enterprise-specific models should lead to time and cost reduction (Schütte, 1998). Especially in the field of software engineering conceptual reference models can be used to improve the customization process e. g. of ERP systems (Davenport, 1998) or as a starting and configuration point within the Model Driven Architecture (MDA) procedure (Soley and OMG Staff Strategy Group, 2000). Conceptual reference models usually represent process and/or data issues of a specific domain (e. g. industry, retail, insurance) (Fettke and Loos, 2003).

To attain a broader customer clientele two directions of reference model evolution can be identified. The first one is to add additional adaptation support to the model to achieve an even greater time and cost reduction of the model application e. g. by defining perspectives on the model or adding variants. The second direction is to broaden the reference model to new application areas (area-spanning reference models) to achieve a more holistic view on the company (e. g. adding state-of-the-art models for data management and decision support to the existing process-oriented reference model). These two directions are almost completely unrelated.

The research contribution of this paper is to consolidate the newer developments in the two directions to create adaptable and area-spanning (refer-

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ence) models. In this paper we concentrate on adaptation support by reference model configuration. The development of configurable models is reasonable because configuration rules in reference models permit the explication of further business knowledge about the connection of business characteristics and business processes. Furthermore, configurable models provide the user with precisely tailored model variants. Instead of limiting these advantages to one area of application, future modeling concepts have to permit an area-spanning consistent definition of configuration rules. Therefore we provide a modeling-language-spanning approach to integrate and customize different areas of reference models by meta-model integration and configuration. This should lead to a more conjoint view on transaction processing and decision support systems.

This work presents first approaches to a solution and is structured as follows: In Section 2, we present an overview of related work and the state-of-the-art in the field of reference modeling. In Section 3, a modeling language is constructed from established modeling approaches. It permits the configuration of a purpose-spanning model system. Severeal dependencies lead to a necessity of a joint and integrated view on business processes, data objects and management views, i. e. reports, in reference models. In Section 4 the application of this modeling technique is presented. It extends the Retail-H-Model by means of a small example. So far, the Retail-H-Model had to be classified as a single-purpose-model with no configuration support. Finally, future research needs are discussed in Section 5.

2 RELATED WORK AND STATE-OF-THE-ART

Existing modeling techniques for reference models can be classified in two dimensions (cf. Figure 1) (cf. (Fettke and Loos, 2003)): As a theoretical structuring of business application systems the information pyramid has found widespread acceptance (Mertens, 2000). The systems are divided into transaction processing systems and decision support systems. The formers support the operational execution of business domains like procurement, production, logistics, and distribution. The latter provide information for management tasks, especially information which is decision-relevant concerning the design of the operational domains. Different modeling techniques have been established for both areas. Process modeling techniques are mainly used in the field of transaction processing, e. g. Event-Driven Process Chains (EPCs) (Keller et al., 1992), Petri Nets (Petri, 1962) or Business Process Modeling Notation (BPMN) (White, 2004). The operational databases are described e. g. via Entity Relationship Models (ERMs) in different variants (Chen, 1976). Object-oriented approaches like e. g. UML (Booch et al., 1999) are suited for the description of dynamic as well as static views on an information system. The modeling of management views is primarily addressed by techniques for semantic data-warehouse-modeling (e. g. (Bulos, 1996, Sapia et al., 1998, Holten, 2003, Golfarelli et al., 1998)).

The second dimension used to classify reference modeling techniques is the consideration of approaches to support adaptation. The aim of adaptation support is to provide reference model content in a more reusable form. The fundamental mechanisms of constructing a company-specific or project-specific model from a reference model are configuration, instantiation, aggregation, specialization and analogy construction (Vom Brocke, 2003). The main feature of *configuration* is the specification of explicit rules concerning how the reference model will be adapted to given contexts (e. g. company classes). *Instantiation* arranges the use of place holders. Reference models supporting *aggregation* are partitioned into modules which can be combined, depending on their gateways, to form new models. In the case of *specialization*, the reference model is kept deliberately on an abstract level. The model user has to adapt it, whereas in contrast to configuration no explicit rules are provided. *Analogy*-based adaptation offers liberty concerning the method of reusing arbitrary parts of the model which are e. g. provided in forms of design patterns.

