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## Accounting information for changing business needs

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# **Part I: Problem Statement**



# 1. Problem Definition

## 1.1 Introduction

Today's organizations operate in a market that is becoming increasingly complex and dynamic. This can be illustrated with a number of examples. The introduction rate of new products and services is gathering pace and as life cycles become shorter, products and services are increasingly tailored to the needs of small market segments or even to the requirements of individual customers. New distribution channels have been created, facilitating quick product introduction. To accommodate and implement this increasing complexity of products, services and distribution methods, organizations are frequently redesigning their organization structures and business processes, also in order to increase effectiveness and efficiency. Acquisitions, mergers and strategic alliances, as well as sales of divisions, are thus all the more often to be considered as parts of ongoing organizational change. Boundaries between organizations are blurring. New financial products are being developed and offered at lower costs while being characterized by higher financial risks. The varying possible coincidence of these phenomena has characterized the business situation with complex dynamism. The degree to which organizations can be successful in competition depends on the speed at which they can adapt to *changed* circumstances. This largely depends on the ability of their business information systems to support *changing* user information needs.

In order to modernize their information systems, many organizations have replaced their legacy information systems by implementing modern ERP systems<sup>1</sup>. In most cases, these investments were made to meet a number of objectives simultaneously. For example, within an organization, many different types of legacy information systems were in use that did not comply with millennium and Euro requirements. The focus of these old information systems was on offering basic transaction-based data with little attention paid to the need to provide decision-support information. Sometimes, organizations went through a business process re-engineering exercise resulting in organizational change, characterized by new information needs. In a number of situations, existing legacy systems were insufficiently flexible to meet these new information needs. However, when the millennium turned and most organizations had implemented their new ERP systems, a growing number of complaints were expressed. For example, implementation cycles were much longer and costly than initially budgeted (Saunders, 1999; Scheer and Haberman, 2000; Waggle, 1998; Chiara, 2001). The ability of ERP systems ever to meet the ROI benchmarks as promised was brought into question (Stedman, 1999), as was their flexibility and future-proofing, supposedly sufficient to enable them to continue to be an organization's central business information system for several years in dynamic circumstances of on-going change. New users starting to use existing and available information and existing users with new or changed information needs characterize the dynamic environment in which these information systems have to accommodate information. Whether ERP systems can adequately respond to these varying information needs is a central question.

In science, business information systems like ERP systems have been investigated from the viewpoint of accounting information systems. The focus in these research initiatives is predominantly on proposing improved accounting data models. The two most prominent examples of these initiatives are McCarthy's (1978) REA model and Riebel's (1984) data

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<sup>1</sup> ERP systems are offered by vendors such as SSA GT, Oracle, SAP, PeopleSoft, et cetera.

recording rules ('Grundrechnung'). Everest (1974) describes the objectives of improved accounting data models as increased sharability of data, increased availability of data, improved evolvability of data and increased data integrity.

This dissertation focuses on the question of how ERP systems can better store data to service internal and external information needs that may change over time. A new method of organizing accounting data, suitable to deploy as an ERP systems data model, is proposed. This data model should be sufficiently complete and robust so as to be implemented as a data model for ERP systems and deployable as a data source in real-life customer situations. It should be able to hold data for existing and new information needs. The completeness of the data stored in this newly proposed data model is validated through answering the question of whether enough data could be held to service the information requirements of a new application. We chose to validate the completeness of the data available through a new application as the value added is better demonstrated when data can be provided for an application not currently supported by data extracted from existing ERP data models. As representative of a new application choice, whether sufficient data can be provided to service hierarchical treasury management decision-making with *ex ante* and *ex post* accounting data to be applied in manufacturing organizations will be evaluated. To attain this objective, the new application has first to be defined by introducing principles of business logistics into the domain of treasury management to obtain a hierarchical treasury management decision framework where decisions are defined at various levels. Following that, management accounting theory will be applied to evaluate which *ex post* and *ex ante* information is required to support these decisions. Once all information requirements for this new application are known, the newly proposed accounting data model's ability to hold sufficient data will be evaluated as validation of the multi-purpose nature of this data organization approach.

The scope of the research project described in this dissertation can also be outlined through a description of the three most important keywords in this dissertation. The keywords are: accounting, treasury management and information systems.

*Accounting* is the first keyword. This domain is usually divided into financial accounting and management accounting. The goal of management accounting is to provide the knowledge required for planning, decision-making and control (Zimmerman, 1997; Anthony, 1988). Financial accounting focuses on providing information to external stakeholders. The overall goal of this dissertation relates to defining an improved accounting data model that can hold more complete data for new and existing information needs. These decisions can relate to internal subjects (in the field of management accounting) or external questions (as discussed in financial accounting). More specifically, the knowledge on decision-making is applied to the domain of treasury management decisions at an operational level, i.e. the management of financial resource flows. These decisions are supported with relevant cost information (see Chapter 6). The goal of financial accounting is to record the relevant financial data on business transactions and provide them to the (mainly external) stakeholders in the organization. The double-entry bookkeeping system is the most widely used format for the storage of financial accounting data. However, later in this dissertation (see Chapter 2), it will be demonstrated that this data recording method has drawbacks when accounting data are provided for decision-making. Therefore, an alternative recording approach for capturing accounting data is proposed (see Chapters 2 and 3).

*Treasury management* is the second keyword and relates to solving two categories of problems. The first category concerns planning and executing the physical flow of financial resources, e.g. optimizing supplier payments, optimizing customer collections, etc. The second category of treasury management decisions concerns the identification and hedging of financial risks related to financial resources used in business transactions, e.g. optimizing currency and interest rate risks. In this research, only treasury management decision support

was considered, which belongs to the first category (i.e. optimizing the physical flow of financial resources), since these decisions can be fully supported on the basis of business transaction data stored in the ERP data model. The other category of decisions (focusing on currency and interest rate optimization) make use of very different types of data (macroeconomic, operations research modelling, etc.) and are consequently outside the scope of this discussion. Treasury management decisions focusing on financial resource flow optimization are usually divided into short and medium-term decisions, and long-term decisions.<sup>2</sup> Decisions typically made for the long term relate to, for example, a decision to expand the volume of financial resources through the raising of capital or the issue of bonds, a decision to invest a strategic surplus of financial resources by taking a stake in another organization, and so on. One unifying characteristic of all these decisions is that, once made, they are difficult to reverse. Long-term decisions essentially determine from a high-level perspective which types of financial resources are used in a business. Short and medium-term treasury management decisions essentially originate from the results of long-term decisions. Decisions typically made in this timeframe are those, for example, optimizing payments and collections of financial resources, optimizing cash surpluses and deficits, minimizing bank costs, etc. Short and medium-term financial policies are instituted to efficiently manage the financial resources of a firm. They are close to the operations of the firm and once implemented, are easier to change. ERP systems hold information to support short and medium-term decision-making in several functional domains, one of which is treasury management. In this research, supporting treasury management decisions in the short and midterm was opted for as being the typical timeframes within which ERP systems facilitate decision support (see Chapter 5).

*Information system* is this dissertation's final keyword. The trend today in business information systems is for so-called Enterprise Resource Planning systems, which are standard integrated business information systems. As previously explained, many organizations invested heavily in these information systems to resolve a number of problems simultaneously. The objective of this research is to propose an improved data model that could be the sole data source for an ERP system.

This research was conducted following a multidisciplinary approach, as a mono-disciplinary approach would have yielded only partial solutions to the research questions. Following the research methodology applied in Industrial Engineering and Management science, this approach takes all relevant viewpoints on the problem into account. In this research, the information technology perspective is studied in relation to a treasury management decision-making viewpoint to coherently investigate the overarching question of '*Is there a better way to define and organize accounting data suitable for implementation and deployment in ERP systems which provides more complete ex ante and ex post data to support existing and new internal and external information needs?*' The newly proposed accounting data model is validated in an application where data has to be provided to support hierarchical treasury management decisions with relevant cost data. 'Hierarchical' is meant to be understood as the relational state where decisions are defined at multiple levels and the outcome of decisions made at a higher level sets the scope in which decisions defined at a lower level can be made.

