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Requirements Specification for Supply Chain Controlling - A Mini Case Study

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ABSTRACT

"If we spoke a different language, we would perceive a somewhat different world." (Wittgenstein)

Supply Chain Management (SCM) deals with the management of flows of goods, funds and information within and between supply chain partners in order to satisfy consumer needs in the most efficient way (Christopher, 1998). Information is one of the biggest drivers of supply chain performance. The concept of Supply Chain Controlling (SCC) aims at supporting SCM by providing accurate information to the right manager at the right time for supply chain wide optimal decision making. Consequently, information from different sources must be integrated in order to set up a supply-chain-wide decision support system (DSS). However, there is hardly any method available that provides guidelines for the requirements specification for SCC. We close this gap by combining a theory based on cybernetics with conceptual modeling and test it in a mini case study.

Keywords

Supply chain controlling, information management, data warehousing, decision support systems, cybernetics, conceptual modeling.

INTRODUCTION

SCM aims at optimizing the flow of goods, funds and especially information within and between supply chain partners from a global perspective. Information management in supply chains is extremely important as information is considered to be one of the biggest drivers of supply chain performance. Any organization needs information flows to coordinate and control its activities. In this paper, we focus on the information flows for coordination tasks of subunits within a supply chain. A supply chain consists of a number of information processing units that are either human beings or information systems. Supply Chain Controlling (SCC) aims at supporting SCM by structuring these information flows. In accordance to Seuring, we define SCC as decision-related provision of information, this includes the process of searching for information as well as its reporting, aggregation and distribution to managers (Seuring, 2006). For supply chain wide optimal decision making information must be integrated from all supply chain partners into a "data pool". Figure 1 shortly summarizes the links between SCM, SCC and data pool:

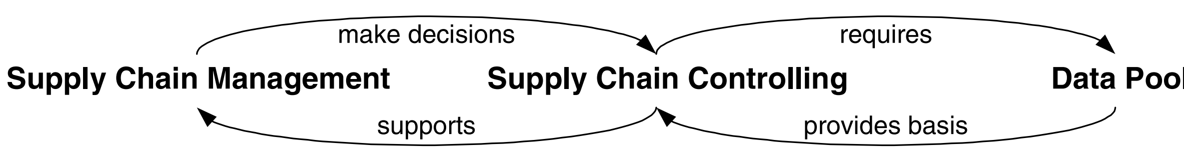

Figure 1. SCM, SCC and data pool for global decision making

Tailored reports and critical exceptions have to be defined and forwarded to the corresponding decision maker along the supply chain. Roles and functions along the supply chain must be clearly specified and reporting must be matched to the specific demands. It is important for the overall success of any supply chain to reduce the risk of misunderstandings while setting up the data pool for rationale decision making. However, it is known that information is prone to errors while it is being transferred from one person to another. A person who receives information might interpret it as it was not exactly meant by the person who gave it to him. These decoding errors lead to deviations between the sent and received message and result in unintentional actions. This is extremely relevant in supply chains, where people from even totally different organizations communicate with each other. Many problems in today's supply chains can be interpreted to be coordination problems (Otto, 2002).

From a theoretical stance each organization in the supply chain forms a separate language community. A consensus of meaning in interpreting events has to be ensured and participants have to agree on a common meaning system. It is strongly necessary that sender and receiver have a minimum set of jointly defined vocabulary in order to communicate effectively (Otto, 2002). By improving the quality of the content of the data pool the rationality of decisions is directly influenced. Guidelines are clearly required for this purpose. Based on the supply chain reality a model of the selected reality is created that forms the basis for later decision making (compare figure 2). A method is required to exactly specify the information flows along the supply chain and to reduce the risk of misunderstandings. Accurate information has to be integrated into a data pool (information gathering) and has to be provided at the right time to the right decision maker (information provision). A large variety of different methods for business process and data warehouse modeling are available, but none of them addresses especially this issue. Therefore we elaborate on an appropriate method to set up a common meaning system along supply chains.