The occurrences of both dimensions, area of application and adaptation support concept, are combined to two oppositional values each, in order to characterize the state-of-the-art of reference modeling research regarding a specific development perspective (cf. Figure 2): Existing reference models and reference modeling techniques usually address only one area of application and do not support configuration. Widespread extensive reference models like those of Scheer (Scheer, 1997), Becker and

Characteristic	Characteristic Occurance				
Area of Application / Purpose	Transaction Processing			Decision Support	
Adaptation Support Concept	Configuration	Instantiation	Aggregation	Specialization	Analogy

Figure 1: Dimensions of Modeling Techniques.

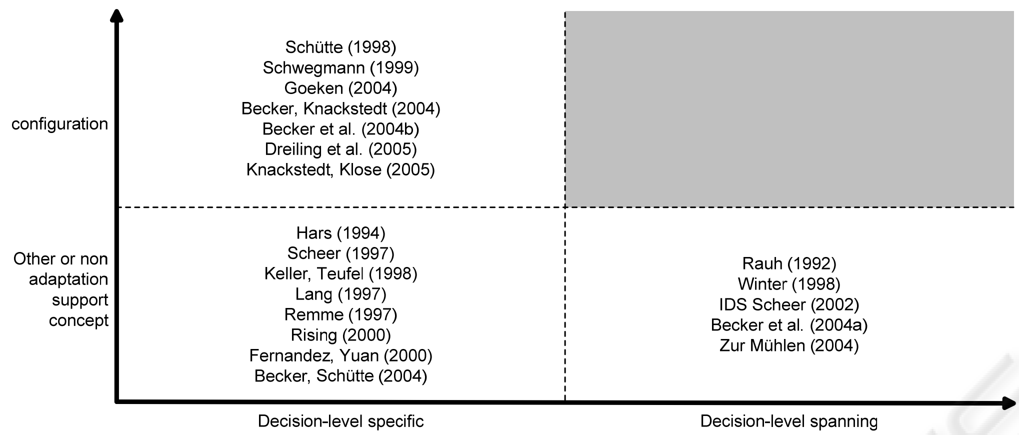

Figure 2: Portfolio of Related Work.

Schütte (Becker and Schütte, 2004) and Keller and Teufel (Keller and Teufel, 1998) address the level of transaction processing and have to be transferred to company-specific models via specialization. Hars (Hars, 1994) focuses on reference modeling with ERMs, without considering adaptation via configuration. Lang (Lang, 1997) and Remme (Remme, 1997) develop concepts for the aggregation of process model parts, Rising (Rising, 2000) and Fernandez and Yuan (Fernandez and Yuan, 2000) provide design pattern libraries for the transaction processing level.

Research dealing with the configuration of reference models is currently rather area-specific. The works of Dreiling et al. (Dreiling et al., 2005) and Becker et al. (Becker et al., 2004b) address the configuration of process models in form of EPCs. Further examples of the configuration of ERMs are provided by Schütte (Schütte, 1998). Schwegmann (Schwegmann, 1999) deals with configuration of class diagrams. The configuration of models covering the decision support-level is discussed in the works of Knackstedt and Klose (Knackstedt and Klose, 2005), Goeken (Goeken, 2004) and Becker and Knackstedt (Becker and Knackstedt, 2004).

Area-spanning modeling is dealt with from different points of view. The derivation of (decision-relevant) data from operational data bases is e. g. addressed by Rauh (Rauh, 1992) and Winter (Winter, 1998). The integration of specifications of management views into EPCs is e. g. suggested by and Becker et al. (Becker et al., 2004a). The usage of process execution data for the process performance manager is e. g. dealt with by zur Mühlen (zur Mühlen, 2004). Corresponding software tools e. g. have been developed by IDS Scheer AG (IDS Scheer AG, 2002). The works mentioned above however do not focus on the concept of reference modeling or in particular on model configuration.