In the remaining part of this chapter, the following topics are discussed. Section 1.2 covers different approaches to support changing information needs in ERP systems. Section 1.3 discusses how accounting data model research results have not been incorporated into the data models of current business information systems on the basis of literature analysis. The problem of restricted data availability is therefore still an existing and relevant problem today. This finding is illustrated by an analysis of the data recording approach in a sample ERP system. Section 1.4 provides an outline of the research objectives and questions covered in

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<sup>2</sup> Hill et al. (1992) argue that it is advisable to define this difference on the basis of the nature of the decision and not on the basis of the timeframe within which the decision is made.

this dissertation. Section 1.5 deals with the research methodology applied in this research. Section 1.6 discusses the research design. Section 1.7 discusses the scientific and practical relevance of this research. An outline of the remaining chapters of this dissertation is presented in Section 1.8.

## **1.2 Different approaches to support changing information needs in ERP Systems**

Several different approaches can be discerned servicing changing information needs in ERP systems. Two of these are used very widely and are therefore discussed here, namely focusing on the support of new algorithms and focusing on the design of improved data organization frameworks. These two approaches are discussed below.

### **1.2.1 Focusing on the design of new algorithms**

Following the first approach, the focus is on the definition of new business algorithms to solve a changed management information problem. Once new algorithms are defined, they are designed and developed in new software applications. The shared data model, which holds the data used to service all ERP applications, is modified, where data proves insufficient, on the basis of the new data requirements. This approach always implies the development of new algorithms and data model extensions. An example within the treasury management domain could be the definition of an algorithm to serve a treasury management decision framework in which decisions are supported hierarchically where there can be several alternative solutions for a single decision. In operations management, a number of hierarchical decision-making applications are already known that focus on optimizing operational resources (see e.g. Bitran and Hax, 1977; Bitran and Tirumpati, 1993; Fransoo et al., 1995; and Hax and Meal, 1975). Hierarchical decision-making relates to decisions that are defined at different levels where the outcomes of decisions defined at a higher level set the scope for optimizing decisions defined at a lower level. Comparable hierarchical decision-making applications could be developed to service treasury management decisions that optimize financial resource usage. Were these functional applications developed as ERP software applications, following this approach would necessitate the ERP data model being modified or extended for missing data.

### **1.2.2 Focusing on the design of improved data organization frameworks**

The second approach focuses on the design of multipurpose data models. Researchers and information system architects advocating this approach point to the advantages that result when business transaction data are organized independently of any application scope, in that there are no restrictions on data availability when stored data are reused to service a newly defined algorithm. A significant number of research initiatives have been defined in this area, see e.g. Verdaasdonk (1998, pp. 88-96), Dunn and McCarthy (1997), Weber and Weissenberger (1997), Sakagami (1995), Murthy and Wiggins (1993). The most important research initiatives in this area are by McCarthy (1982) and Riebel (1994), based on Schmalenbach (1948). This literature will be discussed in detail in Chapter 2. These authors focus in their research projects on improved ways of organizing accounting data stored in information system data models.

The first important research initiative was McCarthy's Resource-Event-Agent (REA) model, which redefines relevant accounting data on economic events in such a way that data can be provided to service requirements for financial accounting information needs. Following this

approach, every financial business transaction is described by its key components: resources, events and agents, and the possible relationships between them. The REA model was first designed using the E-R (entity-relationship) methodology. An object-oriented version of the REA model was later presented (see Dunn and McCarthy, 1997; Geerts and McCarthy, 1997; McCarthy, 1995). The REA model was further developed into the extended REA model (Geerts and McCarthy, 2000, 2002).

The second important research initiative was Schmalenbach's (1948) and Riebel's (1994) 'Grundrechnung' description. Schmalenbach differentiated between 'Grundrechnung' (the data storage area) and 'Sonderrechnungen' (applications making use of 'Grundrechnung'). He described accounting data recording principles for 'Grundrechnung' to guarantee the purpose neutrality of recorded data. Purpose neutrality of accounting data means that data are not defined specifically for one application but can be reused for a whole range of applications. Riebel (1994) extended Schmalenbach's recording rules in order to bring 'Grundrechnung' into practice. This resulted in the definition of data recording principles with which data models have to comply in order to guarantee the purpose neutrality of stored data.

### 1.2.3 Which approach to prefer?

Focusing design efforts on proposing new algorithms could seriously negatively impact the application and data model architecture. Following this approach, the data model is designed after the requirements of new algorithms are frozen, without anticipating the possible need to support additional algorithms at a later date. As a result, the reapplicability of already available data to service new algorithms cannot be guaranteed. When existing data recording is not entirely satisfactory, separate data models are created with the sole objective of supporting the newly designed algorithm. This soon leads to several data sources being used concurrently to service the business information system. These data sources often contain similar data (e.g. one data model holding aggregated data, a second data model holding detailed data; both data models referring to the same business transaction), with the potential risk that data recorded in different data sources are not synchronized. Applications built following this approach look like a patchwork with no transparent, reusable architecture. Scapens et al. (1996) describes this problem as follows: '*... it has also been questioned whether sufficient attention was given to the ability of managers to see through the limitations of data and draw on a variety of information sources in a flexible way for decision-making rather than giving their choices controlled by external reporting in a deterministic way*'. Owing to these drawbacks, defining new algorithms and modifying the data model accordingly cannot be considered as a good approach offering a sound foundation for the guarantee of ongoing support of new and/or changing information needs over the longer term.

Consequently, defining improved accounting data models is the right approach at a fundamental level as objectives like increased sharability and availability of data directly contribute to the ability to service existing and new applications over time without restrictions. However, whether data models of large, modern business information systems are in fact built on the basis of the research result recommendations of the two most important data model proposals, the REA model and 'Grundrechnung', remains in question. Are the data models proposed as a result of scientific research initiatives actually suitable for deployment in practice, or –though fundamentally correct options– do they suffer from another type of drawback that renders them incapable of use in practice? This will be further explored in the following section.



## 1.3 Does the problem of limited data reusability still exist in practice?

### 1.3.1 No adoption of REA and ‘Grundrechnung’ concepts in data models of current business information systems according to the literature

In the last few decades, several scientific research projects have focused on improved accounting data models. Over the same period of time, business information systems have evolved from very specific propriety systems offered by hardware vendors to generic business information systems, like ERP systems, that operate platform independently. These generic systems service the information needs of multiple users in many different types of organization. This section explores whether the recommendations on accounting data model design as formulated –among others– by McCarthy (the REA model) and Riebel (‘Grundrechnung’) have been adopted in current business information systems.

The objective of the REA model was to capture the essential data characteristics of a financial business transaction in a generic way in terms of Resources-Entities-Agents and the relationships between these components. A number of authors have questioned the feasibility of the REA approach as a data model. Sakagami (1995) argues that the REA model is not really suitable for real-life implementation due to features of the modelling technique (entity-relationship) chosen. Applying this modelling technique causes the REA meta model to grow with the number of specific REA components needed in a real-life situation. Sakagami notes that this will inevitably lead to performance problems. Geerts (1997) explains that the REA model lacks ‘reusability’ and ‘extendibility’ when designed using the E-R modelling technique. These drawbacks were subsequently recognized and an object-oriented version of the REA model created (see Dunn and McCarthy, 1997; Geerts and McCarthy, 1997; McCarthy, 1995). The REA model was further developed into the extended REA model (Geerts and McCarthy, 2000, 2002). Except for some examples on the use of the REA model, which might have led to data model prototypes, there is no mention of the deployment of the REA model in actual customer applications in scientific literature.

