Service-oriented Supply Chain Event Management – A Case Study from the Fashion Industry

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Abstract: Service-oriented architectures (SOA) are spreading in many organizations and aim at enhancing efficiency, agility, and productivity of business processes. Standardization and modularity enable the networking of application-based business functionalities especially in inter-organizational settings. This research analyzes the potentials of SOA in the domain of supply chain management (SCM), in particular supply chain event management (SCEM). Among the findings is that SCEM applications focus on specific functionalities and that integration of multiple application is required to support the entire SCEM process. Based on a systematic methodology, the key services required for SCEM are identified also using a case study from the fashion industry.

1 Introduction

Due to its globalized supply chain structures, a large variety in SKU[1]s, short product life cycles, the necessity to react quickly to customer demands as well as volatile business relationships, the fashion industry belongs to one of the most challenging application areas for supply chain management [Bru03, p. 2 ff.; Tro08, p. 22]. One possible concept that has been suggested to cope with this logistical complexity is SCEM. In recent years, various authors like [Wie01; Nis02; Ott03; Bod05; Heu06; Liu07; Mue09] have analyzed the concept of SCEM from different perspectives such as benefits, goals, definition, functionality, modelling, application, need, configuration, and architecture. This research paper was motivated by two hypotheses:

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[1]   SKU (Stock Keeping Unit). In terms of the fashion industry a unique combination of article/ style/ colour/ size.

(A) To date, there has been no contribution addressing SOA in the context of SCEM (though [Spe04] go into the application of web services in general). Due to its flexibility and efficiency, SOA probably is more appropriate than current SCEM architectures.

(B) SOA requires the link to application domains, i. e. services need to be specific to business processes and industries as "… each service is assigned its own functional context and is comprised of a set of capabilities related to this context." [Erl08, p. 39] Thus, a contribution about service-orientation in the area of SCEM in a specific industry seems appropriate.

The remainder of this paper is structured as follows: Chapter 2 provides an overview of SCEM and SOA as well as presents both research questions and methodology. Chapter 3 comprises a survey of current SCEM architectures regarding their functional coverage and component distribution. Chapter 4 starts with the introduction of a systematic service identification methodology, which then is applied to the definition of SCEM-related services using the example of the fashion industry. Based on that, their distribution as well as potential users and providers are discussed. The paper closes with a summary and an outlook on future research issues.

2 Basic Concepts and Research Outline

2.1 Supply Chain Event Management

Supply chain management (SCM) aims at improving the allocation, management and control of logistic resources. One key concept within SCM is SCEM which may be characterized as an approach to achieve inter-organizational visibility over logistical processes enabling companies to detect critical exceptions in their supply chains in time. Thus, measures against those "events" can be taken proactively before they have negative impact on given business plans [Nis02, p. 477; Heu06, p. 19].

Most authors agree on the perception that SCEM encompasses five core functionalities (see Figure 1) [Wie01, p. 66; Heu06 p. 22 ff.; Bod05, p. 58, e. g.], which are illustrated by means of the following example: *(1) Monitor:* Evaluating process tracking data, a delay in material delivery with a manufacturer is detected. *(2) Notify:* This information, along with context data, is reported to the process owner (procurement manager, e. g.). *(3) Simulate:* For decision support, the process owner is provided with an indication of the impact (estimated missed deadline, e. g.) as well as available action alternatives (place order with another supplier; change mode of transportation, e. g.) to handle the delay. *(4) Control:* Having chosen one of the options, the process owner is supported in accomplishing it (place/ change/ cancel material or transfer order, respectively). *(5) Measure:* The last function bridges the gap between SCEM and SCM by analyzing all gathered data (number/ time/ locality of event occurrences, chosen action alternatives, e. g.), thus enabling companies to identify certain patterns related to the causes of events (e. g., supply chain bottlenecks) in order to optimize their supply chain structures.
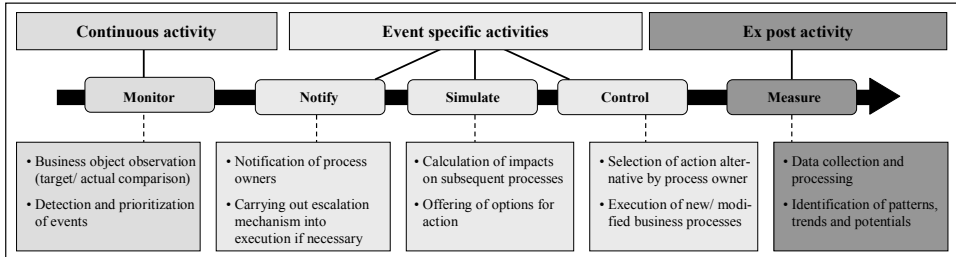
Continuous activity	Event specific activities			Ex post activity
Monitor	**Notify**	**Simulate**	**Control**	**Measure**
• Business object observation (target/ actual comparison) • Detection and prioritization of events	• Notification of process owners • Carrying out escalation mechanism into execution if necessary	• Calculation of impacts on subsequent processes • Offering of options for action	• Selection of action alternative by process owner • Execution of new/ modified business processes	• Data collection and processing • Identification of patterns, trends and potentials

