Supply Chain Event Management: Three Perspectives

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Supply Chain Event Management (SCEM) addresses a fundamental business problem: inter-organizational processes rarely execute as scheduled, since they happen in an environment prone to failure and disturbance. 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. Despite SCEM's well documented attractiveness for practitioners, it has received little attention as a field of academic research. This paper provides an introduction into SCEM from three complementary perspectives: SCEM as a management concept; as a software solution; and as a software component. Each is analyzed in detail and potential fields of research on SCEM are presented.

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A new acronym has made its way into the vocabulary of many managers who are in charge of creating a competitive supply chain. It is called Supply Chain Event Management (SCEM) [1]. Popular management journals and analyst reports cite various success stories [2] and implementation examples [3]. SCEM has emerged as a relevant phenomenon for both the practitioner and the scientific community in supply chain management.

What is SCEM? As with many concepts, there is no single answer. It is suggested that three perspectives can be taken: SCEM can be seen as a management concept, as a software solution, and as a software component. These views are related to each other, as the software component is a part of an SCEM solution and the solution supports the SCEM management concept. There are a number of academic fields that contribute to SCEM, such as cybernetics [4], production data acquisition, process control [5], management by exception [6], and supply chain management [7]. In this sense, SCEM combines existing results of research in different disciplines (management, information technology, and engineering) into a new approach. This is probably why SCEM has not yet been picked up as a separate arena for academic research. However, it is currently the fastest growing segment in the market for supply chain management software. SCEM will grow with cumulative annual growth rate of over 55%, ending up in a cumulated projected sales volume of more than 2.9 Billion USD by 2006. [8].

SCEM manages events, but addresses only a particular class of events, namely those that are related to and occur in the realm of the management of transformational and transfer processes [9]. Although other classes of events may be managed in the same way, this paper is focused on supply chain events only. In order to be helpful, the refinement of the scope must be supported by defining the term supply chain, which is understood here as the "... entire sequence of events that bring raw material from its source of supply, through different value adding activities to the ultimate customer" [10].

The paper is geared towards the practitioner and the researcher looking for a systematic introduction to the field of SCEM.

SCEM as a Management Concept

An example of an application of the SCEM concept is given in the following scenario. A PC manufacturer receives a large order from a PC distributor. The order management system reads this order and creates time-phased requirements for all the necessary activities, such as purchasing,

assembly, and shipping. Thus, an order specific network of processes will be created. These processes are sequentially interdependent, as for example, the assembly cannot start if the components are not available. If the order network does not contain time buffers and the logistical network (plant, warehouse,...) does not contain inventory buffers, upstream deviations between the plan and its execution (time, quality, quantity, etc.) will cause downstream deviations. Consequently, any deviation potentially endangers the ability of the supply chain to meet customer expectations. In this environment, the success of a company becomes dependant on the ability to prevent or at least immediately identify and resolve these deviations.

SCEM addresses this fundamental problem. Figure 1 assumes that the assembly process finishes late due to an unplanned disturbance. In the example, the milestone "End of Assembly" within the assembly process is defined as an event and the late assembly is communicated via an event message to the SCEM system. This lateness is a deviation from the plan and will qualify as a problem, if it exceeds a defined threshold. SCEM may then trigger a sequence of actions to resolve the problem. It may raise an alert to the assembly manager, reschedule the milestones for all subsequent operations, communicate the delay to the carrier, and finally send an early warning to the customer. In a more sophisticated application, SCEM may additionally calculate and propose to use air freight to keep the delivery date, propose to reduce the priority of the assembly shop for future orders, propose to insert a time buffer in the order network for all future planning touching this assembly shop, and finally propose to insert an additional event (e.g. Start of Assembly) to identify deviations earlier.