There is even less literature about and references to applications of the ‘Grundrechnung’ data recording principles. Riebel et al. (1992) and Sinzig (1994) published that the ‘Grundrechnung’ achieved an degree of ‘purpose neutrality’ suitable for application in the ERP system R2 of ERP vendor SAP AG. However, Weber and Weissenberger’s research (1997) indicated that Riebel’s approach has not yet resulted in concrete software applications.

On the basis of literature investigation, it was found that the two most prominent scientific research programs (McCarthy’s REA model and Riebel’s ‘Grundrechnung’) have not yet led to adoption in practice in large-scale implementations of business information systems. Based on this analysis, it can be ascertained that the problem of providing reusable data that allow for data provision to service existing, new or changing information needs, is still not properly resolved to date. More research is needed to make data organization frameworks available that comply with the following two criteria. First, new data models should be able to accommodate data on business transactions to service *existing*, *new* or *changed* algorithms. These data should not only be *ex post* data but also *ex ante* data. Second, these data models should be suitable for acting as sole data sources for large-scale implementation of business information systems like ERP systems.

Questions remain concerning whether and how the problems of providing reusable data to service changing information needs have been solved in practice in real-life situations by software application vendors. Has practice gone its own way and have ERP vendors developed their own sole-source data models, able to service changing information needs, and are these data models simply not consolidated in scientific literature or are ERP data models

still designed on the basis of requirements frozen at a particular moment in keeping with the first approach described (see Section 1.2.1), confirming expectations that capabilities to service information needs changing over time are limited? To gain an impression of how matters stand with this issue in practice, the next section investigates empirically how business data are stored in a sample ERP system.

### 1.3.2 Illustration of business process instance data storage in a sample ERP system

#### 1.3.2.1 Terminology Definition and Situation

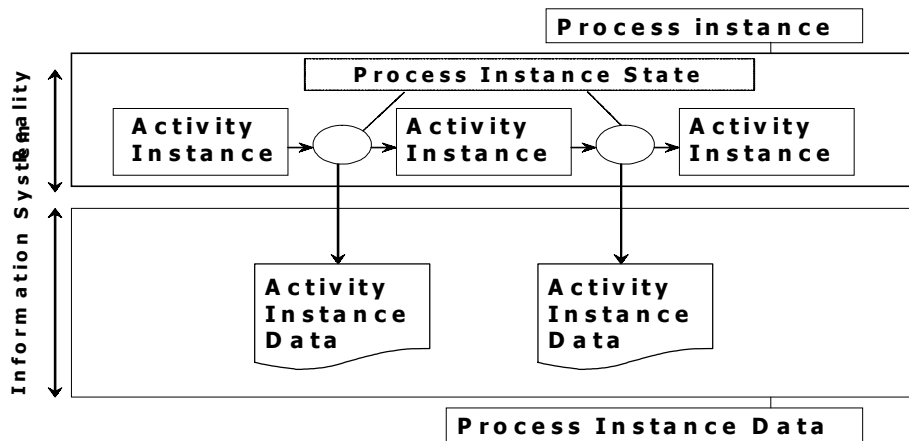
The process of data recording in current ERP systems is analysed through the empirical investigation of a sample ERP system that can be considered as representative in the industry. The following definitions are applied:

- *Business process*. Any set of activities performed by a business that is initiated by an event, that transforms information, materials or business commitments and produces an output. Value chains and large-scale business processes produce outputs that are valued by customers. Other processes generate outputs that are valued by other processes (Harmon, 2002). For example, procure-to-payment, a network of activities to complete the procure-to-payment process
- *Business process instance*. A business process describes a *generic* sequence of activities. A business process instance<sup>3</sup> describes *an actual process in a specific situation*, which includes data, real actions and specific decisions. Workflow systems and simulation systems, for example, both keep track of the data from execution of specific BPIs in order to determine things like how long the process actually takes, who handles a specific instance or how much it costs. In simulation systems, someone has to supply information about a set of actual instances (Harmon, 2002). For example, ‘Process Instance of business process “procure-to-payment” number 85 between business partner “Peters” and “Johnson”’
- *Business transaction*. The execution of one particular activity instance of a process instance. For example, ‘Business partner Johnson *orders* 100 wheelchairs from business partner Peters’ (the activity, ‘ordering’, is an example of a business transaction)
- *Process instance state*. Is used to track the progress of a process instance execution. A state is changed to indicate that one business transaction (i.e. an activity instance of the process instance) has finished and the execution of the network can continue to the next business transaction. At that point, data on the executed activity are recorded in one or more documents.

The relationships between the terms, ‘process instance’, ‘process instance data’, ‘activity instance’, ‘activity instance data’ and ‘process instance state’ are illustrated in Figure 1-1:

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<sup>3</sup> In the remainder of this chapter, ‘business process instance’ is abbreviated to ‘BPI’.



**Figure 1-1. Relevant terminology in the context of a process instance**

Data storage for BPIs in the chosen sample ERP system is analysed below by investigating the data recording process pertaining to data required to service a realistic sample information request. The following information request was chosen: *The Production Manager raises the request for 300 extra units of product 'chair frames' to the Purchase Manager*. To service this information request, data on two different process instances are required:

- BPI #1, specific situation of business process: 'Periodic Material Requirements Planning'
- BPI #2, specific situation of business process: 'Procure-to-Payment'

The activities of these two BPIs are detailed below. The details on recorded data per activity instance can be found in Appendix 1.

**BPI #1, specific situation of business process 'Periodic Material Requirements Planning'<sup>4</sup>**

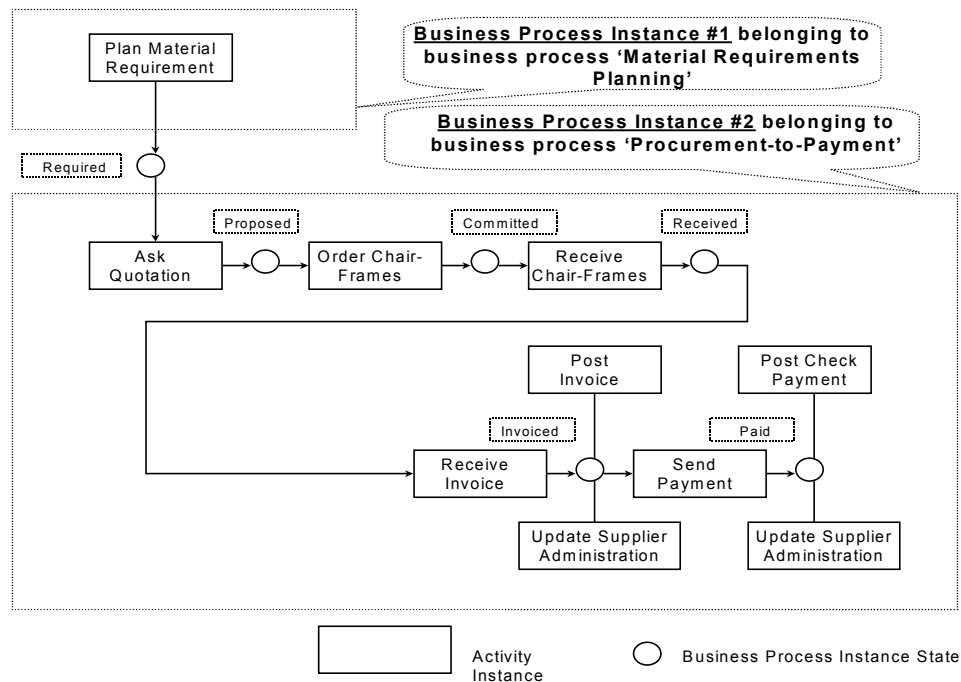
Activity	BPI State	Information stored
Plan Material Requirement	Required	Material Advice Order

**BPI #2, specific situation of business process 'Procure-to-Payment'**

Activity	BPI state	Information stored
Ask Quotation for Chair Frames	Proposed	Purchase Quotation
Order Chair Frames	Committed	Purchase Order
Receive Chair Frames	Received	Delivery Note
Receive Invoice	Invoiced	Purchase Invoice
		Posting Purchase Invoice
		Update Supplier Administration
Payment Invoice	Paid	Check
		Post Purchase Invoice
		Update Supplier Administration

<sup>4</sup> Only the last activity of this BPI is detailed.