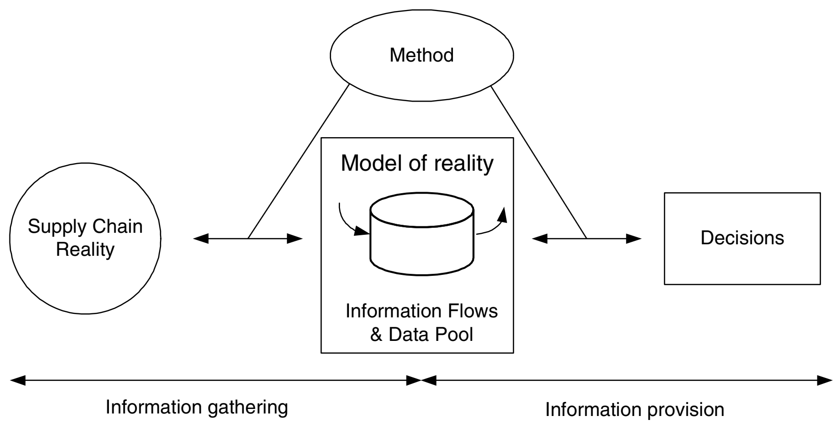

Figure 2. Process of information gathering and provision

The construction of such a company-spanning DSS's design method is motivated by Design Science and is clearly an IT artifact (Hevner et al., 2004). First, we present our research approach and exemplarily sketch the requirements specification process for SCC. Then we will discuss existing concepts for modeling supply chains and their shortcomings, before introducing the Viable System Model (VSM) as a promising theory. Originally developed by Beer (Beer, 1979, 1985), the theory has been applied in various management studies within single enterprises. We will combine this theory with conceptual modeling and present the results of a mini case study before we summarize our findings.

RESEARCH METHOD AND DESIGN

We assume that a real world is existent and independent of any individual cognition. Ontologically it is independent and prior to the existence and consciousness of any single human being. Therefore, our ontological position can be called objectivist or ontological realism. In a debate about rigor versus relevance Benbasat and Zmund discussed the practical relevance of IS research and that it frequently fails to produce output for practitioners (Benbasat and Zmud, 1999). This paper will therefore shortly present the results of a mini case study (Yin, 2003) in order to contribute to these calls. Our focus is on analyzing a specific phenomenon in a given supply chain in depths and not on comparing different supply chains. Language is the object under investigation. We argue that our approach is well suited for our research project, since we will elaborate on social aspects, communication issues and factors influencing how human beings interact with information systems and other human beings while integrating businesses and we aim at easing the communication on information flows in given supply chains in detail.

arvato services (part of the Bertelsmann group) is a world-wide supply chain management service provider and has more than 50,000 employees. In our business case arvato acts as a third party logistics service provider and specialist for the distribution of temperature controlled healthcare products. arvato has more than 15 years of experience in the healthcare market. The portfolio of services comprises multi-lingual order processing, warehousing and transport management, customer loyalty programmes, direct marketing, IT services as well as financial services. The author has been involved as an employee in the supply chain during the last three years and takes a role as a participating observer. The business case has been chosen because of its high complexity and the very specific requirements of the healthcare industry. We had full access to all operational processes, information systems, documents and reports. The observed facts were documented by him and verified by interviewing other involved employees along the supply chain. Furthermore, administrative documents (presentations, data models, reports, etc.) and field notes of the researchers formed the basis for developing the VSM that was discussed with other researchers for reflection. Guidelines to evaluate the design science approach (Hevner et al., 2004) have been applied (compare Table 3). The objective of the mini case study was to test if the VSM and conceptual modeling provide a suitable method to document information flows and requirements for the data pool in a real supply chain.

SCC – REQUIREMENTS SPECIFICATION PROCESS

Figure 3 exemplarily shows the requirements specification process for SCC. In our example a Supply Chain Manager and a Supply Chain Controller both work for a "Producer" - and three supply chain partners ("Order Management Company", "Third Party Logistics Provider", "Carrier"). The process starts with the Supply Chain Manager who wants to make rationale decisions for certain supply chain tasks. The Supply Chain Controller acts as an Information Manager for the Supply Chain Manager: She coordinates the information supply for existing tasks in the supply chain and should anticipate already future information demands and is responsible for carrying out the information demand analysis for decisions for the Supply Chain Manager (step 1), for coordinating the gathering of the required information from the supply chain partners (step 2), for integrating the collected information into the centralized data pool for SCC (step 3) and for providing the Supply Chain Manager the accurate information at the right time (step 4) (Otto 2002, p. 15). Obviously, misunderstandings between Supply Chain Manager and Supply Chain Controller are possible and have to be avoided to ensure rationale decision making. Moreover, the risk of misinterpretations of required information is always present while people communicate about the information required along the supply chain in a non-standardized way. Many information barriers have to be overcome, since business people from different organizations have to communicate with each other and even business and IT-people have to understand the exact information demand and extract the accurate information out of their local information systems. The complexity is very high in a supply chain since not only employees with different backgrounds (IT, business, sales, operations, etc.), but even company-spanning communication is required. Our paper aims at providing a suitable method to overcome these language barriers.

