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Analysing Information Flows for Controlling Activities within Supply Chains: An Arvato (Bertelsmann) Business Case

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ANALYZING INFORMATION FLOWS FOR CONTROLLING ACTIVITIES WITHIN SUPPLY CHAINS - AN ARVATO (BERTELSMANN) BUSINESS CASE

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Abstract

Supply Chain Management (SCM) deals with the management of flows of goods, information and funds within and between supply chain partners in order to satisfy consumer needs in the most efficient way (Chopra & Meindl 2007, Christopher 1998). Along a supply chain, various decisions have to be made continuously, from the simple choice, which customer order to be processed next, to the serious question, whether to select a new supplier or to cancel an existing one (Fleischmann & Meyr 2003). All of these decisions are supported by the provision of relevant information. Therefore, the efficiency of a supply chain is strongly influenced by the accurate setup of information flows for decision support. Supply Chain Controlling (SCC) supports SCM by providing the right information at the right time to the right manager for rational decision making. However, there is hardly any methodology available in order to analyze and redesign information flows for controlling activities in supply chains in a structured way. Based on a business case - a pharmaceutical cold chain - managed by arvato, we show how the informational and organizational situation along a supply chain can be assessed by applying a theory originally grounded in cybernetics.

Keywords: Supply chain controlling, information management, information flows, modelling, organizational engineering, cybernetics, complexity.

1 INTRODUCTION

Today's supply chains are struggling with increasing complexity of products, structures and processes due to customer tailored products, technological innovations, global procurement and distribution, an increasing trend to outsource services and therefore a higher number of supply chain partners involved (Blecker et al. 2005). From an information-processing and systemic view a supply chain can be interpreted as an interwoven network of information flows that is established by the communication taking place between the single elements in the system (Galbraith 1977). One task of management is to design the communication within organizations in an effective way (Mintzberg 1976). Furthermore, the value of information sharing and especially the sharing of on-demand information along a supply chain is high and has been studied in depths (Lau & Lee 2000, p. 599, Lee et al. 2000). We argue that the adequate design of information channels within a supply chain is a crucial prerequisite for the long-term efficiency of any supply chain. One can distinguish between an operational and managerial level of information flows within supply chains. The former includes the information exchange between supply chain partners on an operational level for executing processes and focuses on integrating On-Line Transactional Processing systems on day-to-day basis. SCC belongs to the latter and focuses on decision-related information management within supply chains and entails the information management for repeating controlling tasks within supply chains. SCC aims at providing an accurate information pool for rational decision making along supply chains in order to support SCM (Otto 2002,

p. 7). Therefore, in accordance to Seuring, we define SCC as decision-related provision of information for SCM, i.e. the process of searching for information as well as its reporting, aggregation and distribution to managers (Seuring 2006, Jehle et al. 2002). Thus, from an information-oriented perspective, the concept SCC especially aims at fulfilling the information needs of all actors in the supply chain. SCC covers all controlling activities taking place on an inter- and intra-organizational level of a specific supply chain.

Depending on the time-frame of the corresponding controlling activities and the frequency with which they are conducted, we distinguish between the operational, tactical and strategic level of SCC (Seuring 2006, Laumann & Kolbe 2007). The *operational level* deals with process monitoring in real-time and provides information for day-to-day decisions. On a *tactical level*, general measures are controlled from once per month up to once per year. Long-term effects are examined on a *strategic level*. The evaluation of the overall supply chain performance can help partners to derive suggestions for improvement. Supply Chain Event Management (SCEM) is part of operational SCC and addresses a fundamental business problem: due to an environment prone to disturbance and failure, inter-organizational processes are rarely executed as planned and scheduled, which may influence the fulfilment of customer orders. “SCEM attempts to identify, as early as possible, the resulting deviations between the plan and its execution across the multitude of processes and actors in the supply chain to trigger corrective actions according to predefined rules” (Otto 2003, p. 1). According to Mintzberg, managing exceptions plays an important role in business and is considered one of the main tasks of a manager (Mintzberg 1971, Mintzberg 2001). Therefore, planned and actual values must be assessed for the processes of each hierarchical level. For each deviation between the plan and its execution, the process owners along the supply chain have to be informed. A prerequisite to manage these events is to acquire visibility of the operation and flow of information through information channels based on information systems and/or human actors.

Firstly, from a theoretical point of view, a methodology is required in order to successfully implement the concept of SCC. Secondly, from a practical perspective, the establishment of successfully working information channels is especially crucial for complex service solutions, e. g. distributing chilled pharmaceutical products. For example, global regulatory requirements concerning the handling of thermally labile pharmaceutical products outline the importance of assuring that the product’s quality and integrity are not compromised during the distribution process. The management and documentation of the relevant information in accordance with these guidelines must be guaranteed at all time, but can become highly complicated, because of the high number of supply chain partners involved. Therefore, also from a practical point of view, a methodology is required to model the information flows of the supply chain and to define interaction models (“whom to contact”) in case of deviations in order to intervene into the process and to guarantee product quality.