Figure 1: Functionalities of Supply Chain Event Management

2.2 Elements of Service-oriented Architectures

According to [Erl08, p. 39], SOA is based on the design paradigm of service-orientation, which comprises a specific set of design principles, whereas the most fundamental unit of service-oriented solution logic is the service. Furthermore, SOA "… establishes an architectural model that aims to enhance the efficiency, agility, and productivity of an enterprise by positioning services as the primary means through which solution logic is represented in support of the realization of strategic goals associated with service-oriented computing." [Erl08, p.38] As stated by [Alt09, p. 106], the three major elements of any SOA are services, service repository, and (enterprise) service bus.

(a) Services: Services can be characterized as well-defined, self-contained, and reusable modules providing specific functionalities which are independently deployable and have a standardized interface. According to [Pap07, p. 390], the most popular type of services available are those utilizing web service standards, i. e. Web Service Description Language (WSDL), Simple Object Access Protocol (SOAP), and Universal Description, Discovery and Integration (UDDI). [Koh09] differentiate business-, application-, and IT-services, whereas the first "represent functionality of a specific business activity and transaction (…) [, the second] independently usable and elaborately specified components (…) [whereas the last stand for] encapsulate[d] technical capabilities independent of any business domain" [Koh09, p. 204]. An alternative taxonomy is provided by [Pap07, p. 406] who distinguish basic, composite, and managed services.

(b) Service repositories and directories: A service repository mainly comprises the technical information about the service (e. g. its address and WSDL description) and "… acts as the central modelling and design environment" [Alt10, p. 5]. Service directories (or registries) "… allow service providers to register new services and service consumers to search for and locate services (…) [in order to] match buyers and sellers, to facilitate transactions and to provide the institutional infrastructure for business." [Leg09, p. 70] According to [Alt10, p. 4] two directions can be reported from research on SOA projects in practice: maintaining and establishing individual service repositories as well as utilizing inter-organizational service directories.

(c) Enterprise Service Bus (ESB): An ESB "… is an open, standards-based message bus designed to enable the implementation, deployment, and management of SOA based applications." [Alt10, p. 3] It can also be termed as the integration platform for a SOA as

it is designed "… to provide interoperability between large-grained application and other components via standards-based adapters and interfaces." [Pap07, p. 393] Well-known providers of ESB solutions are *Sun Microsystems* ("Open ESB"), *IBM* ("WebSphere Enterprise Service Bus"), *Microsoft* ("Biztalk Server"), and *Oracle* ("Oracle ESB"), respectively.

2.3 Research Questions and Methodology

In conjunction with the above hypotheses, the following research questions (RQ) were set up:

> RQ1: Which SCEM-related functionalities are included in current SCEM architectures?

> RQ2: How can SCEM-related functional requirements be defined as services?

> RQ3: How can SCEM-related services be distributed in a fashion industry network?

For answering the above research questions a literature analysis along with a case study approach was undertaken. Case studies are the appropriate strategy when "how" and "why" research questions are given priority, "… and when the focus is on a contemporary phenomenon within some real-life context." [YIN84, p. 13] For our purpose, a holistic multi-case study in the fashion industry with seven German fashion companies was conducted, whereas small (Maerz Muenchen, René Lezard, Van laack), medium (Gardeur, Seidensticker) as well as large (Galeria Kaufhof, Gerry Weber) enterprises have been included in order to achieve a characteristic, though not representative sample.

3 SCEM Architectures to Date

3.1 Functional Coverage

In the course of the literature research seven authors were identified who have dealt with possible SCEM architectures by now. Four of them regard SCEM and its corresponding functions as introduced in chapter 2 [Wie01; Nis02; Bod05; Kur05]. The dissenting opinions of the remaining authors can be explained as follows: [Ott03] contemplates SCEM out of three perspectives (as a management concept, software solution, and software component). [Spe04] term their approach "disruption management and controlling", though it follows the same idea as SCEM. Finally, [Tri09] just refer to EPCIS[2]-related architectural components.