3 META MODEL DEFINITION AND INTEGRATION

3.1 Introduction to the Modeling Techniques Utilized and their Meta Models

It is reasonable that reference models make use of well-established modeling techniques to allow the applicability for as many users and as many contexts as possible. In terms of process modeling and data modeling current state-of-the-art approaches are EPC (Keller et al., 1992) and ERM (Chen, 1976) (cf. section 2). Concerning reports, the MetaMIS approach to specify management views seems to be very promising since its integration with the EPC has already been conducted and evaluated (Becker and Knackstedt, 2004, Becker et al., 2004a). Thus, the integration of these three modeling techniques seems to be the preferable approach. Integral part of the mentioned modeling techniques is the modeling language. It is described by a meta model which defines the model elements and their relationships. (cf. the corresponding meta models in Figure 3).

EPCs are a semi-formal modeling technique to model courses of business. They are an integral part of the ARIS framework (Scheer, 2000). ER models were introduced as a semantic data model, as a unifying view, on both, relational and network databases. MetaMIS models (introduced by Holten (Holten, 2003) center on information objects, i. e. reports. The first steps to create an information object are the definition of dimension groupings (e. g. time, product) and its distinct dimensions (e. g. time by week, weekday; time by month, day of month), followed by the reduction of dimensions to dimension scopes (e. g. year 2005; product group one) and combining them into dimension scope combinations which define the specific information requirements of the management. Ratios and ratio systems are assigned to these dimension scope combinations, in order to create business facts such as the stock of products in a certain warehouse at a specific day or the total revenue achieved by one store. This assignment constitutes the navigation space of the information object. In this way, MetaMIS models carry the information needed to describe the content of a report. Exemplary EPC and MetaMIS models of are depicted in Figure 5, Figure 3 shows an ER model.

3.2 Meta Model-based Integration of the Modeling Languages

Our approach of integrating MetaMIS and EPC differs slightly from the one of (Becker and Knackstedt, 2004, Becker et al., 2004a) to allow a seamless integration of the ERM as well:

Functions are a core element of business processes which are performed by persons and/or information systems (IS). These persons or IS need information in forms of reports to make decisions. The *information object* of the MetaMIS meta model is such a report. Thus, the integration of EPC and MetaMIS models is carried out via the reinterpreted entity type *information object* (cf. Figure 3). It can be regarded as a specialization of the *process resource* of the EPC meta model. In this way it is also