The BPIs are illustrated in Figure 1-2:



**Figure 1-2. Relationship between Activity Instance and Process Instance State**

### 1.3.2.2 How data on BPIs are recorded in the sample ERP system

The data recording approach to the data used in BPIs of a sample ERP system is analysed on the basis of the data used to service the sample information request as proposed in the previous section.<sup>5</sup> The details on recorded data are presented in Appendix 1. The following aspects are investigated:

- *data storage in a single BPI*: to understand whether the data of a single BPI is provided using a common, transparent approach to service different information needs
- *data storage approach between different BPIs*: to understand whether the data of different BPIs can be integrated using a common, transparent method to service different information needs.

These two aspects are considered the most important and crucial in understanding how data on BPIs are organized in current ERP systems. There are several other aspects that are worth investigating (e.g. technical aspects like product architecture, database technologies used in ERP systems, etc.) but are considered less important in the context of the research objectives of this dissertation. In addition to these three aspects, whether elements of the proposed data models, namely McCarthy's REA model or Riebel's 'Grundrechnung', are adopted in the data storage approach of the BPIs of the sample ERP system is investigated. These two categories of question result in four findings on the data recording process of the data used in BPIs in current ERP systems, and are described below.

<sup>5</sup> The ERP system used for this investigation is SSA Baan ERP from ERP vendor SSA GT.

**- Findings on the data storage of data used in a *single* BPI -**

***Finding 1:***

**There is no equivalent of the BPI at a data level. Data on a single activity instance are persistently stored but the *network* activity instance (i.e. the BPI) itself is lost at the data level.**

When the BPI state changes, the data for the new BPI state are entirely re-established.

This finding concerns the question of how data on a single BPI are recorded. Figure 1-1 visualizes that a state change in a BPI occurs when an activity is finished and the execution of the BPI is continued with the next activity instance. At that point, data on the conditions of the finished activity are recorded. This raises the question of how data on such a finished activity are stored in the data model and whether data on different activities of the same BPI can be made to cohere, answered by examining how data on BPI #2, ‘Material Procurement’, are stored. In Section 1.3.2.1, information on the following aspects of this network is presented: the activity instance network, the BPI states and the data stored per BPI state (for more details, see Appendix 1). Examination of Appendix 1 reveals that no BPI state is maintained. Data necessary to support the information needs of one BPI state (i.e. one finished activity instance in the BPI) are always redefined from scratch. This is either done by copying and modifying the data from the previous BPI state or by creating an entirely new definition. An example of the former option is the data creation for the ‘order chair frames’ BPI state (following ‘quotation for chair frames’). Some data are copied (e.g. the business partner data) whereas others are redefined (e.g. *proposed* quantity, *proposed* delivery date, etc. become *committed* quantity, *committed* delivery date, etc.). An example of the latter option is the data creation for the ‘post invoice’ BPI state (following BPI state ‘receive invoice’). Posting an invoice is only a summary recording of the total amount categorized in specific general ledger accounts. In comparison with the previous activity (i.e. ‘receive invoice’), all other invoice data are lost. In view of the data over the entire lifecycle of a BPI, it can be said that a BPI always carries all its data (of different BPI states) with it but that there is no central mechanism bringing data of a given BPI into coherence. There is no option to retrace the BPI data to any of the various activity instances of a BPI, as a consequence of the data organization methodology applied (i.e. copying and modifying). Consequently, there is only limited possibility of enhancing application functionality supported for a BPI state because it is restricted by the available data for that particular BPI state with no option to reuse data defined for other business process instance states.

***Finding 2:***

**Every completed activity instance of a BPI results in BPI state, domain-specific data recording. This data record of the state of a BPI is stored in isolation and not as a sub-category of a BPI.**

No data organization mechanism is used to track BPI data across different states in its lifecycle.

Each activity instance in the BPI belongs to a specific functional domain. This is illustrated on the basis of the activity instances of BPI #2 (as described in Section 1.3.2.1 and see Appendix 1 for details). For example, the ‘Ask Quotation’, ‘Order Chair Frames’, ‘Receive Chair Frames’ activities belong to the ‘Distribution Logistics’ functional domain and the ‘Receive Invoice’ and ‘Payment Invoice’ activities belong to the ‘Finance’ functional domain. The nature of the information requests belonging to a functional domain, even those belonging to a subdivision of a functional domain, prescribes that data should be *presented* in a particular format. For example, within the ‘Distribution Logistics’ functional domain, the presentation of the ‘quotation’ is similar to the presentation of the ‘order’ but different from the presentation of the ‘delivery note’. The question, therefore, is whether data should be

recorded in the format used by the target user group of the information related to an activity or whether the data should be recorded independently of the format in which it is used. McCarthy (1979) claims that when data are stored according to the requirements of a certain artefact (e.g. general ledger accounts), they are only reusable to a limited extent (i.e. within the scope of new requirements based on the chosen accounting artefact). An investigation of the sample ERP system highlights that data are indeed stored specifically in the format prescribed by the information requests of a specific BPI state. For example, for the 'post invoice' activity, data are stored in general ledger format, for the 'order chair frames' activity, sufficient data on the order are stored to handle information requests of the 'Distribution Logistics' domain but there is limited availability to support financial information requests. Besides, in an ERP system, data belonging to a BPI state are stored in isolation and are unrelated with respect to the data stored on BPI state, which immediately precedes or succeeds the focused data item. In current ERP systems, the relationship between data of different activities needs to be defined by means of a workflow management tool. These tools are not truly integrated with the information system itself; rather than being an embedded and integral part of the information system, these tools are mostly offered as bolt-on add-ons for the ERP system. The data model itself lacks the definition capability to compose all data over different activities of a single BPI.

#### - Findings on data organization *between* BPIs -

##### ***Finding 3:***

**As data on a single BPI are not stored in a structured manner, there is no structured data organization approach between different BPIs.**

There is no generic integration between data between different BPIs. When data on different BPIs are integrated, they are integrated to support specific, predefined functional requirements.

This finding concerns the question of how data on *different* BPIs are integrated with each other. Prior to investigating how data on BPI #1 are integrated with data on BPI #2, how the *activity instances* of these two BPIs are integrated should be considered (the activities are described in Section 1.3.2.1, with details on recorded data described in Appendix 1). As explained earlier in this section under Finding 2, data on activity instances of a BPI are stored in isolation; however, they can be made to cohere using a workflow management system, an add-on tool on top of the ERP system. These tools support the definition of activities at different levels of detail. Accordingly, first the highest level is defined (integration between BPI #1 and BPI #2), then the integration between individual activity instances of a BPI are defined at a lower level. It is prone to the same drawbacks as defined for Finding 2. The workflow management tool, which facilitates integration between activities over different BPIs, is only defined on top of the information system and is not really integrated. Its only function is to invoke activities in a certain sequence. As the execution of activities implies reading data on the chosen activities, this approach facilitates bringing data on different activities into context. The possibility of defining an activity chain over *different* BPIs is thus achieved through selecting a sequence of activities out of a predefined set of possible activity combinations. The number of possible integration options between activities of different BPIs is predetermined. The source of this limitation can be found in the data structure. As stated in Findings 1 and 2, in current information systems, data are provided in a contextually specific BPI state. Of relevance to this finding is the fact that a number of possible integrations between different BPIs are provided from a data viewpoint as domain-specific BPI state data. If a generic, transparent data definition concept was used to organize the BPI data, then transparency for data between different BPIs could be achieved, allowing for more flexible integration. As this is not yet the case at the level of a single BPI, it can be concluded prior to any discussion of the data organization between *different* BPIs that the data on a single BPI should first be organized consistently and coherently.