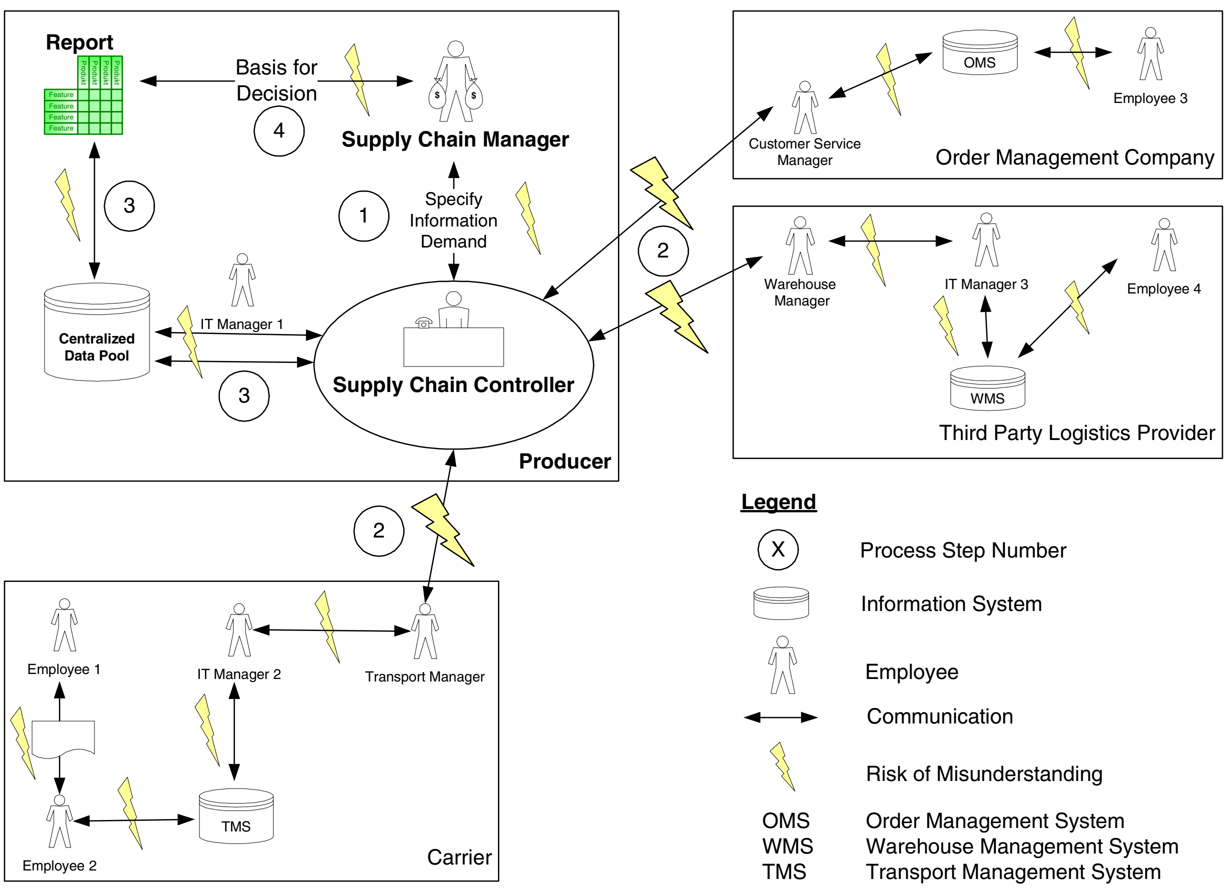

Figure 3. Exemplary requirements specification process for SCC

MODELLING INFORMATION FLOWS WITHIN SUPPLY CHAINS

While there are many different approaches for modeling business processes available, most of them rather focus on the analysis of business processes as sets of interrelated activities than on the explicit analysis of information flows in those processes (Kock and McQueen 1996, p. 16). For modeling operational processes Business Process Modeling (BPM) provide notations, methodologies and tools for analyzing and optimizing value chains. Value Chain Diagrams have a global view on operational processes and match each process step to the responsible supply chain partner. They can be analyzed in more detail by applying Event Driven Process Chains (EPCs). In this context, Kugeler discusses different notations for the documentation of inter-organizational processes (Becker et al. 2003). However, these concepts mainly focus on the flow of material and goods (Davis 2001, pp. 1-5). A sophisticated concept for the optimization of business processes within supply chains is the Supply Chain Operations Reference (SCOR) Model of the Supply Chain Council which includes standard inter-organizational business processes (SCC, 2006). But, the model is based on standard processes and it is not always feasible to introduce standard processes in already existing supply chains. To summarize, the business-process-oriented approaches mentioned before do not provide a suitable notation to analyze and design information flows for SCC with given supply chain processes.