The example introduced some terminology. However, additional definitions are necessary. First, it is useful to think of an event as a milestone in a process, for which a status report is expected. Thus, an event does not always represent a deviation or a problem. It is only a sensor, which has been deliberately positioned into a process. Second, an event message is a data feed that reports a predefined set of characteristics of an event. Third, an SCEM object is a business entity (order, shipment, railcar, etc.) that is monitored by the SCEM solution. Fourth, a deviation is defined as a difference between a planned status and an actual status of a particular attribute of the object (time,

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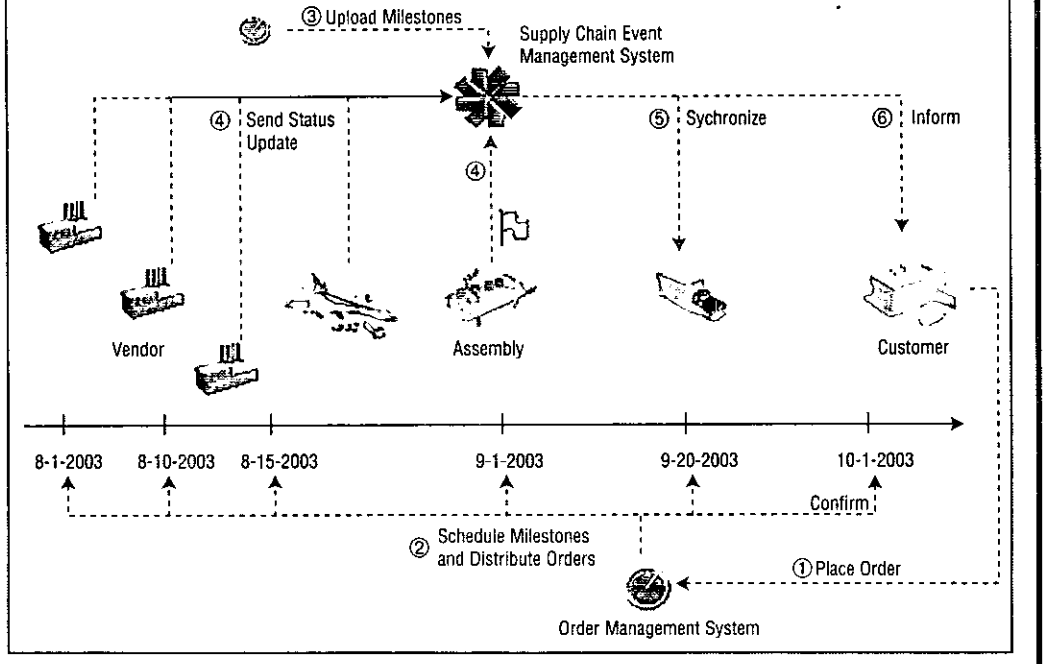
Figure 1
What is SCEM? - An Explanatory Scenario



quantity, quality, etc.). Fifth, a deviation is a problem, only if it exceeds the defined thresholds. This interpretation is in line with the basic understanding in management thinking - that a problem is associated with the difference between an existing and a desired situation [11]. The process of problem solving starts with the definition of meaningful differences.

The above described how SCEM might be applied. In any realistic managerial setting, the transformation of a plan into practice is always imperfect [12]. For a multitude of reasons, unplanned disturbances produce deviations between target states and actual states. These deviations need to be reduced, either by changing the plan (target), or preferably, by changing or adapting the execution (actual). The goal of SCEM is to identify deviations and minimize their negative impacts before they are detrimental to customer satisfaction and operational efficiency. Thus, managing an event requires two actions: First, eliminate the delay between when an event happens and when the responsible decision makers find out about it [13]. Second, eliminate the delay between sensing a problem and generating a satisfying response. It is this immediacy that draws the line between supply chain planning and SCEM. SCEM does not re-generate a plan [14], but generates rule-based resolutions to minimize the gap [15]. SCEM tries to reap benefits by the speed of the response rather than by its "optimality".

The goal of SCEM is to identify deviations and minimize their negative impacts before they are detrimental to customer satisfaction and operational efficiency.

Although the goal of SCEM is to manage events "online", its footprint transcends the here and now of the sole event situation. To explore this, I will differentiate between the four event management modes shown in Figure 2: repair, reschedule, re-plan and learn.