The construction of such a methodology as an IT artefact is motivated by Design Science (Hevner et al. 2004). The goal of Design Science research is utility. Here, utility lies in the vocabulary, symbols and concepts provided by the methodology. As a first step in a Design Science project, we look at the existing knowledge base and combine our search process with an application of an existing theory within a case study, thereby ensuring rigor. By analyzing a real life phenomenon, it is ensured that we deal with relevant questions. Our paper is structured in the following way: first, we will discuss existing concepts available for the analysis and modelling of information channels. We will then shortly introduce the Viable System Model (VSM), present our research approach and sketch the underlying business process. We apply the theory to our supply chain case from the pharmaceutical industry in order to test its usefulness for a methodology. Finally, we summarize our findings and future prospects for research are discussed.

2 MODELLING OF INFORMATION FLOWS IN SUPPLY CHAINS

Several different approaches for modelling a supply chain’s complexity exist in SCM (Blecker et al. 2005, p. 51). But none of these provides an explicit focus on the information flows for rational decision making in existing supply chains. Moreover, Kock and McQueen found that, paradoxically, most of business redesign practices focus on the analysis of business processes as sets of interrelated activities, and pay not enough attention to the analysis of information flows in those processes (Kock & McQueen 1996, p. 16, Kock 2001). However, rationale decision making is based on accurate information supply. We argue that more attention and explicit focus must be paid to designing information flows for controlling tasks along supply chains in order to clearly coordinate interactions in case of crucial deviation, to define escalation models and responsibilities and required information for specific tasks along the supply chain.

Most of today's data and information flow analysis notations rather focus on the activities and the business process itself than on the required information flows for decision making. While there are many different approaches for modelling processes, the explicit focus on the analysis and modelling of the information flow for decision support (interactions and content) in supply chains has not been addressed in depths yet (Kock 2003). On the one hand, traditional approaches for information system (IS) development are usually activity-flow-based and not information flow focused (Kock 2001). On the other hand, organization charts only show "who to blame if something goes wrong" (Beer 1979, p. 204). In this context, Business Process Modelling (BPM) tries to provides sophisticated notations, methodologies and tools for analyzing and optimizing value chains. These concepts have been applied successfully in many business scenarios. For example, company-spanning processes can be analyzed and optimized with the help of *Event-driven Process Chains* (EPCs). In this context, Kugeler discusses different notations for the documentation of inter-organizational processes (Becker et al. 2003). However, EPCs mainly focus on the flow of material and goods, while the information flow perspective within organizations is just *implicitly* included. As an extension to EPCs, the *Information Flow Model* introduced by Jost proposes a formal method for modelling information flows between functional areas or organizational units of industrial manufacturing enterprises (Jost 1993, pp. 112-123). However, the approach is mostly data-oriented, showing data interdependencies between processes. It does not include responsibilities and information needed for coordination of processes, which is especially important in supply chains. A promising concept for the optimization of business processes within supply chains is the *Supply Chain Operations Reference (SCOR) Model* of the Supply Chain Council which specifies standard inter-organizational business processes (SCC 2006). The SCOR Model contains measures for operational control and best practices of process design. But information flows are not specified until Level 3 (Hieber 2002). The SCOR processes also focus intensively on operational issues for a single enterprise within the supply chain and do not focus on the overall aspect from the perspective of the whole supply chain. Besides, what is missing are essential information for dealing with problems and exceptions, since explicit responsibilities and matching to resources are missing. In addition, as the SCOR Model is a reference model, its value to the analysis of an *existing* specific organization with unique business processes and an existing supply chain is questionable. To summarize, a methodology is required that enables the analysis of already existing supply chains. Although approaches such as EPCs or SCOR provide a good starting point, we argue that there is no suitable methodology for the explicit analysis and optimization of information flows for controlling tasks in already *existing* supply chains at hand.

In order to model the information channels of an organization and to provide a rigorous theory for backup of a methodological approach, we propose to apply the Viable System Model (VSM) developed by Stafford Beer. The VSM, according to Beer, specifies the minimum functional criteria by which a given organization (e. g. a supply chain) can be said to be capable of independent existence (Beer 1981, Beer 1979, Beer 1985). Theoretically, Beer grounds the VSM in cybernetics. The essential principle for structuring within the VSM is based on recursion: each sub-system needs the same structural composition as the whole system, each level of organization is a recursion of its super-system (Beer 1979, p. 68). A system is viable if it is able to maintain its configuration over some time. The VSM consist of six main components (cf. Table 1), or sub-systems, and a set of information channels between the sub-systems (Beer 1985, pp. 19-35). The VSM has been discussed in various applications in IS development in intra-organizational scenarios (e. g. Vidgen 1998, Kawalek & Wastell 1999). We choose the VSM due to its explicit focus on information flows (Mintzberg 1979, p. 37).