The left side of Table 1 shows the coverage of SCEM-specific functionalities. A filled circle indicates that the architecture explicitly addresses the respective functionality,

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[2]   EPCIS (Electronic Product Code Information Services)

whereas an empty circle signifies that it is either not addressed or not specified. Interestingly, even though (mostly) naming all SCEM-specific functionalities in their contributions, none of the authors actually consider all five functions in their proposed architectures. For instance, [Nis02, p. 478] claims that monitoring and notifying represent the most innovative elements of SCEM while referring to existing SCM planning tools and data warehouse solutions which were already capable of covering the three remaining functionalities. A similar view can also be found in the contribution of [Kur05, p. 23]. Regarding RQ1, available SCEM architectures do not cover SCEM-related functions to 100%. In most cases, they just focus on *monitor*, *notify*, and *measure*, which probably is due to the fact that the latter are less innovative as they are realizable through various and already available means. With regard to *simulate* and *control*, the analysis discloses a research gap. SOA could be the way to close this gap by providing the missing functionalities through utilizing (external) services.

3.2 Components and their Distribution

The following architectural components were named repeatedly by the above authors in support of the functional range of SCEM: Enterprise resource planning (ERP) systems, advanced planning systems, tracking & tracing (T&T) systems, sensor systems, transport management systems (TMS), EPCIS repositories, web server/ clients, short message service (SMS) server/ clients, e-mail server/ clients, data bases, and data warehouses. However, the central component of SCEM systems is the "SCEM Engine" [Wie02, p. 66; Nis02, p. 478; Ott03, p. 9], which itself consists of several sub-components: an *event processor* for input data analysis (matching with predefined event profiles, e. g.), a *rule processor* for triggering activities based on assigned rules, an *alert manager* for communicating with process owners and applications and a *configurator* for defining and maintaining event profiles and rules (if-then-else statements, e. g.).

Authors	Focus	Coverage of SCEM functionalities (●...yes, ○...no/ n. s.)					Distribution of architectural components (l...local, c...central)					
		Monitor	Notify	Simulate	Control	Measure	SCEM Engine	Monitor	Notify	Simulate	Control	Measure
[Wie01]	SCEM with mySAP SCM	●	○	○	○	○	1	1	-	-	-	-
[Nis02]	Conceptual introduction to SCEM	●	●	○	○	●	1	l/c	l/c	-	-	1
[Ott03]	SCEM as management concept, software solution and component	●	●	○	○	●	1	l/c	l/c	-	-	1
[Spe04]	Disruption management with web services	●	●	●	○	●	1	l/c	l/c	l/c	-	1
[Bod05]	Proactive SCEM with agents	●	●	○	○	○	1	l/c	l/c	-	-	-
[Kur05]	SCEM with mobile/ agent technology	●	●	○	○	○	1	l/c	l/c	-	-	-
[Tri09]	EPCIS-based SCEM system architecture comparison	●	○	○	○	○	1	l/c	-	-	-	-

Table 1: Evaluation of existing SCEM architectures

The findings concerning the distribution of the aforementioned components are as follows: In case of the SCEM Engine as well as the components enabling the *measure* function, the respective authors indicate a local implementation by common consent. As for the components regarding *monitor* and *notify* almost all authors see both local and centralized components fit to accomplish the required processes. With regard to *simulate* and *control*, none of them but [Spe04], who makes use of local as well as centralized components for the *simulate* function, explicitly suggest any components. Thus, no conclusion regarding their distribution can be made. The results are shown in detail in the right columns of Table 1.

4 Identification and Distribution of SCEM-related Services

Generally, in a SOA environment, the function of the *SCEM Engine* instead of being part of a monolithic SCEM application (see chapter 3.2) can be covered by the ESB (see chapter 2.2), which invokes the SCEM-related services defined in the following. This requires the transformation of event profiles and corresponding rules into conditions and workflows which are defined and maintained through the ESB user interface.

4.1 Service Identification Framework

For the definition of SCEM-related services, the service identification framework by [Alt09/ Koh09] was used, which in turn is based on the Business Engineering approach by [Oes95]. It pursues a "… hybrid service design capturing business-oriented and technical-driven service identification" [Koh09, p. 203] as neither technical-driven (bottom-up) nor business-driven (top-down) service modeling is sufficient on its own. Service identification according to the top-down approach "…is based upon business processes or business events while applying wide-spread design principles of SOA (…) [whereas] bottom-up refers to service modeling based upon the analysis of existing applications and their IS functionality (…) focusing on consolidating and rationalizing access to IS functionality by using services." [Koh09, p. 204] To answer RQ2, the framework was adapted as follows:

(1) Analysis of supply networks of the fashion industry, encompassing their business models, structures, major processes, roles, and dependencies.