In many cases, the obvious reaction to a deviation is to correct it immediately (late delivery - call driver). SCEM identifies and evaluates the event and suggests a resolution.

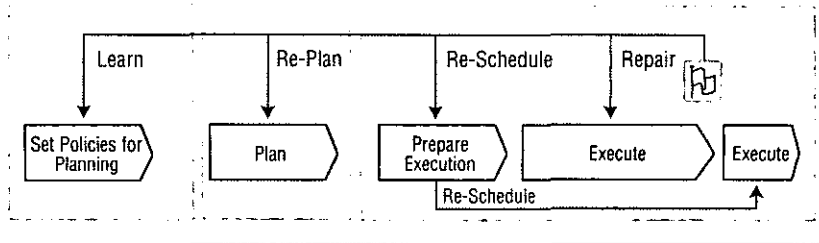
Sometimes a failure cannot be repaired. If a delivery truck is one hour late at the first stop, it is unlikely that the subsequent stops will be in time. SCEM can reschedule the remaining part of the process and communicate the updated milestones.

A further escalation is to re-plan the complete process. If a truck breaks down, the complete shipment has to be re-planned in a subsequent planning run. This immediate planning is seen as an important feature of SCEM as opposed to supply chain planning, which remains in the realm of long, mid, and short term but not immediate planning [16].

Although learning is not needed for the immediate resolution, it holds the key to prevent future exceptions (preventive SCEM). If experience shows that a particular carrier continuously delivers late, the control parameters for planning (carrier selection) need to be improved. By embedding this single deviation into a larger context (time, region, etc.), poor planning policies and operating procedures can be identified and brought to the proper managerial attention. The learning mode of SCEM mimics the tradition of industrial quality management [17], which as well pursues to reduce deviations, preferably by prevention. As in statistical process control (SPC), the challenge for a "learning" SCEM will be to isolate the root causes (which can be eliminated) from the random, often externally caused out-of-control conditions.

A precondition to manage events in the supply chain is to have visibility. Although this term is often used in the management literature [18], it is not well defined. Visibility should be defined as an informational status. A supply

Figure 2
Modes of Managing an Event



chain is visible or, transparent, if all the information needed to make a certain decision is available to the SCEM decision-making unit. This can be either a human or an electronic decision-maker. The SCEM decision-making unit needs a three dimensional matrix of information. One dimension is defined by the object that is monitored by SCEM. For example, if the object is a shipment, then all relevant steps to execute the shipment need to be transparent. The second and the third dimensions are the set of data describing each stage of the shipment both in terms of planned and actual events. If one of the steps is "shipment loaded", the characteristics may be loading time, loaded quantity, and loaded weight. This definition of visibility leads the attention towards some important aspects of the visibility concept: situation, decision-making unit, and availability.

Visibility is situation specific. Propagating a set of information throughout the supply chain may be sufficient to support a decision in situation A, but may be insufficient for situation B.

Different decision-making units may use different sets of information to make a decision. Thus, for decision-making unit 1 the supply chain may be fully transparent, whereas unit 2 misses information.

Information must be accessible in time and space to the decision-making unit. Although a set of information may be basically available, a decision-making unit may lack visibility since it cannot access the information as needed.

Since SCEM is, at its heart, a decision making process (identifying deviations and suggesting a response), visibility is of pivotal importance. Thus, the second goal of SCEM, understood as a precondition to the first goal (manage events online), is to create supply chain visibility. But, as the definition suggests, visibility is not a status of "knowing everything in whatever detail". Visibility entails only the informational context as defined by the SCEM decision-making unit. Literature confirms, SCEM is closely associated with visibility. Kemmeter and Knickle (2002) observe that companies implement SCEM solely for the sake of creating supply chain visibility [19]. Some authors even define SCEM as a concept, which provides "real-time information" across the complete supply chain [20] and lets"... companies see... if their existing supply chain management (SCM) systems are working" [21].