The VSM allows us the analysis and evaluation of a supply chain's information channels from an intra- and inter-organizational perspective with regard to different levels of recursion and specific functions, responsibilities and management requirements. The concept of SCM can be mapped to the VSM by interpreting all supply chain participants as the independent Management Units and Operational Units (System One) on the highest recursion level. The idea of SCM as a global optimization of the different supply chain participants fits to the tasks of System Two. In order to reduce the oscillations between the different business units (Systems One), System Two looks for an optimization of the entire system from a global supply chain perspective.

Component	Description
System One	On each given recursive level, Operational Divisions are responsible for certain parts of an organization's activities and have contact to the outside environment. The divisions are each managed by a divisional Management Unit. Together, they form an Elemental Organizational Unit. All Operational Divisions and divisional Management Units on one level of recursion together form System One.
System Two	Each System Two conducts a service function for System One (e. g. Finance, Human Resources or IT services), and serves to damp oscillation and disruptions that occur between the divisions on an operational level.
System Three	System Three supervises all internal operational activities of all divisions from the 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 operations. System Three can obtain immediate information by using System Three*, instead of relying on information passed by divisional management.
System Four	System Four deals with the diagnosis of the long-term connection of a viable system to its outside environment and its adaptation to future trends.
System Five	The ethos of the whole viable system is formed by System Five. It embodies supreme values, rules and norms for the stabilization of the whole system.
Information Channels	Information channels exist between all sub-systems. They are pairs of variety amplifiers and attenuators which need to be designed with respect to the Law of Requisite Variety.

Table 1. Components of the Viable System Model

3 A CASE IN SUPPLY CHAIN INFORMATION FLOW ANALYSIS

3.1 Research Methodology and Data Collection

Before developing a new methodology, in order to acquire an understanding of how information flows influence SCM, we must play part in the development and decision processes belonging to SCM (Lee 1991). Following this, we focused on how the information systems and information channels in SCM actually work in practice. In order to satisfy these objectives, we engaged into a case study (Yin 2003). The described case was documented by both authors. The first author is a manager at arvato and was involved in the supply chain during the last five years. He takes a role as a participating observer. The observed facts were documented by him and verified by interviewing other involved stakeholders of the supply chain. Furthermore, administrative documents (meeting protocols, presentations, data models, reports, etc.) and field notes of the researchers were collected in a case study diary. The diary served as the main source of data for the following interpretation, and was used to corroborate the presented facts. The other author was not involved in the project as an active participant but takes a role as a remote interviewer and review partner. The development of the VSM was the responsibility of the first author who interpreted the obtained data. The other author reflected on this interpretation and provided feedback and critique on the model. The objective was to test if the VSM provides a suitable explanation for the observed phenomena and could act as an underlying theory of a methodology for the analysis of information flows for SCC.

3.2 Case Description and Relevant Business Processes

arvato services healthcare (a company of the Bertelsmann group) acts as a third party logistics service provider for the distribution of temperature-controlled pharmaceuticals and medical products to pharmacies, hospitals, laboratories and wholesalers. The major requirements of the European Union Guidance on Good Distribution Practices (GDP) constitute that the quality system operated by distributors of medicinal products must ensure a permanent monitoring of the storage conditions. Furthermore, products which require controlled temperature storage must also be transported by appropriately specialized means. Therefore, arvato and all third parties involved have to guarantee the control of all logistics processes during distribution from the manufacturing plants to the end-customer.

Figure 1 gives a simplified overview on the process steps and parties involved for the order fulfilment process. While order management and all logistics processes within the warehouse are directly executed by arvato, the outbound transportation process is completed by specialized carriers. In order to continuously maintain product quality and integrity, companies must assure that chilled products do not leave their defined temperature range longer than specified. Either all processes in the warehouse are performed within a temperature-controlled environment, or for the duration a product is not cooled this period is continuously monitored and documented. The first alternative is no industry standard and regarded as too cost-intensive. The second alternative is feasible and efficient. Inside arvato's warehouse, consecutive processes are executed within different areas (from goods receipt to high rack storage, to replenishment storage, to picking area and goods dispatch area). Afterwards, the product is finally handed over to a carrier for the final dispatch to the end customer. The network infrastructure of these carriers enables an on-time-delivery within 24 to 48 hours within Europe. Next, we explain the business process in detail before mapping it to the VSM for an information flow analysis.