From a data-oriented perspective there are different approaches available in order to set up tailored data pools. In the last few years many organizations have been developing data warehouses to support their decision making process. The business integration framework shown in figure 4 illustrates the different IT connecting points of partners in a supply chain from an operational and a management perspective. On an inter-organizational operational level, data is directly exchanged between participants in a standardized form. Enterprise Application Integration (EAI) is a concept for the integration of heterogeneous IS of supply chain partners using standards for data transmission. For decision making a local data warehouse for each partner in the supply chain provides the local DSS, a data warehouse on the inter-organizational level provides the perspective necessary for SCM and SCC from a global perspective. The latter is in the scope of our paper. The global data warehouse provides managers on an inter-organizational level with the information they require. Extraction, transformation, and loading tools (ETL) connect each On-Line Transactional Processing (OLTP) system to the corresponding data warehouse.

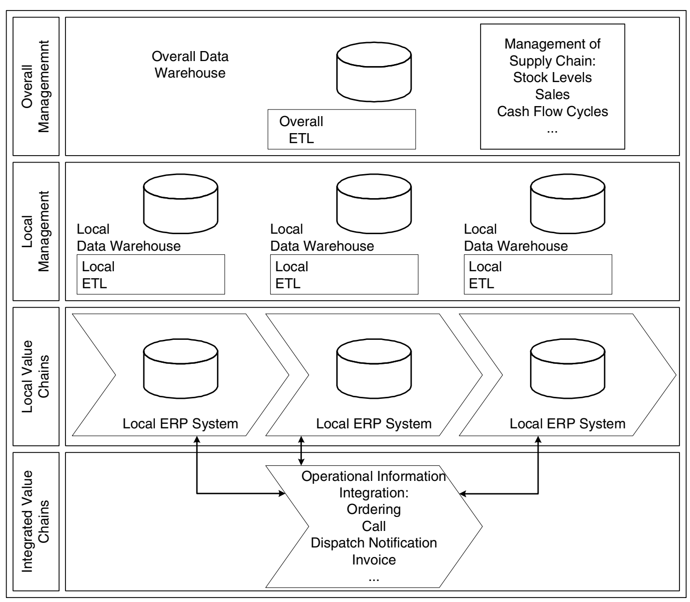

Figure 4. IT-architecture for business process integration (Holten 2003, p. 30)

One key role for the success of any data warehouse project is the design approach that is chosen. Traditional approaches suggest using entity relationship models (ERM) from OLTP systems as an appropriate starting point. These types of data warehouse development methodologies are called source-driven approaches (Inmon, 2002). Moody and Kortink start the design process by classifying the entities in the OLTP systems into three different types - transactional, event and measurement entities - before identifying hierarchies and producing dimensional models (Moody and Kortink, 2000). User-driven approaches, on the other hand, start with the specification of users' information needs. In 1995 Kimball introduced a very practice oriented iterative five-step approach, known in literature as dimensional modeling, which is in literature also known as the "star schema approach" (Kimball, 1996). Kimball stresses the need for and the importance of business requirements definitions by end-users (Kimball, 1996). Requirement elicitation should be oriented at the business functions executives need to carry out and the kind of decisions they make. Conceptual modeling approaches like MetaMIS provide a notation for modeling information demands of managers in non-technical terms (Holten et al., 2005) and are at the same time easily understandable by IT experts.

Summing up, business-process oriented approaches rather focus on the process itself than on the information required for decision making. On the other hand the data-oriented perspective on organizations is hardly understandable by business people as they are not familiar with ERMs (Kimball, 1996, p. 9). Furthermore, there is no real focus on tasks and decisions of the business perspective. User-driven approaches on the other hand provide a good starting point for the definition and analysis of information flows within organizations, but do not define roles and responsibilities. Also, they do not focus on overall information interconnections in the supply chain but rather focus on the content – the "what" - of certain information channels. In order to address the former we will now introduce the VSM and combine it with conceptual modeling (in our case MetaMIS) to present the content (the "what") of information channels. The VSM describes the minimum functional criteria by which a given organization can be said to be capable of independent existence (Beer, 1979, 1985). The theory is based on recursion: each sub-system needs the same structural composition as the whole system and each level of organization is a recursion of its super-system (Beer 1979, p. 68). The VSM consist of six main components (compare Table 1), or sub-systems, and a set of information channels between the sub-systems (Beer, 1985). We choose the VSM due to its explicit focus on information flows within organizations.

System	Description
System One	On each given recursive level, Operational Divisions are responsible for certain parts of an organization's activities. The divisions are each managed by a divisional Management Units. System One is formed by all Operational Divisions and divisional Management Units on one level of recursion.
System Two	Each System Two conducts a service function for System One (e. g. Finance, Human Resources, IT), and damps oscillations and disruptions that might occur between the divisions on an operational level.
System Three	System Three monitors all internal operational activities of all divisions from a higher point of view of the total system. It optimizes the allocation of resources, assigns them to the divisions and regularly checks the use of these resources. Standard reports belong to System Three.
System Three*	System Three* is the audit channel, which gives System Three direct access to the state of affairs in the operational activities. System Three can receive immediate information by using System Three*, instead of relying on information passed to it by divisional management.
System Four	System Four focuses on the diagnosis of the long-term connection of a viable system to its outside environment and its adaptation to future trends.
System Five	System Five embodies supreme values, rules and norms for the stabilization of the whole system.