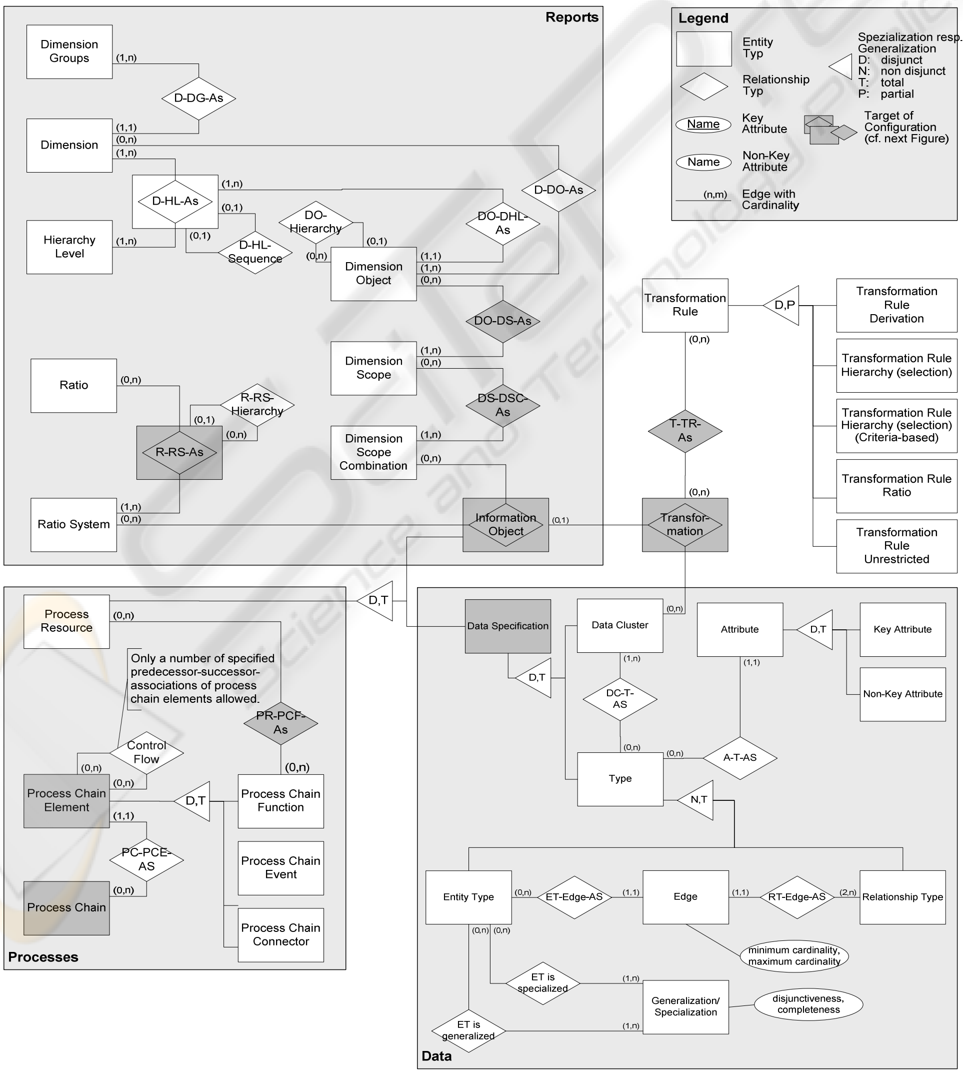

Figure 3: Integration of Modeling Language Definitions.

linked to the entity-type *process chain function* by the relationship type *PR-PCF-As* (Process Resource-Process Chain Function-Association), as Becker et al. argue in their approach (Becker and Knackstedt, 2004, Becker et al., 2004a).

The integration of the ERM meta model and EPC meta model can be performed similarly. The entity type *data specification* can also be regarded as a specialization of the entity type *process resource*. Thus, it is also linked to the entity type *process chain function* via the relationship type *PR-PCF-As*. The core element types of any ERM, *entity types* and *relationship types*, are specializations of the entity type *data specification* and therefore are also linked to *process chain function*. The *data cluster* is a scope of an ER model and is also a specialization of the entity type *data specification*. This entity type is of major importance concerning the following integration of MetaMIS and ERM.

The integration of MetaMIS models and the ERM technique cannot follow a similar pattern. The element types of METAMIS models and ER models cannot be used interchangeably as with the EPC technique that has over time developed a universal connector, an interface called *process resource*, to any modeling language, the integration of the data and report meta model has to be done via sets of transformation rules (*transformation*) which specify the underlying dependencies. This is necessary since the constructs of both modeling techniques do not map one to one and rather represent views on the same data. Whereas the ER models form the analysis fundament, MetaMIS models try to explicate the information contained therein. Thus, a transformation is essential to sophistically configure reference models for operational and planning purposes (Rauh, 1992). Cf. to Figure 3 for the integration of the meta models and the description of the transformation relation between MetaMIS and ER models.

3.3 Consideration of Configuration Aspects

As stated in Section 1 for the course of this paper we will focus solely on the configuration of reference models for adaptation support. Configuration can be achieved by model projection, the exclusion of model elements according to configuration rules. Targets of the model projection can be whole model types (*selection of model type*; e. g. to build model technique specific views), element types of the language definition on meta level (*selection of element type*; e. g. to support variants of model techniques), instance model elements (*selection of element*; e. g. for the exclusion of specific model elements due to a specific company class), denotations of the model elements (*variation of denotation*; e. g. for exchanging names and labeling of model elements depending on user groups) and representational aspects (*variation of representation*; e. g. for using alternative symbols or topologies) (for comparable approaches cf. e. g. (Darke and Shanks, 1996, Engels et al., 1997, Nissen et al., 1996)).