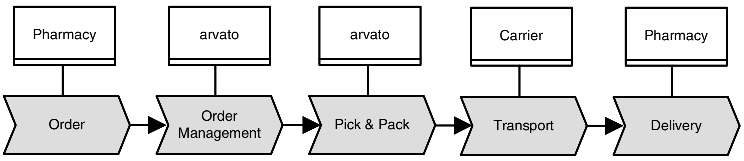

Figure 1. Exemplary Order Fulfilment Process (Value Chain Diagram)

The customer (e.g. a pharmacy) submits its orders electronically or via a call centre. All orders are aggregated in the order management system (OMS). On basis of the warehouse management system (WMS) batches and the required replenishment orders are automatically produced. These orders for the transfer from the buffer storage to the pick & pack area are printed out in the pick & pack area. By scanning the transport order, the corresponding location in the buffer stock area is displayed on the scanner. Quality is assured by scanning the barcode on the bin location in the buffer stock area (a non-equivocal storage location per article number and lot number in the WMS) and by confirming the quantity of products to be moved for each article of the transport order on the scanner. After having moved the products into the corresponding pick & pack area, the transport orders are scanned immediately and an internal countdown for storing the products at controlled ambient temperature is activated in the WMS. The transport orders for replenishment are confirmed and the pick slips and the delivery notes are produced automatically. Each document contains an unequivocal number in form of a barcode for later tracking and tracing. The upper part of the pick-slip already contains all the information required (barcodes with all routing information of the shipment for the carrier) for the labelling of the final shipment and is produced directly out of arvato's WMS. In order to ensure the product quality at all times, the time-frames have to be monitored and documented when the product is located at controlled ambient temperature. Therefore, every time a product is moved inside the warehouse, it is checked with the help of scanners and directly documented in the WMS. For applying real time monitoring, the temperature range of each area in the warehouse has been defined in the WMS. A picker in the warehouse scans the barcode on the pick slip and collects the corresponding products within the pick & pack area. The location of each product is automatically shown on the scanner. Each product is then scanned, the quantity is confirmed on the scanner and the articles are put into the corresponding cooling box. The quality and integrity of temperature-sensitive products during transport to the final customer is ensured by using a passive cooling solution (validated cool boxes containing cooling devices). A particular packing configuration (e. g. summer/winter) preserves a specified temperature for a limited duration (48 hours in our case). After having closed the parcel, the packer finally scans the shipper and thereby stops the countdown for storage at ambient temperature and activates the time-frame for the mandatory delivery within 48 hours.

All shipments are handed over to different carriers at predefined time-frames. In order to plan the transportation, all shipments are electronically assigned to the corresponding carrier in order to determine the number and size of required trucks. All shipping information of the corresponding carrier is directly printed out of arvato's WMS. The carriers scan all shipments while collecting them. Subsequently, the carriers' ISs send files of all the registered and scanned shipments directly to arvato's Transport Management System (TMS). The transportation is carried out by standard carriers that use trucks or vans and hubs without any cooling device. During transportation all shipments are scanned several times (e. g. after taking-over parcels, within receiving hub, airport, regional HUB, van, final delivery) before they are finally handed over to the customer. This status information per scan per shipment is directly integrated from the different carriers' systems into arvato's TMS.

3.3 Case Analysis – Mapping the Order Fulfilment Process to the VSM

In the following, we map the part of the order fulfilment process described before to the VSM (cf. Figure 2) and shortly sketch some of the most important VSM systems and information channels for controlling tasks carried out (cf. following tables). There are three Operational Units (System A, B and C) presenting the three process steps (order management, pick & pack and transport, cf. Figure 1) that are managed by different process owners. For each process step a manager (Customer Service Manager (CSM), Operation Manager (OM) and Transport Manager (TM)/ Carrier's Key Account Manager (KA)) is responsible for controlling the activity (cf. Figure 2). A central Key Account Manager (KAM) is the overall process owner of the order fulfilment process and serves as a central contact person for the pharmaceutical company ("Customer1"). The presented business case focuses on the information flows for controlling and interactions on an intra- and inter-organizational level in case of deviations. Different supply chain partners have been included as different management units (arvato, carriers: Systems 3) and on different recursion levels ("Customer1": System THREE on next recursion level) of the VSM (cf. Figure 2).