**- Finding on the use of a generic data organization concept -**

***Finding 4:***

**Data on BPIs are not organized according to REA or ‘Grundrechnung’ principles. No other equivalent data organization concept<sup>6</sup> is used to define data on BPIs consistently and transparently.**

Double-entry bookkeeping is implemented as a data recording method to support financial information needs.

Earlier in Section 1.3.1, it was found on the basis of literature analysis that principles of REA and ‘Grundrechnung’ have not been adopted in ERP systems to date. However, it is possible that current ERP systems have been adopting some of the recommendations of REA and ‘Grundrechnung’ without these having resulted in scientific publications. In order to understand the actual status of REA and ‘Grundrechnung’ adoption in existing ERP systems, three different aspects are investigated in more detail for the ERP system under investigation. First, the extent to which the research results on the most prominent research initiative, McCarthy’s REA Model, have been adopted in the data models of the sample ERP system are investigated. Second, whether or not the ERP data models take into consideration the data recording principles prescribed by ‘Grundrechnung’ is evaluated. As a third and final topic, whether data models of current ERP systems suffer restrictions because of the adoption of application artefacts such as general ledger accounts, debit/credit, etc., is explored. The outcome of the investigation of these three topics is described below.

First, the adoption of research results on REA in current ERP systems is investigated. McCarthy (1979) noted that business transaction data could be reused to service multiple information needs from various different users when essential data characteristics are recorded. In his REA model, he defined ‘Resources’, ‘Events’ and ‘Agents’ as the essential components to be consistently recorded in the data model. The question remains whether ERP system designers ever followed this advice. As already highlighted in Section 1.2.2, among the other drawbacks reported by several researchers, Sakagami (1995) remarked that the REA model is not really suitable for large-scale implementations and Geerts (1997) indicated that the REA model lacks ‘reusability’ and ‘extendibility’. Owing to these drawbacks, it is not expected that ERP system data models have adopted features of the REA framework in their basic format. However, ERP designers could have modified the REA model into one suitable for implementation in ERP systems. It was stated in Finding 2 that in the sample ERP system, data are recorded specifically in the format used by users of a functional domain. For example, the ‘post invoice’ activity implies that the financial result of the ‘receive purchase invoice’ activity is recorded in the general ledger accounts. Data on essential REA components such as the ‘Resource’ or the ‘Agent’ are lost. This simple example illustrates the contention that no extended version of the REA model was applied as a data storage approach in the sample ERP system.

Second, the extent to which the data models of existing ERP systems comply with ‘Grundrechnung’ data storage principles was investigated. With respect to the possible application of the data recording principles of ‘Grundrechnung’ (Riebel, 1994; see also Verdaasdonk, 1998, pp. 91-92) in the data model design of current ERP systems, an investigation of the sample ERP system illustrates that none of the prescribed data recording rules have been followed for BPI data recording. These data recording rules are:

1. *‘No heterogeneous classification or summarizing of data elements’*. This data recording principle prescribes that data should be classified homogeneously and that detailed data should be recorded in all situations. In Finding 2, it was indicated that data on a

<sup>6</sup> In this context, a ‘data organization concept’ is defined as one transparent data organization ‘vehicle’, reusable and capable of holding the data of one entire network of financial obligations in a commonly agreed format.

completed activity are always stored in a domain specific format. For example, data on ‘Posting the Invoice’ are stored in general ledger accounts whereas data on ‘Quotation for Wheelchairs’ are stored in a Distribution Logistics-specific format (see Appendix 1 for details). It is therefore ascertained that data on different completed activities are recorded heterogeneously. Depending on the characteristics of the activity, detailed or summarized data are recorded.

2. ‘*No arbitrary division and allocation of accounting data*’. This data recording principle suggests that accounting data should be recorded as they occur in the BPIs prior to defining calculations or allocations. Again, Finding 2 showed that data on some of the completed financial activities are stored in general ledger accounts (see Appendix 1 for details). Data stored in general ledger accounts are by definition arbitrarily categorized and specific to the details of the BPIs (i.e. the choice of general ledger accounts depends on the nature of the BPIs and the calculation or allocation of data could have taken place before the actual data recording on general ledger accounts).
3. ‘*Recording an entry at the lowest level possible*’. This data recording principle prescribes that data should be recorded with as much detail as possible. In some situations this recording principle is achieved, e.g. data on the ‘Purchase Order Wheelchairs’ are stored with full detail (i.e. ‘at the lowest level’). However, in other situations, this recording principle is jeopardized, e.g. when data on the BPI are stored in general ledger accounts, only a ‘financial summary’ of the data on the finished activity is stored – detailed data are lost.
4. ‘*Characterization with all attributes of interest and importance*’. This data recording principle suggests that full data should be available to service all attributes of interest and importance concerning a broad user community. See also recording principles 2 and 3. General ledger accounts do not hold data on the circumstances in which an activity took place. Data stored on the ‘Order chair frames’ activity (see Appendix 1) only hold scant financial information. In other words, no data are accommodated in the representative sample ERP to service the general notion of ‘attributes of interest’ of different information users.

This elaboration is to clarify that ‘Grundrechnung’ data storage principles have not been applied in the data model design of the sample ERP system.

The third and final aspect of this investigation was to examine whether data models of current ERP systems still contain application artefacts. For decades, research aimed at improved accounting data models has been initiated as the various drawbacks of double-entry bookkeeping became apparent (e.g. as described by McCarthy 1980, p. 628; see also Belkaoui, 1992, p.110; Hollander et al., 1996, pp.49-54 and Verdaasdonk, 1998, pp.87-88). These researchers have consistently advised avoiding adopting application artefacts in the data model design in order to avoid possible restrictions in data storage because of limitations to a chosen application scope. This raises the question of whether ERP system designers have followed this advice and abandoned double-entry bookkeeping features in data model design. Investigation of the sample ERP system has revealed that data on some financial activities are still stored in general ledger accounts (see Appendix 1). Despite frequent advice from scientists, the adoption of double-entry bookkeeping artefacts continues in today’s information systems. However, some additional explanation is required here. Not all of McCarthy’s drawbacks on double-entry bookkeeping are applicable to characteristics of ERP system data models since in addition to this data recording technique, other data recording also takes place. If several data recording methods are concurrently applied in ERP systems, the next question is whether double-entry bookkeeping is only implemented as an optimization of the shared data model to service external control-related information needs. Thus the question is whether data recorded in general ledger accounts are only *derived* from a transparent, reusable data model or whether several data sources are *concurrently* maintained. Investigation of the representative sample ERP system has revealed that BPI data are not organized as transparent, reusable data objects as explained earlier in this finding. Therefore, it can be ascertained for the sample ERP system that data recorded in general ledger accounts



is not derived from a transparent data organization concept. The application of double-entry bookkeeping in the ERP system could therefore lead to limitations in the availability of data.

The outcome of the investigation of these three aspects (nonadoption of REA aspects, noncompliance with ‘Grundrechnung’ data recording principles, and the adoption of application artefacts in the data model) indicate that practice did not follow the recommendations made in scientific literature.

### **1.3.2.3 Summary of business transaction data recording in current ERP systems**

In Section 1.3.2, two different aspects of data recording in a representative sample ERP system were empirically analysed, namely the data organization of a single BPI and the data organization between different BPIs. The next matter under scrutiny focuses on whether research results on prominent data models like REA and Grundrechnung are used in practice in a sample ERP system deployed in several large-scale customer implementations. This investigation resulted in the definition of four findings that all apply to the sample ERP system. Though other ERP systems have not been the subject of this investigation, it is expected, based on experience in practice with other ERP systems, that a comparable empirical investigation of other systems would yield results in line with the findings as defined for this sample ERP system.