To sum up the first perspective, SCEM can be defined as a management concept that helps managers to implement reliable inter-organizational processes, despite acting in an environment prone to disturbances. The goal is to execute order fulfillment processes as planned throughout the complete supply chain, although the execution is adversely impacted by disturbances. To achieve this stability, SCEM continuously identifies deviations between the plan and its execution, and immediately triggers a resolution according to predefined rules. As a precondition, SCEM creates supply chain visibility. McCormack and Lockamy (2001) define SCEM as a supply chain management best practice construct: a process, which simulates, responds to, and controls exceptions to planned and unplanned events in the supply chain [22].

SCEM as a Software Solution

So far, SCEM has been described from a business perspective, but has neglected the organizational and technical aspects. The remainder of this paper will focus on SCEM as a software solution. This is examined from a systems view, which recommends analyzing a phenomenon along three basic categories: function, processes and structure.

The Functions of an SCEM Solution

To analyze the function we begin with the most basic question: What does a system do? What is the system's function? It is suggested that SCEM has two primary functions: stabilization and re-synchronization of inter-organizational processes. Both need explanation:

An inter-organizational process is a sequence of activities geared towards effecting a desired outcome [23] and one which involves at least two organizations (companies). A logistical process is a process, which controls and/or effects the physical movement of goods [24]. Stability is the ability of a process to effect desired outcomes despite disturbances [25]. It refers back to cybernetics, which also deals with the

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problem of keeping a process on track despite disturbances.

Sequentially interdependent work processes lose efficiency if their preplanned synchronization is destroyed. SCEM has the function to re-synchronize the supply chain after a deviation has occurred [26]. Whereas supply chain planning systems do the initial synchronization, SCEM does a permanent event-driven re-synchronization.

Stabilization and re-synchronization, as the primary functions, are supported by a set of intermediate, second level functions:

- Collect: The planned and actual status data must be collected from the multitude of actors in the supply chain.
- Document: The planned and actual status data must be documented and made available to the users and the decision-making units.
- Analyze: The event situation is continuously analyzed in order to identify problems.
- Decide: Based on the analysis, the SCEM solution must be able to generate a resolution.
- Implement: The resolution must be implemented, either automatically or through human interaction.
- Learn: Finally, the SCEM solution is capable of learning.

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An SCEM solution has a set of capabilities that allows it, as a by-product, to mimic other important functions to manage a supply chain. As a side effect, an SCEM solution will also function as a track and trace solution. The term "track and trace" identifies a class of software solutions that is used to document and report the path of an object through a sequence of process steps [27]. In the inter-organizational realm, track and trace solutions are primarily used by logistics service providers to monitor their logistics operations and to report the shipment progress to the customers. Since the functional scope of a track and trace solution (collect and document) is a subset of the SCEM scope (collect and document, analyze, decide, implement and learn), the latter is fundamentally able to mimic a track and trace solution.

SCEM can only work if the object process is well documented in terms of its structure (milestones and events). Thus, to implement SCEM, a process analysis must be undertaken. This will bring light into the detailed structure of the inter-organizational processes. SCEM collects execution data, which serves as a data pool for performance measures. Although the final goal of SCEM is not to measure, but to improve performance, the data offers the basis for measurement.

SCEM pursues stable inter-organizational processes. But, this does not imply that stability can only be achieved via SCEM. In fact, companies have often attempted to shield their operations from external uncertainties and to stabilize their processes. Traditionally, this has been achieved by buffering (information, time and inventory) [28], by introducing automated process monitoring techniques like SPC (statistical process control) [29], and finally, as a second best solution, by applying expensive and error prone human attention. The innovative aspects of SCEM in this regard are twofold. First, stability is effected via an infusion of software, which replaces human attention by "electronic" attention. Thus, SCEM is only one out of many strategies to stabilize inter-organizational processes, and it promises to stabilize them more efficiently and more effectively. Second, the collection of inter-organizational execution data in one central database will allow transferring proven intra-organizational monitoring techniques (i.e. SPC) to inter-organizational processes.