As a basic mechanism to support detailed configuration, the mechanism of element selection is depicted in Figure 4 and addressed in this paper. Targets of the selection of element projection – which are relevant for this paper – are the following (cf. to the shaded entity types in Figure 3):

- **regarding process aspects:** *process chain elements*, *process chains* and the association between process resources and process chain functions (*PR-PCF-As*) to exclude whole processes or only parts of them,
- **regarding data aspects:** *data specifications* to exclude whole data clusters or several entity and relationship types,
- **regarding transformation aspects:** *transformations* and associations between transformations and transformation rules (*T-TR-As*) to exclude whole transformations or to build variants of them,
- **regarding report aspects:** *information objects* and associations between dimension scopes and dimension scope combinations (*DS-DSC-As*), dimension objects and dimensions scopes (*DO-DS-As*), and ratios and ratio systems (*R-RS-As*) to exclude whole information object specifications or to modify them depending on the configuration context.

To allow the configuration of these model elements, the meta model of the modeling language has to be adapted. The model elements on the meta level have to be assigned to a configuration term that determines the elements to be shown in user-specific views. A configuration term is specified in a grammar which is also depicted in Figure 4. Configuration terms denominate characteristics of company classes and their instance values. They express that model elements are part of the configured model if the company using the reference model is part of the respective company class.

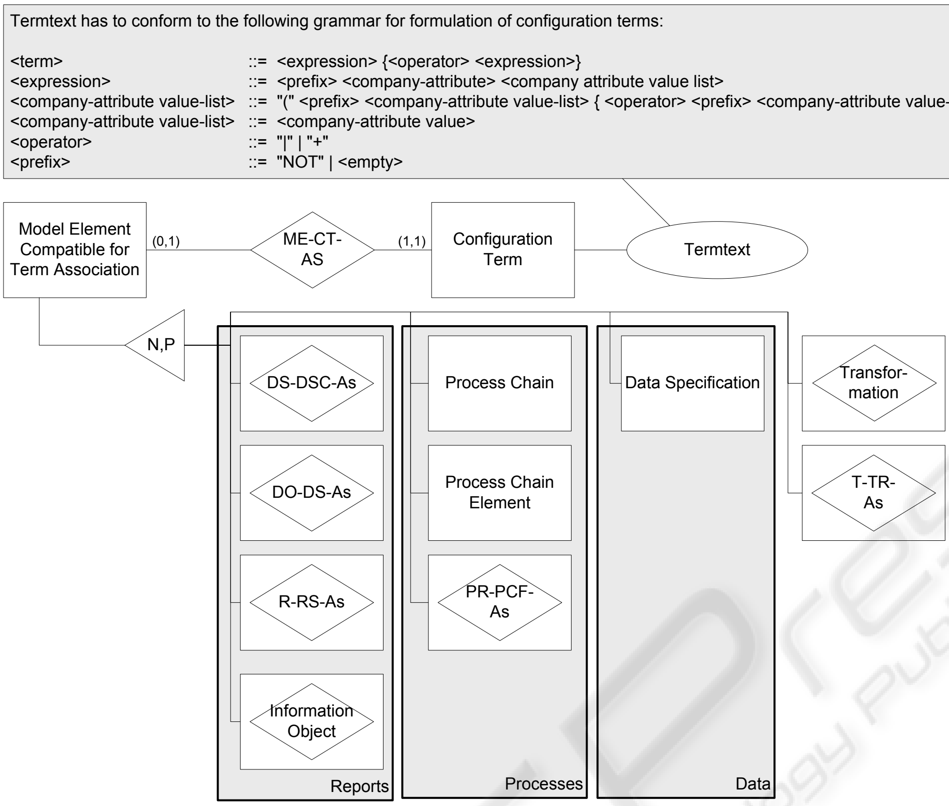

Figure 4: Extension of the Modeling Language Definition with Configuration Aspects.