(2) Identification of required SCEM-related functionalities and – based on that – corresponding services (in identifiying conponents that can encapsulate those functionalities as services or by refering to already available services) [chapter 4.2].

(3) Determination of potential service providers and users, including the actual or presumable origin and level of standardization of the concerned services [chapter 4.3].

Regarding step (1), research findings by [Bru03] were utilized, who – based on an empirical study – identified four supply chain types for the apparel industry [Bru03, p. 36 ff.].

4.2 SCEM-related Services

As a basis for defining SCEM-related key services (listed in the left column of Table 2), the ten supply chain incidents most frequently mentioned by the case study companies were applied: short-term change in design, delay in lab dip process, capacity constraint, machine breakdown, sudden employee leave, force majeure (thunderstorm, earthquake, e. g.), too late arrival of fabrics/ trimmings, missing customs documents, lost of maritime container, and traffic jam.

Monitoring: As for input data, the following sources were considered to be appropriate for the above mentioned events: T&T data (provided, for instance, by DHL's service *TrackIT*); EPCIS data retrievable from EPCIS repositories "…which are hosted at each supply chain participant (…) [and provide] web services (…) that can be accessed to retrieve the EPC-related data" [Tri09, p. 494]; intra- and inter-company process tracking data which either can be made available via proprietary query services (as most of the case study companies accomplish that with excel-based workflow applications), via services provided by ERP systems (*SAP*, e. g.), or via web-based platforms (*OSCA*, *TXTCHAIN*, e. g.). For target/actual comparison, target data (ideally, object identity, place, time, quantity, and costs as they correspond to the 5 "R's" of Logistics) is to be retrieved from the business objects (i. e., production/ transfer/ customer order; schedules) stored in ERP systems, TMS or local data bases. Since some events like force majeure and strikes cannot be perceived by the aforementioned means, it is advisable to integrate services like *Metro Monitor* or *Google alerts* supplying news data about severe incidents in relevant countries (exceptional weather, traffic, or political conditions), too.

Notification: As soon as an incident has been detected the process owner is to be determined. This, for instance, can be accomplished by a service querying an authorisation directory. For alerting the person in charge, all communication media in use with the organization shall be supported. Relating to the case study companies, e-mail and SMS (for mobile phones without e-mail functionality) were named as communication media to be supported. Since firms usually operate their own e-mail server, they can specify company-specific e-mail services. As for SMS alerts, numerous web service offers (*top concepts* or *StrikeIron,* e. g.) are available. One way to realize an escalation mechanism could be in composing a service that checks if a person in question is in office (by querying the time management database for clock in/ out data, e. g.) with services that query the contact data of representatives and forward the alert message.

Simulation: As for the evaluation of impacts on subsequent processes, an indication about the extent to which due dates (customer delivery date, e. g.) are at risk was considered to be sufficient by the case study companies. To this end, services can be employed which calculate updated due dates from input data gathered by the monitoring services and average lead times queried, for instance, from a data warehouse. With regard to the generation of action alternatives it was asked for reliable real-time information (free capacities, material on stock, freight tariffs, etc.) from the supply chain partners. As for this, the latter ones have to offer web services encapsulating the relevant functionalities (*SAP*'s enterprise service *Query Material In*, e. g.) of their ERP systems or TMS. However, with the exception of inventory status services similar to *Amazon*'s *Inventory Service*, there are no such web services actually offered to date. As an interim solution, a company can load empiric lead times along with schedules and freight tariffs in a database which can be queried by a local service.

Controlling: As for supporting the operator in accomplishing the selected option(s), again, some web services concerning inter-company activities (such as enquiries for placing/ modifying/ cancelling of production, transport, delivery, and customer orders, e. g.) necessary to this end are not yet available. However, the opportunity to encapsulate those TMS/ ERP/ advanced planning systems functions as services exists for those fashion companies operating own production plants, warehouses or means of transportation, which holds true for 5 out of 7 of the case study companies. Apart from this, certain event types have no need for IT support as their handling is possible just manually and a notification of the persons in charge (for speeding up design process, customs declaration, e. g.) was considered to be adequate.