Table 1. Components of the Viable System Model

MetaMIS (Holten et al., 2005) is a user-driven approach and includes an easily understandable, non-technical language to specify information demands. Originally, it aims at overcoming the communication problems between business and IT people in an organization. The approach starts with the definition of n *dimensions*, which span an n-dimensional *information space*. *Dimensions* are attributes that can be used to group or browse quantifying values, called measures. A *dimension* can contain one or more hierarchy levels, while each level comprises certain reference objects. If an identical set of objects can be aggregated in different ways, different dimensions have to be introduced and combined to a *dimension group*. The *leaf elements* of the *dimension group* are the same for all of the combined dimensions. *Dimension scopes* are used to tailor dimensions to the individual information needs of management by restricting the information space specified by dimensions. *Dimension scope combinations* are used to customize the information provided by limiting the drilling operations in order to avoid an information overflow. Depending on reference objects and their corresponding *dimensions*, *ratios* are determined that represent quantitative values. *Ratio systems* combine ratios for a certain business analysis purpose. *Information objects* are created by assigning one *dimension scope combination* to one *ratio system*. *Calculation expressions are used to to specify additional operations relevant for business management.* Figure 5 summarizes the MetaMIS symbols used to present the content of certain information channels. Please note that the MetaMIS notation can be transformed into data warehouse schemata, thereby bridging the gap between IT and business people.

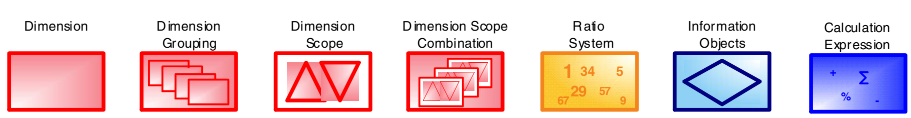

Figure 5. MetaMIS symbols

We argue that the VSM provides a well-suited approach for modeling information flows and the interactions through information channels between different organizational units (the "who"), MetaMIS can be perfectly used to highlight the content of these information channels (the "what"). By combining both approaches the shortcomings of each single and isolated approach can be overcome. Figure 6 gives an overview on the introduced concepts and method for modeling supply chains and maps them to the principles of SCM, SCC and data pool. The information view and the proposed method have already been included.