System/ Channel	Description
System ONE	In accordance with the business process steps introduced before (cf. Figure 1), three Operational Units form System ONE: A) Order Management, B) Picking and Packing and C) Transport.
System TWO	All job descriptions, standard operating procedures (SOPs) and the capacity planning for the three Systems ONE belong to this system. Weekly team meetings between all local managers (CSM, OM; TM/KA) 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 is also part of this system. Moreover, the IT department supports the KAM in case of IT problems and takes care of system extensions in close cooperation with the pharmaceutical company by communicating via the KAM.
System THREE	The KAM at arvato is responsible for the order fulfilment process. He is the central communication point for the pharmaceutical company ("Customer1") and coordinates all activities for the described order fulfilment process. In addition, the Quality Manager at arvato supports the KAM and is responsible for ensuring the correct implementation of the defined SOPs. The Oder Management System (OMS), WMS and TMS are also part of this system, since some actions are directly executed on basis of predefined rules in these information systems (blocking stock in case of cool chain interruptions).
System THREE*	This channel is used by the KAM and Quality Manager to carry out direct ad-hoc assess-

	ments of the business process within the Operational Units A, B and C.
System FOUR	The KAM analyzes future trends in the market and evaluates future possible business developments and service extension potentials for the pharmaceutical company. Strategic SCC is part of this System, since the KAM evaluates possible future suppliers (carriers) and or internal resources to improve this specific business process.
Information Channel: Management Unit A, B, C > System THREE	a) Tactical SCC: The OMS, WMS and TMS provide the information required for the entire order fulfilment process. The following standard reports are generated out of the information systems: + *no. of orders received (per type of transfer), + no. of incoming calls, + no. of answered calls, + average duration of call, + no. of products shipped, + no. of picking errors, + no. of on-time deliveries per carrier, + no. of delayed deliveries per carrier per months per region.* All these reports are used for mid-term controlling on a monthly basis. b) Operational SCC: the channel also fulfils a SCEM 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 underlying information system (OMS, WMS, TMS) or by the responsible local manager (CSM, OM, TM) in order to intervene directly into the process and to coordinate appropriate actions (e.g. to inform the pharmaceutical customer and Quality Manager about the deviation and to execute a recovery plan). This channel fulfils the function of SCEM, since crucial exceptions (cold chain interruptions, chilled warehouse alarm, etc.) are forwarded to the KAM. The KAM receives a daily exception report containing all the shipments where deviations occurred during transportation. This allows him to directly control the actions to be executed by the Transport Manager (System 3 of Unit C). By matching the order numbers from OMS, WMS and TMS, all orders and articles/lot numbers can be unequivocally tracked and traced from order taking to the final delivery. This is extremely crucial in case of a recall. Therefore, a report is available that shows the order status for all orders containing a certain article.

Table 2. First Recursion Level

System/ Channel	**Description**
System 3	The Customer Service Manager (CSM) is responsible for the proper handling of all orders and monitors daily operations. All orders are entered into the OMS. This part of the process starts with entering the orders into the OMS and ends with printing the delivery notes in the warehouse. The CSM has to ensure the proper electronic transfer of all orders.
System 2 ("S2 OM")	Weekly team meetings with the employees taking care of the OM for the pharmaceutical company are carried out. Theses meetings take place before the weekly team meetings on the next hierarchy level (System TWO), in order to collect the problems that have occurred during the last week and to discuss the relevant ones on the next hierarchy level.
Information Channel: Management Unit A1, A2, A3 > System 3	Operational and tactical SCC: On basis of a daily report, the CSM controls the process. The following reports for controlling the activities are available: + *no. of incoming calls,e-mails, facsimiles + number of answered calls, + no. of orders, + no. of faults per customer group (pharmacy, wholesaler) per day/ month.* In case of a deviation in daily operations (e. g. problems during execution of an order) the CSM is directly involved. If the CSM cannot solve the problem, he escalates the problem to the next hierarchy level to System Three (KAM) via the information channel (telephone, mail) between CSM (System 3 of Unit A) and KAM (System THREE). The channel is used for SCEM concerning customer services. The order number in the OMS provides all tracking information for this part of the process.

Table 3. Second Recursion Level, Unit A – Order Management

System/ Channel	**Description**
System 3	The Operations Manager (OM) manages and controls this part of the order fulfilment process. This part of the process starts with receiving the delivery notes in the warehouse and ends with handing the shipments over to the specific carrier.
System 2 ("S2 P+P")	Weekly meetings are carried out in order to discuss operational problems that do not have to be solved directly in daily operations and are not critical and urgent.
OB3	Packer 1 is responsible for the proper packing of the products (with chilled aggregates) of the shipments, labelling and the final goods-out scan.
B3	A final weight check is carried out in order to compare actual (+/- tolerance) and planned weight on basis of the geo-data in the WMS. Deviations are monitored and the shipment is

	automatically transferred to a different conveyor belt for manual check, if the tolerance is exceeded. The WMS itself is the Management Unit (System 3) on this recursion level.
Information Channel: B1, B2, B3 > System 3	Operational SCC: The following reports are generated automatically out of the WMS: *+ no. of filled orders, + no. of filled order lines, + no. of picking errors, + no. of shipments handed over to carrier, + number of products shipped per country per day.* The same report on a monthly basis is used for tactical SCC. The productivity (order lines shipped per day/ number of FTEs) is discussed on a daily basis. The location (and thereby the storage conditions), the period of time, the quantity per article number and lot number is monitored constantly within the WMS. In case of a predefined deviation (cf. next section for details) during the picking and packing process, the OM is directly informed in order to intervene. This SCEM report for Unit B will be presented in more detail in the next section. The unequivocal shipment number (WMS) provides all tracking information for this part of the process.