### **1.3.3 Approach chosen in this research**

The problem of providing reusable data suitable to service existing, new or changing information needs remains unsolved today. This was found as a result of literature analysis in Section 1.3.1 and was illustrated for a sample ERP system in Section 1.3.2. The following approach has been chosen in this research to solve this problem. In order to achieve the research objectives as defined later in this chapter (see Section 1.4), the following questions need to be answered. First, a new way to define and organize accounting data has to be proposed, resulting in an accounting data model suitable for ERP implementation and deployment in real-life customer situations. Within this data organization approach, data will have to be defined in a neutral and objective fashion (according to Schmalenbach’s Grundrechnung approach) so that they can also be reused to accommodate data to service other applications at a later date. This part of the research clearly focuses on the second approach as explained in Section 1.2.2 (i.e. focusing on the design of improved data organization frameworks). Even when the objective is to support existing, new and changing information needs on the basis of neutral and objective data, a scope consideration still has to be made. Here, the existing, new or changing information needs are envisaged as those that are typically solved by ERP systems today and for which no entirely new type of data (such as risk data, macroeconomic data, environmental data, etc.) are required. The aim is to avoid, within this context only, a situation where new or changing information needs enforce data model changes by proposing an improved data organization framework. Second, the reusability of data accommodated through the newly proposed accounting data model should be illustrated by evaluating whether sufficient data can be provided to support hierarchical treasury management decision-making at multiple levels with *ex post* and *ex ante* accounting data. This part of the research could be considered as an example of the first approach as outlined in Section 1.2.1 (i.e. new algorithms are developed in addition to the body of knowledge concerning treasury management). However, the data provision to support this algorithm in information systems will not be facilitated by specifically enhancing the existing ERP data models to comply with the new requirements on data availability. On the contrary, since a new data organization method aiming at providing data for multiple purposes is described in the next three chapters of this dissertation, the newly required data will be accommodated by this new accounting data model. The ability to provide data to service the

newly outlined application in the treasury management domain will be used to validate the capability to provide data to many other new applications in the future.

## 1.4 Research Objectives and Questions

This section concerns the problem statements of this research. Verschuren and Doorewaard (1995) indicated that a research problem statement consists of the *research objective* and *research questions*. This research project can be broken down into two research objectives, each with a list of research questions.

The central objective of this research, as outlined in Section 1.1, is to answer the following: ‘*Is there a better way to define and organize accounting data suitable for implementation and deployment in ERP systems which provides more complete ex ante and ex post data to support existing and new internal and external information needs?*’ This question was the result of the observation in the literature that research results on accounting data model research have not lead to data models which were useful for implementation in large ERP systems on the one hand, and the finding that existing ERP systems still struggle under the same limitation of insufficient data being capable of being provided to handle existing, new and changing internal and external information needs. Therefore, there remains justification for additional research towards improved accounting data models. This is outlined in the following research objective.

### **Research Objective 1**

- To propose a data organization framework allowing the storage of *ex post* and *ex ante* accounting data on BPIs suitable for supporting *changing* accounting information requests defined by *different* users.

A solution to this research objective consists of three steps. In Section 1.2.2, it was explained that data need to be organized independently of any application scope in order to be reusable for existing, new and changing information needs. McCarthy (1979) argues that this is only possible when aspects of reality are incorporated into the data model. As a first step to the solution of this research objective, investigating which aspect of reality occurs as a recurring pattern in the BPI data is necessary. This will be the central entity of the data model. Once this recurring pattern is identified, the data components of this recurring pattern, essential to supporting information needs, have to be defined as the second step. Since the objective is to design an accounting data model which can be implemented in information systems, it is crucial to define these data components as design features that have to be taken into consideration when designing the data model. The third and final step is that the new accounting data model has to be designed in a commonly used data modelling language on the basis of the design features of essential data components as defined in the second step.

Research objective 1 can be redefined by means of the following research questions:

1. How should an alternative data organization method be defined from the recurring pattern recognisable in BPI data?
2. What are the essential data components of the BPI data pattern required to service new and changing information needs?
3. How can design features of essential BPI data components be modelled into an accounting data model which can be implemented in large business information systems?

These three research questions refer to the two problem areas as described in Section 1.3.2.2. The first research question relates to the lack in current ERP systems of a central generic data organization concept that allows the retrieval of data on a BPI at different stages of its life

cycle at once. The second research question investigates which essential data components need to be modelled in the data model so that sufficient data are available to service new and changing information needs. The third and final research question deals with the problem of how the essential data components of the proposed data organization methodology identified can be modelled so that an accounting data model becomes available that can be implemented in business information systems and provide data in real-life customer implementations.

The newly defined accounting data model is designed to be implemented in large ERP systems and to hold data to service existing, new and changing information needs from various internal and external information users. While this data model is expected to hold data to service a broad spectrum of applications, one application has been selected to validate whether the data model can indeed hold the data required to support all the information needs that occur in this application scope. The choice was to prefer a new application over an existing application in order to understand whether the proposed accounting data model could overcome restrictions encountered with existing data models. The application chosen is hierarchical treasury management decision support based on relevant cost data (*ex ante*) and *ex post* data. In this instance 'hierarchical' is to be taken to mean that decisions are defined at different levels whereby the outcome of decisions defined at a higher level define the scope in which decisions at a lower level can be made. The application chosen for validating the newly defined accounting data model is defined as the second research objective.

#### **Research Objective 2**

- To propose a framework of hierarchical treasury management decisions where *ex post* and *ex ante* accounting information is used for decision support in information systems.

Owing to the fact that the application chosen (hierarchical treasury management decision support with relevant cost data) is new, several steps have to be taken prior to actual validation on data completeness. Firstly, the new application has to be defined. Since hierarchical decision support also occurs in the domain of business logistics, it is logical to define the different treasury management decisions in a decision framework along the same lines as applied in business logistics decision frameworks. Supporting the treasury management decisions with relevant cost data was opted for. Therefore, as a second step, the relevant cost data, which actually play a role for decision support has to be defined for each of the decisions. Since the objective is to support these decisions with data held by the newly defined data model, what the requirements on data availability are have to be outlined alongside the definition of the relevant costs for each of the treasury management decisions. The third step is that an algorithm has to be defined for each of the decision alternatives that allows the calculation of what the decision outcome in terms of relevant costs will be for each treasury management decision generically. Since the treasury management decision framework is defined along the lines of business logistics decision frameworks, it is a natural choice also to redefine algorithms borrowed from this discipline and modify them to render them useful in the domain of treasury management. Again, since the objective is to support the decisions with data held by the new accounting data model, additional requirements on data availability encountered by the newly defined algorithm have to be outlined. Finally, the actual validation of the data model, which is the research result of research objective 1, can take place. The validation relates to the question of whether the data model can hold sufficient data to fulfil the data requirements defined for supporting decisions with relevant costs (see Step 2), and the data requirements defined to support the calculation algorithm (see Step 3).

The following research questions are defined to solve research objective 2:

1. How should a framework of hierarchical treasury management decisions based on concepts of business logistics be defined?
2. Which are the relevant *ex ante* and *ex post* accounting data suitable to service treasury management decisions with financial information?
3. How a consistent process be outlined to define relevant costs in such a way that an information system can determine incremental and opportunity costs for any treasury management decision scenario?
4. How do additional functional requirements of the new treasury management application impact on its ability to provide data through the accounting data model proposed as the research result of research objective 1?