Measuring: Since all case study companies have reporting solutions available (either proprietary ones or standard products such as *MicroStrategy* and *Business Objects*), the most convenient way to accomplish the last of five SCEM functionalities is to apply an archiving service which continuously transfers and stores event data in a specific database as well as ETL (Extract, Transform, Load) and data mining services which provide the process owners with regular reports containing key figures such as supply chain partner performance ratings (number of event types, e. g.), fill rates (in terms of production, transfer, and customer orders, e. g.) as well as trends and patterns (regarding place, frequency and probability of critical incidents) in order to get indications for the optimization of supply chain performance in the middle and long term.

4.3 Distribution, Potential Providers and Users Of SCEM-related Services

As a basis for presenting our conclusions regarding the distribution of SCEM-related services, the 2x2 matrix for classifying service repositories and registries by [Alt10, p. 7] is used (see Table 2). It is extended in such a way that it not only distinguishes the origin of services and their level of standardization, but also assigns the identified services to potential providers and users. Nevertheless, the table just can provide an indication since our analysis was based on a non-representative sample. Thus, numerous other SCEM-related (web) services are possible, too.

Cluster	Services	Potential service provider(s)	Potential service user(s)	Origin of services			
				Centralized		Decentralized	
				Standards			
				global	local	global	local
Monitor	Get T&T data	FWD	LSP/FC/CU	x		x	
	Get EPCIS data	INS/MR/FWD/LSP/CU	FWD/LSP/FC/CU	x		x	
	Get process tracking data	INS/MR/FWD/LSP/FC	FC			x	x
	Get target data	CU/FC	FC				x
	Get news data	OTH	FC	x	x		
Notify	Get contact details	FC	FC				x
	E-mail alerting	FC/OTH	FC			x	x
	SMS alerting	OTH	FC	x		x	
	Absence check	FC	FC				x
Simulate	Update due dates	FC	FC				x
	Get available inventory	INS/MR	MR/FC			x	x
	Get production tender	MR	FC				x
	Get transportation tender	FWD	FWD/FC			x	x
	Get empiric/ target data	FC	FC				x
	Create action alternatives	FC	FC				x
Control	Place/ change/ cancel item/ material order	INS	INS/MR/FC			x	x
	Do., for production order	MR/FC	MR/FC			x	x
	Do., for transfer order	FWD/FC	FWD/FC			x	x
	Do., for delivery order	LSP/FC	LSP/FC				
	Enquire change/ cancellation of customer	CU/FC	FC			x	x
Measure	Data archiving	FC	FC				x
	ETL	FC	FC				x
	Pattern/ trend analysis	FC	FC				x
	Report generation	FC	FC				x

Legend: INS … ingredients supplier | MR … manufacturer | FWD … forwarder | LSP … logistics service provider | FC … fashion company | CU … customers (retail/ wholesale) | OTH … others

Table 2: Classification of selected SCEM-related key services

After all, event types and the respective business processes to be supported are always specific to the application domain. Addressing RQ3, both global and local providers for services related to *monitor* and *notify* were identified, whereas services for the remaining functionalities can either be provided by the fashion company itself or their supply chain partners. Only in case of the services concerning *measure* there seems to be limited potential for service-orientation as the identified services tend to be too company-specific.

5 Conclusion and Future Research

This research was motivated by two major issues: first, SCEM architectures never have been analyzed from a service-oriented point of view; second, to enhance service-orientation in the area of SCEM and the fashion industry. After introducing basic SCEM and SOA concepts, present SCEM architectures were analyzed with regard to their functional coverage and component distribution Thereby, a research gap concerning the functionalities *simulate* and *control* was disclosed. In order to identify SCEM-related services, a modified service-identification framework was applied, whereas findings from a multi-case study in the fashion industry were utilized. It became clear that SCEM systems are characterized by a heterogeneous range of functions which – encapsulated as services – can be used by various supply chain participants and provided by multiple service providers as well as available components. In doing so, SOA was discovered to be applicable in order to cover all SCEM-related functionalities.

Various interesting subjects for future research emerge: (I) As for the (not yet available) web services (potentially provided by MR, FWD, LSP, and FC) supplying other business partners with real-time data as well as making it possible to place, modify, or cancel orders, a business model analysis seems promising. (II) Since this research has limited representativeness, further identification of SCEM-related services (referring to other industries, e. g.) is required. (III) A survey of commercial SCEM solutions (especially concerning their functional coverage and service-orientation) is appropriate. (IV) Last but not least, an illustration of an actual realization seems useful in order to demonstrate both feasibility and potentials of service-oriented SCEM

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