Table 4. Second Recursion Level, Unit B – Picking and Packing

System/ Channel	Description
System 3	After having handed over the shipment to the specific carrier the Transport Manager (TM) at arvato together with the Carrier's Key Account Manager (KA) are responsible for controlling the on-time delivery to the final customer.
System 2 ("S2 TM")	The TMS acts as System 2, because the very heterogeneous status information provided by the different carriers is standardized automatically in order to make the carriers' performance comparable and to reduce the overall complexity. The TMS thereby serves as an intermediate system and filter. By filtering information and forwarding only relevant exceptions the work-load for communication and analysis can be reduced. Weekly telephone calls with the assigned carriers are initiated in order to discuss the exception report in detail and to jointly define corrective actions.
C1, C2, C3	The TMS fulfils the management function for these process steps.
Information Channel: C1, C2, C3 > System 3	Operational and tactical SCC: The following reports are produced out of the TMS and support the TM to fulfil his System 3 function: *+ no. of shipments "on time", + no. of shipments 1.day-late, + no. of shipments 2-days-late , + type of exception per carrier per service per country per day/ per month.* Exception reports are generated and forwarded on a daily basis to the TM. The shipments are monitored in real-time during transport from the warehouse to the customer. Each scan is included in the carrier's system and directly forwarded to the TMS. Each shipment can be monitored (shipment number per location, point in time and status). Based on rules in the TMS, events (e.g. notification by mail or mobile phone message) are triggered in order to allow the TM / KA to intervene. Each shipment number in the WMS is an unequivocal assigned to one shipment number in the TMS to guarantee the tracking and tracing during transportation.

Table 5. Second Recursion Level, Unit C – Transport

We now shortly exemplarily sketch the exact content of an operational SCC report belonging to System 3 of Unit B (cf. Figure 2) that concerns a small piece of the overall process (cf. Table 4 (information channel) and Figure 3). As pointed out before, for each movement, the countdown for storing the products at ambient temperature is initiated, tracked and documented in the WMS with the help of scanners. Please note that this report is an intra-organizational report and has been included for simplicity reasons. However, as SCC includes the intra- and inter-organizational reporting along supply chains the report is also part of SCC for this specific supply chain. Furthermore, the required interactions between the supply chain partners are sketched in case of deviations in this area. The report is used to monitor the flow of products through the different temperature areas (storage conditions: controlled chilled and ambient temperature) in the warehouse. If a predefined time-frame for storing the chilled products at ambient temperature is exceeded (compare yellow (second) traffic light), an alarm is automatically initiated within the WMS. The OM is responsible for the pick and pack process (System 3 of Management Unit B, cf. Figure 2) and is automatically informed by a text message to his cell phone or/ and an e-mail (information channel from Operational Units B to the corresponding Management Unit B) generated by the WMS (representing together with the corresponding employee Management Units: B1, B2, B3).