The four research questions detail the application chosen to validate the accounting data model that is the result of research objective 1. The first research question refers to the problem of defining treasury management decisions hierarchically. The second research question refers to the definition of the accounting information relevant to supporting the treasury management decisions with financial information. The third research question refers to the difficulties of converting an advanced accounting theory into a process suitable for implementation in an information system design. The fourth research question relates to whether the data needed to support treasury management decisions using the chosen accounting technique can be provided through the proposed accounting data model that is the result of research objective 1.

## 1.5 Research Methodology

The research project discussed in this dissertation was conducted according to the methodology applicable for design-oriented research. In design-oriented research, the ultimate goal is the description and design of a model, which might take many different forms, such as a framework, a design, a software model, etc. (see De Leeuw, 1993). The following methodological steps have been taken to achieve this goal. The project was initiated by outlining a problem statement. The problem statement is the generalization of the issue as perceived by all representative stakeholders. The first step in the solution was the definition of requirements for the data model. These requirements can be based on multiple sources: literature analysis, case studies, workshops, etc. Then the data model was designed on the basis of these requirements. The design of model was the result of an iterated process: when necessary, requirements were further refined and the data model got improved as a logical result. When the model was considered to have some state of maturity, it was validated. The actual validation relates to investigating whether the newly designed model sufficiently solves the research objectives derived from the problem statement (Bilderbeek et al., 1998).

This methodology has been applied to this research subject as follows. The problem statement ('how to provide data for existing, new and changing information needs') was defined on the basis of literature analysis and discussions with ERP system architects. Requirements for an improved accounting data model were defined on the basis of recommendations in literature and the author's own experience with the design of ERP systems. After a couple of iterations, these requirements resulted in the definition of the design features for the accounting data model and ultimately in the design of the contract data model, expressed in UML (Unified Modelling Language), see Chapter 4. This contract data model is the end result of this research. Several different aspects could be chosen to validate the proposed data model, as explained further in Section 5.2 of Chapter 5. Whether the data model could be built can be validated (i.e. the development aspect), as can whether a customer could deploy the data model as data source in a real-life customer implementation (i.e. the implementation and

deployment aspect) or whether the data model could hold sufficient information (i.e. the completeness aspect). The completeness aspect was chosen to validate the suitability of this model for holding data for new and changing information needs, i.e. can the data model hold sufficient information to support existing and new applications? An application has been outlined to answer this question (i.e. operational treasury management decision-making). Again, according to the methodology of design-oriented research, requirements for data availability for this new application were defined first. Subsequently, an algorithm suitable for executing the treasury management calculations was defined. Additional data requirements for this algorithm were defined as well. Ultimately, the validation consisted of evaluating whether the data model could support the two sets of additional data requirements to service the application (operational treasury management) chosen for validation. It should be emphasised that the target audience for the treasury management application is primarily the system architects of large ERP systems who want to design a treasury management application as a logical extension of an ERP system. The target audience is not the professional treasurer whose daily activities consist of making these treasury management decisions in practice.

## 1.6 Research Design

This section concerns the research design applied to this research subject. This research focuses on designing a new accounting data model supporting new and changing information needs from various types of users and which can be implemented in real-life customer situations. The outline of this research project has been defined in five parts:

- Part 1: Problem statement
- Part 2: Functional architecture
- Part 3: Object architecture
- Part 4: Validation
- Part 5: Conclusions

The research approach chosen in each of these 5 parts will be elaborated in the remainder of this section.

### **Part 1: Problem statement**

The problem statement proposed in this research relates to the fact that data models of current large ERP systems are only capable of holding data to support existing, new and/or changing information needs from various types of information users to a limited extent. This problem has been derived from literature analysis. Research results on accounting data model research as consolidated in scientific literature are characterized by only describing the mechanics of the new model and the examples provided, offer only a limited illustration of its performance. These newly proposed data models have not led to publications on actual implementation and deployment of the proposed designs in ERP systems used in real-life situations. The problem of restricted data provision by existing data models is also illustrated through investigating how data on BPIs are recorded in a sample ERP system.

### **Part 2: Functional architecture**

In the second part, the functional architecture of the newly proposed accounting data model is presented. This is carried out in three consecutive steps.

The *first step* deals with an outline of the requirements the proposed data model needs to fulfil in order to meet the objectives on data provision to service existing, new and changing information needs. These requirements are defined on the basis of literature analysis, investigation of current ERP systems and discussions with information system architects.

Literature describes that new data models should ideally be designed in close relation with aspects of reality in order to avoid restrictions emergent from incorporating application artefacts such as debit/credit, a general ledger, etc. (see e.g. McCarthy, 1979). Therefore, as a *second step*, the aspects of reality that correspond to the phenomena of BPI data were investigated and subsequently analysed in two ways: firstly, through the analysis of the recurring pattern found in different business transaction data types (such as sales transactions, purchase transactions, etc.), as recorded in double-entry bookkeeping since its inception; secondly, through the analysis of the recurring pattern in BPI data as recorded in a sample ERP system. The recurring pattern is proposed as the 'contract', a formal record of agreements made between parties.

In the *third step*, the essential data components needed to provide data for existing, new and changing information requests are defined. The essential data characteristics are found on the basis of literature investigation. Defining the essential data components as design features to facilitate the design of the technical architecture in the next phase concludes the definition of the functional architecture.

### **Part 3: Technical Architecture**

The purpose of this research project is to obtain a data model that can serve as the sole data source of ERP systems deployed in large-scale customer implementations. Therefore, it is critical to express a technical design following a commonly accepted design method with no known restrictions. On the basis of the design features, the results of Step 3 of Part 2, the contract data model is designed in UML (Unifying Modeling Language). The usability and completeness of this data model was discussed with various ERP system architects.

### **Part 4: Validation**

Many different aspects could be relevant subjects for validation in this research project. Two of the most trivial choices are, first, is the data provided through the new contract data model sufficiently complete so as to be able to accommodate data to service existing, new and changing information needs? Second, can the data model be implemented in large business information systems and can it satisfactorily hold data in a real-life customer situation. Since validation of the second aspect (suitability for technical implementation) implies building an entire business information base with the contract data model as the sole data source and subsequently organizing full customer implementation with this information system, this aspect is beyond the scope of this research. Validation on completeness of the data source has been conducted in four consecutive steps as discussed below.

#### ***Step 1: Definition of the representative application***

The goal of completeness of data provision by the newly proposed data model relates to its ability to service existing, new and/or changing information needs. From a validation perspective, a representative information request needs to be outlined first, against which it is later evaluated to determine whether sufficient data could be provided by the data model. Hierarchical treasury management decision-making was selected for support as a new and representative treasury management application focusing on optimization of financial resource use in manufacturing organizations. This approach to treasury management decision-making is based on concepts from the business logistics domain. Because current treasury management information systems are not defined following this approach, this is considered a sufficiently representative application to validate the completeness of the data stored in the newly proposed data model. The definition of a new application consists of defining three different frameworks for hierarchical treasury management decision-making, namely a centralized, decentralized and hybrid model for decision-making. The definition of these frameworks for treasury management decision-making are defined on the basis of analogy with decision-making frameworks in business logistics as described in the literature of this domain.

***Step 2: Data requirement definition of the new information needs***

Having outlined the scope of the application chosen for validation in the previous step, the next question relates to the required data availability. Prior to defining the requirements on data availability, a method for decision-making has first to be determined. The method of decision-making is the relevant cost method. This choice is based on literature research in the domain of management accounting. For each of the treasury management decisions in the hybrid treasury management decision framework, it was first determined which relevant costs play a role in supporting the decision. Subsequently, the requirements on data availability were determined for each of the decisions individually. The complete list of different data requirements is ultimately derived from the list of data requirements per individual decision.