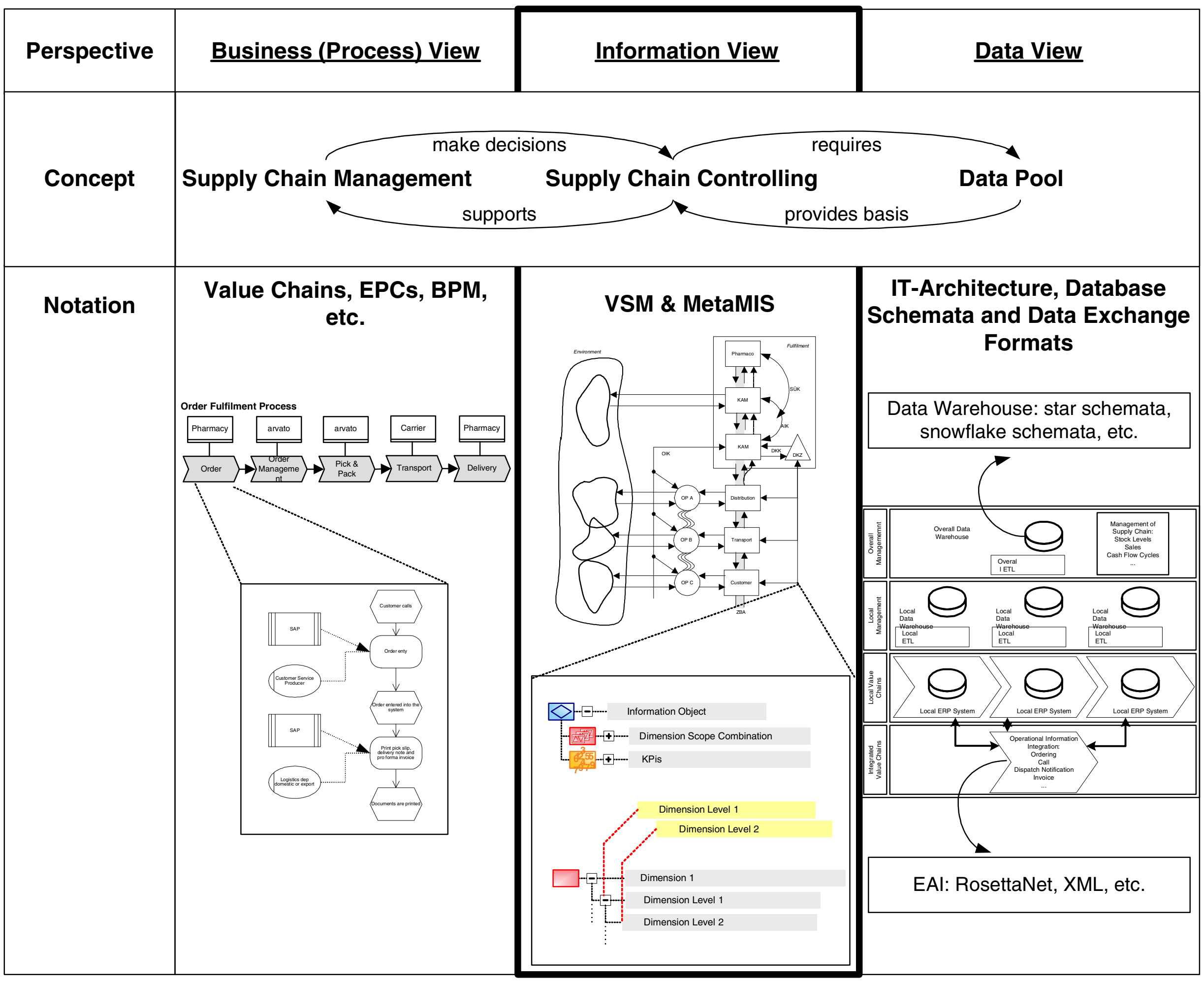

Figure 6. Overview on methods for integrating business-, information- and data-oriented perspective

MINI CASE STUDY EXTRACT

arvato acts as a third party logistics service provider and specialist for the distribution of temperature-controlled pharmaceuticals to pharmacies. Figure 7 gives a simplified overview on the process steps and parties involved from the production plant to the pharmacy. Pharmacies in Germany directly order specific drugs via mail, fax or telephone. The orders are transformed into delivery notes and picked and packed in the warehouse. Afterwards the deliveries are handed over to carriers that take care of the transport (mostly next day deliveries) from the warehouse to the ordering pharmacy. While the order management and all logistics processes within the warehouse are directly executed by arvato, the outbound transportation process is completed by specialized carriers managed by arvato.

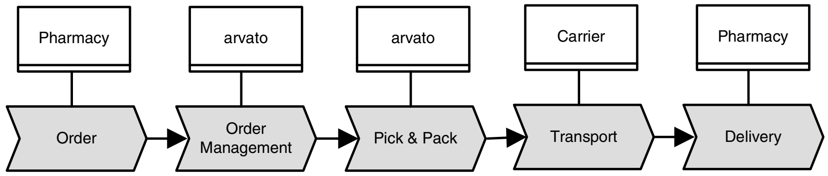

Figure 7. Exemplary order fulfilment process (Value Chain Diagram)

For our mini case we mapped the part of the order fulfilment process managed by arvato and described before to the VSM (compare Figure 8). We shortly sketch some of the most important systems and information channels in the VSM for the controlling activities carried out (compare table 2). There are three Operational Units (System A, B and C) presenting the three process steps (order management, pick & pack and transport, cf. Figure 7) that are managed by arvato. For each process step an employee at arvato (Customer Service Manager (CSM), Operation Manager (OM) and Transport Manager (TM)) is responsible for coordinating the activities. A Key Account Manager (KAM) is the overall process owner of the order fulfilment process and is the central contact for the pharmaceutical producer ("Customer1") and is interpreted in our case as the "Supply Chain Manager" of this specific process. The KAM reports to the Supply Chain Manager of the pharmaceutical producer who coordinates of the overall end-to-end-supply chain (production, replenishment, etc.).