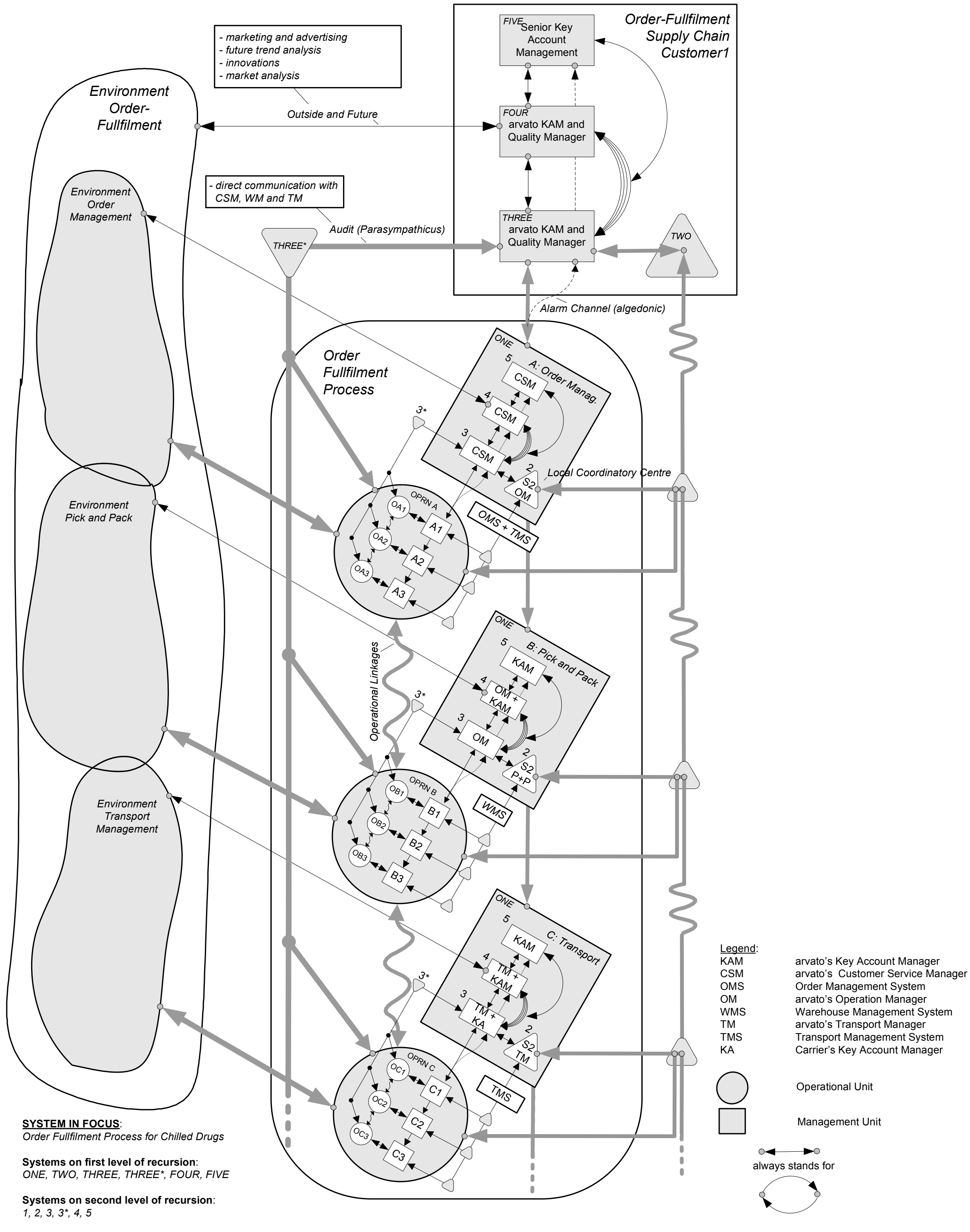

Figure 2. Exemplary VSM of the Order Fulfilment Process at arvato for "Customer1"

Additionally, a horn is activated in the picking and packing area in order to inform the employees about the deviation (information channel from Operational Unit B to Management Unit B). The OM can then intervene directly in the process and e.g. monitor the immediate re-allocation of the products back into the chilled buffer stock area. In case of a critical interruption, an exception is automatically created in the WMS (cf. red (third) light in Figure 3). The status of these products is directly changed to “blocked” within the WMS (automated decision of WMS (System 3)). The KAM at arvato (representing System THREE on the highest hierarchy level) is informed automatically via an e-mail (information channel between System 3 and System THREE) on basis of the WMS. The KAM has to inform the SC-Manager and Quality Manager at the pharmaceutical company (System Three on next higher hierarchy level) immediately. At the same time the Quality Manager (System THREE) coordinates the physically allocation of the products into quarantine stock (internal action via execution channel to Management Unit B) with the OM. Summing up, with the help of the WMS it is possible to document where the products have been located, at what temperature for how long during storage and transportation within the warehouse. The report generated on basis of the WMS belong to operational SCC and fulfils a System 3 and THREE function within this specific VSM, since it focuses on day to day business. The information for operational SCC (SCEM) is provided by the information channels between the Management Units (B1, B2, B3) and System 3 (OM) within Unit B and the information channel between System 3 (OM) and System THREE (KAM and Quality Manager).