The Processes to Implement and Run an SCEM Solution

A system achieves its goals by executing processes. Two kinds of processes should be distinguished. SCEM processes are those processes needed to implement and run an SCEM solution. Object processes are those processes that are managed by the SCEM solution. The following section focuses on the SCEM processes. An SCEM solution runs three classes of SCEM processes, which are labeled "Configure SCEM Solution", "Trigger SCEM" and "Manage Single Event" [30]. Whereas the configuration is done once, the triggering and the management of single events are recurring in daily order fulfillment.

Configure SCEM Solution. The configuration of the SCEM solution consists of three steps, which are labeled "define event profile", "establish connections", and "define rules".

- Define Event Profile: The first step is to define event profiles. An event profile is a

template that specifies how a given class of object processes should be monitored. Table 1 gives an example of an event profile for a simple business process (delivery by truck). Column one describes the steps of the process. Columns two and three define what to report and who to report. A company will need to define a multitude of event profiles. A delivery by rail may be monitored differently than a delivery by truck. Again, a domestic delivery needs to be monitored differently than an international delivery. Further, SCEM will reveal over time that certain processes are stable (i.e. create few deviations), whereas others are not. Stable processes allow for less dense event profiles. The definition of an event profile is a crucial decision, for it determines which milestones will be monitored, which disturbances will be identified, and to which failures SCEM will remain blind. As Figure 3 outlines, several factors impact the profile definition. The basic structure of the profile will result from a process analysis, which reveals processes and milestones (in Figure 3: warehousing, loading, delivery and return). Although the event profile will most likely reflect these processes, the process analysis alone may not be sufficient since there is no need to interpret each milestone as an event. For example, why closely monitor the loading process if it proved to be stable? The results of the process analysis can be mirrored against the company objectives. Broken down to an operational level, they specify the phenomena that need to be measured. For example, if a company stresses the goal of maximizing customer satisfaction, an event profile should contain an event that reports the timeliness of delivery. The analysis of historical performance may reveal weaknesses in the process. These weaknesses should be analyzed by SCEM in greater detail, following the logic of "What gets measured gets managed". Finally, the costs of technically obtaining status information will also shape the density of an event profile.

- Establish Connections: The configuration also includes the technical means to connect the different actors in different locations to the SCEM component. Despite the various efforts to establish standards to communicate data between systems, a large share of the SCEM budget is expected to be consumed in establishing the connections.
- Define Rules: Finally, a set of rules has to be defined. Rules have the format of "if-then" clauses and serve the purpose of distinguishing non-critical from critical deviations ("if") and specifying responses to the latter ("then"). The rules represent the knowledge of the different decision-making units, which monitor the object as it flows through the supply chain. In this aspect, SCEM supports a collaborative resolution of problems. If it covers the entire supply chain, the SCEM solution will hold a multitude of rules and by this becomes a central rule repository. These rules represent the resolution strategies and the resolution know-how of different organizations. This

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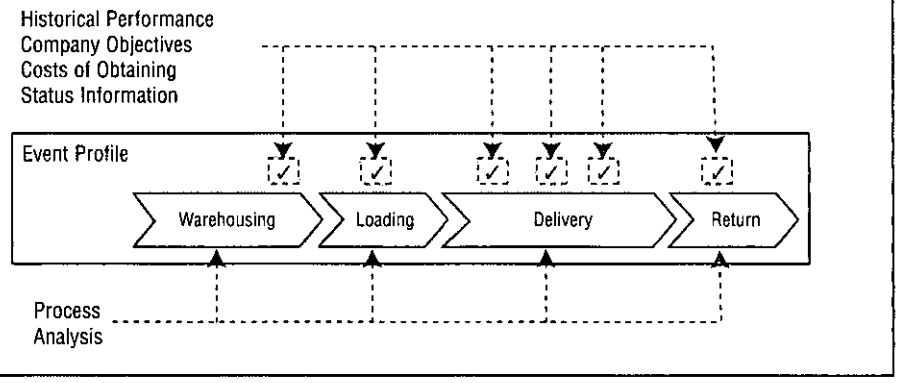
Table 1
Event Profile for the Business Process: "Delivery by Truck"