System/ Channel	*Description*
System One	In accordance with the business process steps introduced before (cf. Figure 7), three Operational Units form System One: A) Order Management, B) Picking and Packing and C) Transport.
System Two	Weekly team meetings (System Two) between all local managers (Customer Service Manager, Operation Manager, and Transport Manager) together with the KAM (System Three) are carried out in order to solve and discuss locally non-solvable problems due to the daily operational interactions. The definition of standard key performance indicators and the "information management function" of the Supply Chain Controller belongs to this system, as information demand from the Supply Chain Manager (System Three) is specified and gathered from the "Systems 3" on the next recursion level.
System Three	The KAM at arvato is responsible for the order fulfilment process. He is the central communication point for the pharmaceutical company ("Customer1") who coordinates all internal activities at arvato.
System Three*	This channel is used by the KAM to carry out direct ad-hoc assessments within the Operational Units A, B and C. The KAM talks once per week with different employees in the Operational Units in order to assess the actual state of affairs without any filter.
Information Channel: Management Unit A, B, C > System 3	The OMS (Order Management System for Unit A), WMS (Warehouse Management System for Unit B) and TMS (Transport Management System for Unit C) provide the information required for SCC and the data pool for the order-fulfilment process. An example report is displayed in MetaMIS notation on the right site of figure 8 in MetaMIS. The KAM receives on a monthly basis a report including the following ratios (compare ratio system): number of orders received (OMS), shipped (WMS), picking errors (WMS), on-time deliveries and late deliveries (TMS) for the pharmaceutical company. The ratio system can be analyzed through different dimension scopes: a) per month or quarter or year, b) per article (even batch) for c) his specific customer ("customer 1"). All dimension scopes together form the dimension scope combination "Business Review". The information object (representing the entire report) is created in non-technical terms by assigning the ratio system to the specific dimension scope combination. The channel fulfils also a real-time function. In case of a crucial and/or not locally solvable deviation within one of the three Operational Units (Unit A, B, C), the KAM is directly informed by phone or mail (on basis of the OMS, WMS, TMS) by the responsible local manager (CSM, OM, TM) in order to intervene directly into the process and to coordinate appropriate actions.

Table 2. First recursion level of VSM of supply chain in focus

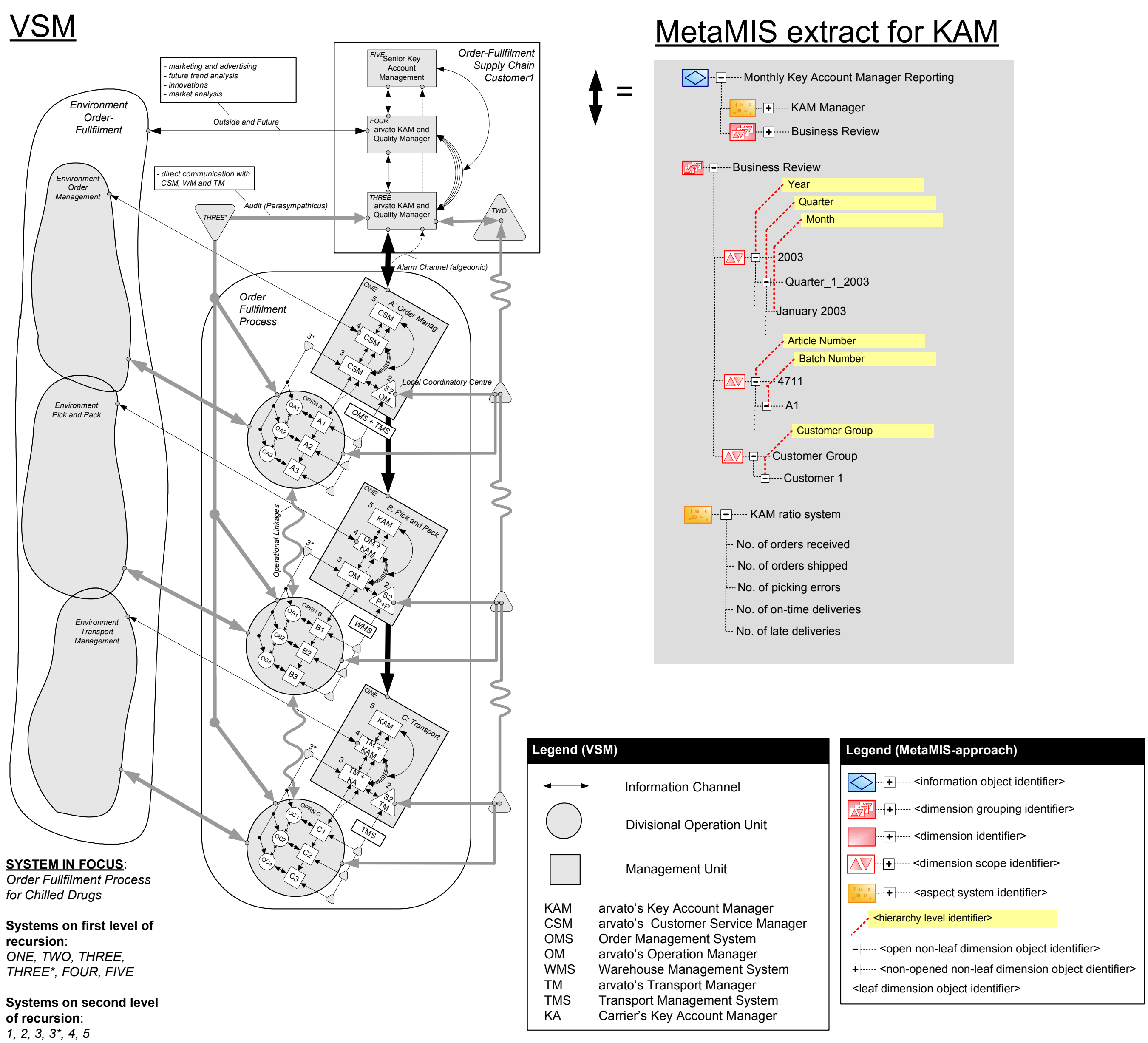

Figure 8. Exemplary VSM and conceptual models for KAM for the order fulfilment process

Please note that due to the predefined size of this paper it is not possible to include the next recursion level of the VSM or further MetaMIS examples.