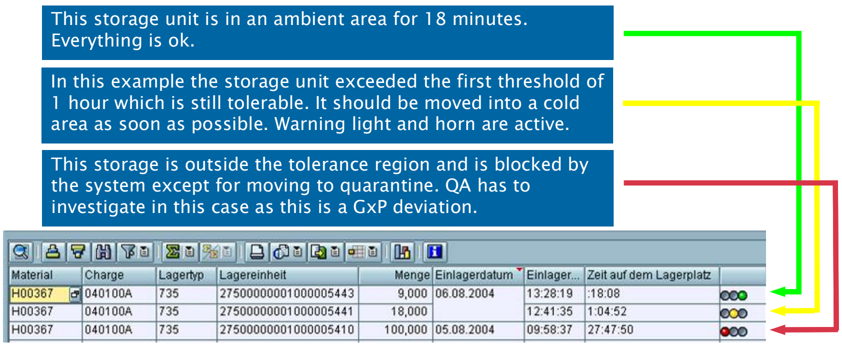

Figure 3. Example Report for Monitoring Picking and Packing within the Warehouse

3.4 Discussion and Evaluation

The VSM helped us to analyze the information flows for controlling activities of a specific business process within a complex supply chain. With the help of the VSM, it becomes possible to document and understand the information management along the supply chain in more detail and provide more transparency on deviations and controlling activities to all participants (pharmaceutical company, arvato, and carriers). Functions and responsibilities have been analyzed and checked successfully along the exemplarily mapped business process, and interfaces between process steps have clearly been defined. The VSM thereby serves as a roadmap in order to reduce the overall number of critical deviations thereby ensuring product integrity along the supply chain. For operational SCC the handling of exceptions is extremely important while distributing chilled pharmaceutical products. As showed before, operational SCC (SCEM) includes the information channels transferring real-time information from the Management Units to System THREE in the VSM. Therefore, the VSM and descriptions provide an important perspective on the critical process steps and clearly highlight which employee is responsible for which part of the process and who to contact along the supply chain in case of any deviation. It was possible to identify bottlenecks with the help of the approach and to setup emergency plans for certain exceptions. Obviously, it is not possible to plan every exception beforehand. By providing transparency on the overall interactions and information flows, the manual and unforeseen exception handling can also be improved, since the VSM helps to better understand the overall interactions along the supply chain. Also, by defining clear rules for communication (especially escalations) not every exception has to be communicated up the hierarchy (e.g. to the KAM or pharmaceutical company) thereby avoiding an information overload and leading to a higher efficiency in communicating. On a tactical level it was possible to analyze mid-term reporting for controlling activities in a structured way. As shown with the help of the VSM, all channels between Systems ONE and System THREE on all recursion levels include standard reports for business process management. Strategic

SCC can be interpreted as System 4 or FOUR within the VSM, since this system focuses on the future of the organization in scope and aims at evaluating and choosing the right carriers and internal resources for the future. Summing up, we argue that the VSM fits well to the concept of SCC.

The proposed theory helped to analyze the information flows in a *given* supply chain in a structured way, produced more transparency on the critical processes, revealed missing responsibilities and information flows, clarified interactions in case of deviations and provides the missing and more explicit focus on the information flows for controlling activities of the underlying business process. By defining and discussing the information flows and KPIs on an inter-organizational level the overall interactions on the supply chain were made more transparent to all participants.

4 CONCLUSIONS AND OUTLOOK

Thus far, hardly any methodology was available that enabled management to analyze the *information flows for decision support within given supply chains in a structured way*. Based on a real case scenario at arvato, we introduced the business processes for critical cool chain distribution. The VSM provides guidelines for structuring the analysis of existing information channels, to identify possible bottlenecks and to provide more transparency on responsibilities and process owners. We matched the concept of SCC successfully to the VSM which provides a theoretically grounded approach for the analysis of information channels for controlling in *already existing supply chains*. The focus within the VSM is explicitly on the information flows for decision support and helps to highlight the interactions of the different partners. During our case it became very clear that the integration of ISs is crucial for successful company-spanning SCC.

Although bottlenecks and escalation schemes in case of deviations have been documented in a structured way by applying the approach, the VSM is just one possible approach that worked out in our specific business case. With the help of our business case possible future extensions of the theory have been identified: A more detailed and structured analysis of the content of certain information flows should be included. Important information on the type of information exchange (e.g. mail, telephone), the source (information system, human being), frequency and clear structure for deviations should be included. Future research will therefore look into combining VSM (with a focus on roles and interactions) with conceptual modelling (for presenting the content of information channels). Summing up, the approach itself served as a communication tool and helped to derive a joint and common understanding on the tasks, roles, information flows for controlling and interactions along the supply chain.

In the end, SCC will only work if all employees involved act in accordance with organizational guidelines. Rules like e.g. scanning each product movement have to be trained and respected by employees. The best information management approach will fail if people do not act in accordance with these rules. The VSM does not provide any guidelines on how to deal with these issues and is in itself not easy to understand. Therefore, more specific guidelines for practitioners are required. Even though the theory worked in our business case, no general validation of the theory is possible. The introduced business case is based on the very special requirements of this case, and transferability to other industries and supply chains has to be tested. Future research will aim at extending the VSM, providing more guidelines for practitioners and testing the knowledge gathered from this case study in other supply chains.

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