Expected Event (1)	What to Report (content of message)? (2)	Who to Report? (3)
Cargo picked and packed	Date/time, quantity, SSCC (Serial Shipping Container Code) for each handling unit	Picker
Cargo loaded	Date/time, quantity, SSCC for each handling unit	Driver
Distribution center left	Date/time, identification of truck	Automatic gate reader
Arrival at customer	Date/time, identification of truck	Driver
Cargo delivered	Date/time, identification of truck, shipment number(s), SSCC for each delivered handling unit	Driver
—- same for each customer on trip —-		
Returned to distribution center	Date/time, identification of truck	Automatic gate reader

Figure 3:
Factors Impacting the Definition of an Event Profile



repository may serve as a basis for a supply chain-wide collaborative and integrated event management.

The SCEM rules will, in most cases, evaluate the contents of the received event messages. The content will vary according to the purpose of the monitoring. However, information on time, place and quantity will likely be reported. Additionally, an SCEM solution must also address the following situations:

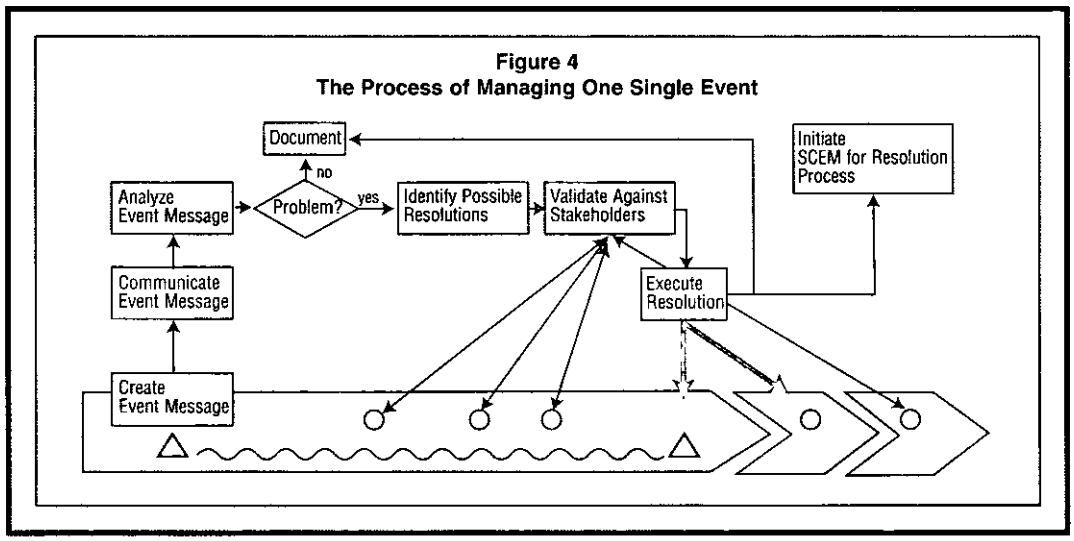
- No Message: At the expected point in time, no message has been received.
- Unexpected Message: The monitored process creates more event messages than expected. A truck may report a traffic jam as an unexpected event.
- Wrong Sequence: Finally, event messages may be received in the wrong sequence. Although they may be re-sequenced, this can be documented as a suggestion of poor process quality.

As the object process is executed over time, the different actors in the supply chain reach events. These need to be reported into the event management engine by creating an event message, which translates a physical or logical state into a signal that can be communicated electronically.

Trigger SCEM. To monitor an object (i.e. order, shipment,...), the SCEM solution needs to be triggered, usually by another system. If the SCEM object is a shipment, the transport management software that creates the shipment will trigger the SCEM process. This causes an event handler to be created in the SCEM solution and populated with the event profile including the series of planned events. An event handler is an electronic object within the event management engine (see below). It serves as a container that holds both the plan and the actual status information of the SCEM object. It lives as long as the SCEM object lives. The event profile holds the target states for the particular SCEM object. The triggering is done once per instance of the monitored process.