4 APPLICATION FOR A RETAIL REFERENCE MODEL

4.1 Overview of the Reference Model

In the following, the developed modeling technique will be applied to expand the reference model for integrated information systems in retailing companies of Becker and Schütte (Becker and Schütte, 2004). To provide an overview and a navigational structure for the numerous models included, the reference model is structured by the retailing-H-architecture (cf. the left side of Figure 5; the H stands for the German term “Handel” which translates as retail). The architecture identifies the tasks of retailing companies at an abstract level using a selected structuring paradigm:

Whereas all tasks concerned with the suppliers are placed on one leg, all tasks associated with the customer are placed on the other leg. The logistical functions covering goods receipt, warehouse and goods issue are arranged horizontally. The merchandising management-related areas of a retailing company then form the letter H. The grouping of the bookings in the general ledger accounting and other functions of the business-administrative-system (asset accounting, cost accounting and human resources management) are assigned to the foot of the H. Long-term planning functions build the roof of the architecture pictogram.

In accordance with the architecture of integrated information systems (ARIS) (Scheer, 2000) different viewpoints on information systems are taken into account. The original retailing H-model differentiates between functions within the identified tasks of the architecture (the subtasks to be performed), data (the structure of the tasks), and processes (the behavior of these areas). Since function and process view are not completely distinct (the process describes the temporal and logical sequence of functions) and the function view is obsolete from an ontological perspective (Green and Rosemann, 2002), we substitute the function view for a reports view. Reports are needed for basically all tasks of the retailing company.