CONCLUSION AND OUTLOOK

Thus far, hardly any method was available that enabled management to carry out a requirements specification for SCC. We combined the VSM with conceptual modeling to close this gap and present the application of the design science guidelines:

Guideline	Assessment
Design as an artifact	The contribution of our paper is the proposed and applied method for the requirements specification for SCC.
Problem relevance	SCC aims at supporting SCM, but there was a lack of existing methods to carry out a requirements specification for SCC in a structured way and to reduce the risk of misunderstandings (compare chapter 4).

Design evaluation	Functions and responsibilities have successfully been checked within an observational mini case study. It was possible to define the reporting requirements by mapping the information flows for the coordination of inter-organizational processes to the VSM and presenting the content of the information channel in a standardized form (MetaMIS). In our case the proposed method helped the KAM to understand the overall information flows and produced more transparency. He was able to specify his information demand and to communicate it via the method in a structured way to CS, OM and TM. It was possible to avoid unclear requirements and misunderstandings. The method was accurate for the requirements specification for SCC in our case.
Research contributions	The artifact is the proposed method for the structured requirements specification of a DSS in inter-organizational scenarios.
Research rigor	The VSM has been applied to a new setting (a supply chain scenario) and we showed that conceptual modeling and VSM can be combined to specify the information flows for SCC. Furthermore, the method has been tested successfully in a mini case study. Language communities within supply chains can be formed more easily by using a common notation while analyzing and defining information flows along supply chains. Last but not least an explicit information view perspective on supply chains has been introduced.
Design as a search process	The proposed method worked. However, based on our mini case study it became clear that the analysis of information flows can be improved. Important information on the type of information flows and frequency should be added to the VSM and roles and task descriptions should be structured in more detail. MetaMIS could be extended by including reports for real-time-events and some specific metadata (e.g. frequency and form of reporting, contact person, priority and format of report).
Communication of research	The paper addresses both technology- and management-oriented audiences by discussing business process- and data-oriented approaches for inter-organizational DSS design and links both worlds by explicitly introducing an information perspective for SCC. The proposed artifact aims at easing the communication between both audiences.

Table 3. Application of the design science research guidelines (Hevner et al., 2004)

The set-up of a company spanning data pool for rationale supply-chain-wide decision making is very complex. Like in all data warehousing projects misunderstandings between business and IT people have to be avoided. Additionally, misunderstandings between business and business people belonging to different organizations within the supply chain might occur. It is necessary to exactly define the expected information for supply chain wide decision making and to have a method to communicate and explain these requirements to business and IT people along the supply chain.

We argue that while from a technological perspective well-known concepts like data warehousing are available to integrate information systems, it is extremely important in supply chain scenarios that interaction of human beings and information systems for decision making must be supported by providing common methods to guide the communication on these requirements. The structured approach of the VSM and MetaMIS helped to close this gap between the purely business-process- and data-driven perspectives on supply chains (compare figure 6). In our business case it was possible to more quickly derive a common understanding between the supply chain partners and employees with totally different backgrounds due to the standardization of communication. The method helped to directly connect the business- and process-oriented perspective with the data-oriented perspective, documented the requirements in a neutral way and thereby reduced misunderstandings. While the content of an information channel was documented with the help of MetaMIS, the actors and required interactions were defined with the help of the VSM. From a data perspective MetaMIS provided the basis for the data warehouse schemata to be implemented, while the VSM documented organizational interactions (which employee receives when which report, etc.).

However, the VSM is in itself not easy to understand and more guidelines for practitioners are required. Even though the theory worked in our business case, no general validation of the theory is possible. Also the transferability of the approach to different scenarios has to be tested. The proposed approach is obviously just one possible approach for carrying out a requirements specification for SCC. Future research will aim at providing transformation schemata for the semi-automatically matching the business, information and data perspectives on supply chains. The effectiveness of the method could be evaluated by measuring the time spent because of misunderstandings leading to increased communication efforts and rework during implementation when not using a method. Another idea could be to compare the quality of decisions (and e.g. costs of non-optimal decisions) with and without using the method.

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