***Step 3: Data requirements on the calculation algorithm applied in the new application***

Once the data requirements per individual decision are known, whether there are additional requirements on data availability related to the calculation algorithm of the new application needs to be examined. A suitable calculation algorithm has first to be determined before these additional data requirements are defined. Since the hierarchical approach to treasury management decision-making is based on knowledge of the business logistics domain, logic suggests that the literature of business logistics be investigated with a view to finding a suitable algorithm that can be used in the new application. In fact, the literature investigation indicated that the MRP<sup>7</sup> netting algorithm is effective in supporting treasury management decisions defined in a hierarchical framework. Additional data requirements to support treasury management decisions with relevant costs on the basis of MRP netting calculation are derived.

***Step 4: Validation of the completeness of data provided by the contract data model***

Validation on completeness of the data provided by the contract data model has been evaluated by investigating whether the data requirements on decisions and the algorithm as outlined in Steps 2 and 3 can be fulfilled by data provided by the contract data model. Two treasury management decisions have been investigated in particular to understand whether the contract data model can indeed hold all required data to support this new and relevant application.

**Part 5: Conclusion**

The research objective of this research project is to propose a new accounting data model, capable of holding sufficient data for new and changing information needs. After some minor modifications, the proposed contract data model proved to be sufficiently complete to hold data to support a new representative application in the context of treasury management decision-making.

**1.7 Research Relevance**

This section discusses the scientific and practical relevance of the outcome of this research project. Scientific relevance of research projects concerns itself with determining to what extent fundamental insights are elaborated and new knowledge is acquired. Professional or practical relevance relates to the question of how relevant problems in practice can be solved or simplified on the basis of the conclusions of the research. The scientific and practical relevance is noted separately for the two research objectives.

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<sup>7</sup> 'MRP' stands for 'Material Requirements Planning'.

### 1.7.1 Scientific Relevance of the Research Questions

The scientific relevance of a research project relates to the new fundamental knowledge acquired that can be used and further elaborated in later research projects. The first research objective is 'To propose a data organization framework allowing the storage of *ex post* and *ex ante* accounting data on BPIs, suitable for supporting *changing* financial information requests defined by *different* users'. Previous research towards improved accounting data models is represented by the American School, predominantly the REA model, presented by McCarthy (1979, 1982) and the German School, namely 'Grundrechnung', data recording rules presented by Schmalenbach (1948) and later operationalized by Riebel (1994). These research projects resulted in the presentation of accounting data models that focused on the structure of *ex post* data only (under the REA model) or the definition of data recording rules only (following 'Grundrechnung'). Neither approach has led to data models suitable for accommodating data in real-life scenarios. The scientific relevance of this research objective is the definition of an accounting data model that can be used to provide data in real-life situations and that not only covers *ex post* data but also includes *ex ante* data.

The second research objective is 'To propose a framework of hierarchical treasury management decisions where *ex post* and *ex ante* accounting information is used for decision support in information systems'. Numerous research projects have long dealt with subjects in the fields of 'operations management of physical goods' and 'operations management decision-making'. Contributions can be found in domains like 'business logistics', 'physical distribution', 'management accounting', etc. However, this optimization question has not been investigated with respect to financial resources. Almost no research has been done on the topics of 'operations management of financial resource flows' and 'operational treasury management decision-making'. The scientific relevance of this research objective is that the operational treasury management decisions are redefined from a financial logistics perspective and supported with accounting data. Therefore, some new treasury management algorithms have been defined which are based on principles of business logistics.

### 1.7.2 Practical Relevance of the Research Questions

The practical relevance of a research subject relates to the extent to which the outcome of this research can be used in a professional context. Van Aken describes a 'professional' as '*a person from a well-described professional group who, with creativity and application skills, makes use of scientific knowledge when solving "value" problems*' (Van Aken 1994, borrowing from Freidson, 1973, Schön 1983). These 'value problems' are problems in the real world where the 'value' of those who have the problem has to be improved, this in contrast to 'knowledge' problems that can also be described as 'truth' problems.

The practical relevance of the outcome of the first research objective ('To propose a data organization framework allowing the storage of *ex post* and *ex ante* accounting data of BPIs, suitable for supporting *changing* financial information requests defined by *different* users') is the fact that system architects are now able to build more efficient and more complete information systems because an appropriate data organization methodology suitable as a data model for ERP systems, and allowing its deployment in large real-life customer implementations, is now available. In current information systems, the financial information is accommodated fragmentally and incompletely and is only reusable to a limited extent. The output of data models described so far in scientific literature did not allow for deployment in real-life customer situations.

The practical relevance of the outcome of the second research objective ('To propose a framework of hierarchical treasury management decisions where *ex post* and *ex ante* accounting information is used for decision support in information systems') can be defined at two levels. It has now been demonstrated to system architects how to implement treasury



management decisions supported by incremental and opportunity cost accounting data in information systems. At a later date, once these information systems have become available, it will be possible to explain to end-users (the treasurers) how they can optimize the treasury management decision-making process on the basis of relevant financial information. The latter question is not solved in this dissertation.

## 1.8 Outline of this dissertation

This dissertation comprises nine chapters:

*Chapter 1: Problem statement.* Argues that accounting data models as proposed in scientific literature (e.g. REA and ‘Grundrechnung’) are not used in ERP systems on the basis of literature analysis. This statement is illustrated by the analysis of the data model of a sample ERP system. This chapter also outlines the research objectives and questions, the research design used, and illustrates the scientific and practical relevance of this research.

*Chapter 2: Contracts as aspects of reality in designing the data model.* In keeping with recommendations made in earlier research, new accounting data models may not contain application artefacts and should be based on aspects of reality. An analysis of the recurring pattern in BPI data is therefore conducted in this chapter. Contracts are found to be the relevant aspect of reality and the contract data model is proposed as multipurpose, single data source. This chapter also outlines the functional requirements with which an accounting data model that can accommodate data to meet changing information needs of various types of end users should comply.

*Chapter 3: Design features of the contract data model.* This chapter contains a discussion of the fundamental information components of the contract data model. It illustrates how the various fundamental information components composing the definition of the contract data model all meet the relevant functional requirements of the multipurpose data model as defined in the previous chapter. Chapters 2 and 3 can be taken together as the scientific answer to the first research objective.

*Chapter 4: Object model of the contract data model.* The design of an object model for the implementation of the contract data model in information systems is described in this chapter. This chapter provides an answer for the ‘professional’ or practitioner to the first research objective.

*Chapter 5: Outline of hierarchical treasury management decision framework.* The validation of the contract data model as an improved accounting data model is accomplished by analysing whether sufficient data can be accommodated to service a new application. Supporting hierarchical treasury management decisions is chosen as the relevant application scope. The treasury management decisions, which compose the hierarchical treasury management decision framework, are outlined here.

*Chapter 6: Data availability requirements to service treasury management decisions with relevant costs.* In order to validate the suitability of the contract data model as a sole data source, the data availability requirements of the chosen application must be made explicit. For each of the treasury management decisions outlined in the previous chapter, this chapter investigates which data are required to service the decision with relevant cost information.

*Chapter 7: Algorithm to support treasury management decisions with relevant costs.* In this chapter, a suitable algorithm is provided to calculate and compare the financial impact for

each possible alternative to solve a treasury management decision in a particular situation in a generic way. The definition of this algorithm results in the definition of additional requirements on data availability. Chapters 5, 6 and 7 can be taken together as the scientific answer to the second research objective.

*Chapter 8: An information framework, defined as an extension of the contract data model, to service treasury management decisions.* This chapter concludes the validation of the contract data model as a data source to service changing information needs. The requirements defined in Chapters 6 and 7 are brought together here and whether the new requirements have already been incorporated in the object model of the contract data model as discussed in Chapter 4 is evaluated. An extension of the contract data model is described to incorporate the remaining requirements. This chapter offers an answer for the ‘professional’ or practitioner to the second research objective.

*Chapter 9: Conclusions in this research.* This chapter formulates conclusions and reflections on the two research objectives. Recommendations are made for future research.