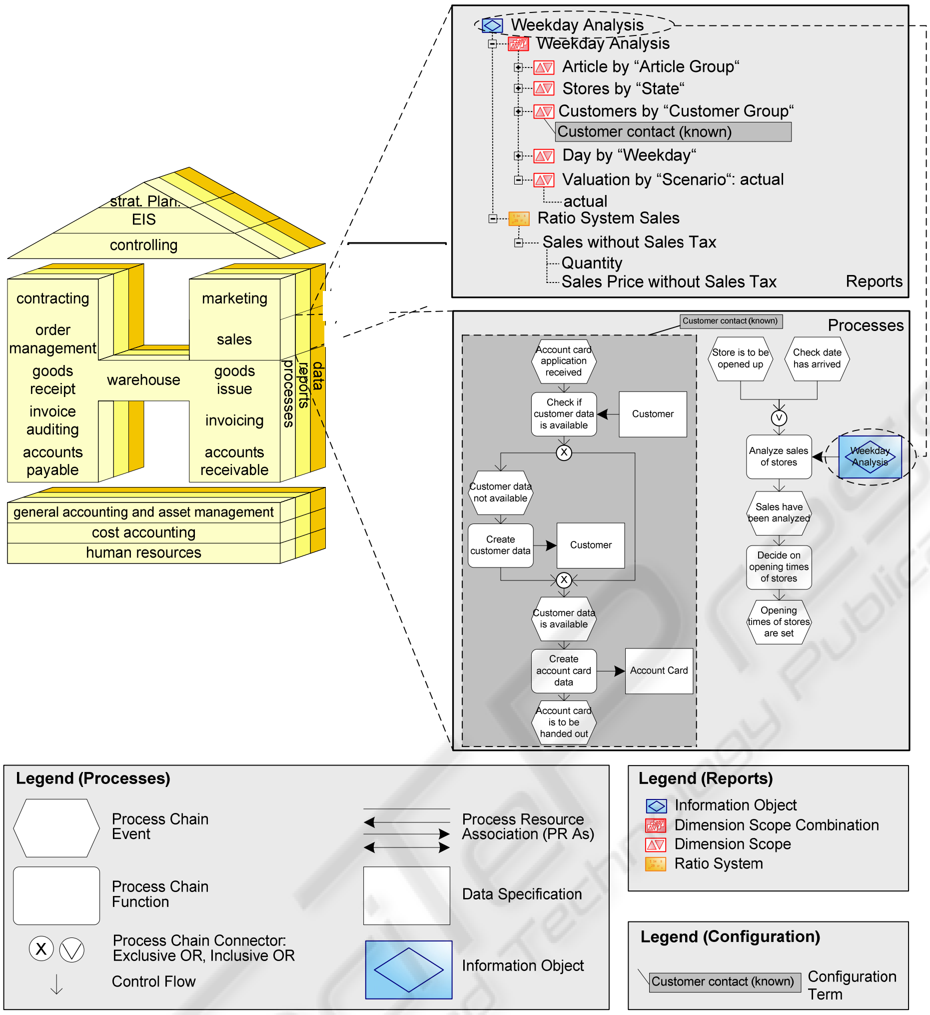

Figure 5: Modified Retailing H-model.

4.2 Example of the Modeling Language Application

The application of the modeling technique introduced in Section 3 to construct configurable and area of application-spanning reference models is shown in the following example where a company wants to apply the H-Model. The company supports individual marketing methods to address the customers. Thus, the configuration parameter in this case is the differentiation, whether customers are known to the company or whether they remain anonymous.

In this case, account cards are the method considered to reach customers individually. This decision influences the company's processes since full processes and parts thereof can be omitted (cf. the right side of Figure 5). For example, if customers are addressed anonymously only, processes and functions concerning the maintenance of account cards are omitted. Whether customers are known or unknown to the company is a distinctive attribute which not only influences functions which are to be modeled as process chains but also the resources which are accessed during the execution of these processes. For example, the analysis of opening times cannot be realized based on customer group differentiation if no customer data is available. In the process model depicted in Figure 5 this context can be exemplified by the fact that the specification of the report used for *Weekday Analysis* is configurable. The configuration term *Customer contact (known)* connected to the dimension scope *Customers by "Customer Group"* makes sure that the navigation space only contains customer group structures if the individual customer can be identified via account cards.

A model-independent adaptation can cause inconsistencies in relation to other models. Data elements that are connected to functions concerning account card handling will for instance never being read or written, if these functions were omitted. Therefore the ER models of the reference model also have to be adapted. The decision whether customers are treated anonymously or not does also affect the entity types customer card and account card and model elements whose existence is dependent on them via the configuration term Customer contact (known).

With the omission of the entity types *Customer* and *Account Card* in the scenario *Customer contact (known)*, the possibility to derive ER model elements based on these types is lost. By the omission of original ERM elements, further transformation rules are disregarded, too. This is because they are either directly (e. g. with the transformation of *dimension scope Customers by "Customer Group")* or indirectly (e. g. with the transformation of ratios from derived model elements) dependent on ERM elements assigned to configuration terms. If the configuration-based elimination of processes omits the use of reports in the reference model, complete report definitions and their assigned transformation rules are disregarded.

5 FURTHER RESEARCH

The integrative configuration of the retailing H-Model was described by means of a clear and concise example. Process models, data models and report specifications were configured while preserving existing dependencies between the views. The ongoing development of the model must consider much more configuration causes. This can be exemplified in a compact manner by the company attribute business type on the architecture level. The retailing H-Model shown in Figure 5 describes the classic type of retailing business which is warehousing business with procurement, storing and distribution functions. In addition to the classic warehousing business, third-party business and the pooled payment business have established themselves. A retailing company can practice one or more types of business, which have large-scale consequences for the adaptation of the reference model. Greater parts of the reference model become obsolete in such types of business.

Beside the enhancements of the retailing reference model other areas are of interest: The results of this ongoing research can be employed for other areas besides reference modeling such as integrated process and data warehouse documentation (Becker et al., 2005) or in the context of service companies (Klose et al., 2005). Furthermore we will focus some methodical research questions. Our modeling and configuration approach moves complexity to the reference model creator. Thus, the creator has to deal with a highly increased load of complexity. In particular the management of the dependencies of several models and their configuration roles seems to be a matter of special importance. The resulting effort can be neglected due to economies-of-scale effects. In this context we will develop methodical solutions to reduce respectively to handle the complexity of the presented configurable and area-spanning model systems.

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