Management Single Event. In contrast to the preceding, this process runs once for each event of the event profile and consists of seven steps (Figure 4):

- As the object process is executed over time, the different actors in the supply chain reach events. These need to be reported into the event management engine by creating an event message, which translates a physical or logical state into a signal that can be communicated electronically.
- The event messages are communicated from the different locations in which they originate to the location where the event management engine resides. Although this is a technical step, Kemmeter and Knickle (2002) report that the majority of companies use SCEM primarily to improve the way they share information with business partners [31].
- The incoming signal will be stored and analyzed to check for deviations.
- For an identified problem (i.e. deviation beyond the threshold), SCEM determines potential resolution paths.
- If the resolution process (decision making and action) involves different parties, SCEM may invoke a joint or collaborative decision making process.
- Once a decision has been made, the resolution is executed.
- If the resolution process itself is complex, it may also be supported by SCEM.



The Structure of an SCEM Solution

Managing events is a complex task that calls for an integrated system of different actors, some of which are humans and some are software components. To ease the analysis of a complex system, general systems theory recommends a split into subsystems and relationships. Following this approach, it is useful to differentiate the components shown in Figure 5.

Event Management Engine. The event management engine is a software component and can be viewed as the brain of the SCEM system. It is called engine since a standard user will usually not have to interface with the system in the day-to-day operation. It runs in the background. Like a brain, it continually receives event messages from different locations in the supply chain, describing the status of the execution of all processes currently covered by the SCEM system. The communication between the engine and the other subsystems is done solely by exchanging messages [32]. At any point in time, it ideally has complete visibility of the execution status. It uses this information to make decisions. Analogous to the brain, the event management engine does not have the "muscles" to execute these decisions, it only triggers. The execution is done in other subsystems. It should be noted here that the analogy with the brain falls short in one important aspect, since the brain of a human being does both, planning a course of action and correcting deviations as they occur. SCEM only does the corrections, it does not plan. It only manages the deviations from plans, but the plan itself is an input, not an output. Thus, SCEM itself is again only a subsystem of a larger super-system, which may be called the supply chain management system.

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Alert Manager. The human brain communicates with the arms and legs of the body in order to execute its decisions. The SCEM solution does the same using the alert manager. This separate subsystem has the function to ensure that the informational output, the command of the engine, is communicated to the recipients. It is called an "alert" manager, since the event management engine only communicates if a problem is identified. If all processes run according to plan, no response is needed. It is called a "manager" since it ensures that messages reach recipients regardless of contingencies (different data formats; different communication channels; staging and sequencing due to unavailability; etc.).

Human Decision Maker. Only in a limited number of cases will the event management engine be given the authority to resolve a problem completely on its own without any human interaction ("auto-responsive" [33]). Although the solutions may have ample functionality, Kemmeter and Knickle (2002) do not see any companies pursuing this venue [34]. Thus, a human decision-maker is an important part of the SCEM system.

Leading Application. The leading application is software that initiates the SCEM process. In most cases, it will be an order management, a warehouse management, a transportation management, or an advanced planning and

scheduling system [35]. The leading application performs two tasks: It triggers the SCEM process and generates event messages.

An SCEM solution may consist of many applications, which have the task of creating and communicating event messages to the event management engine.

Application. An SCEM solution may consist of many applications, which have the task of creating and communicating event messages to the event management engine. For example, a warehouse management application reporting the end of a picking process, a yard management system reporting an outbound truck movement, or an order management system of a logistics service provider reporting a late arrival of a long-distance truck. The reason for having multiple application systems is that in most cases the business process crosses several organizational boundaries; therefore, messages enter and leave the realms of different application systems. Viewed from the perspective of the "owner" of the event management engine, these applications are foreign systems that offer only limited access, but which are nevertheless important since they contribute to the order fulfillment process.

Mobile Application and Mobile Device. Many events are not located in, but between companies. In order to collect event data during the stages of the process, mobile applications are used. An SCEM solution will be particularly dependent on them, since especially the processes between companies are prone to disturbances and often lack proper visibility. Examples of mobile applications can be found in the logistics service provider industry. Delivery trucks are often equipped with mobile devices, like scanners, which are used to generate and communicate event messages immediately after an event has been reached.

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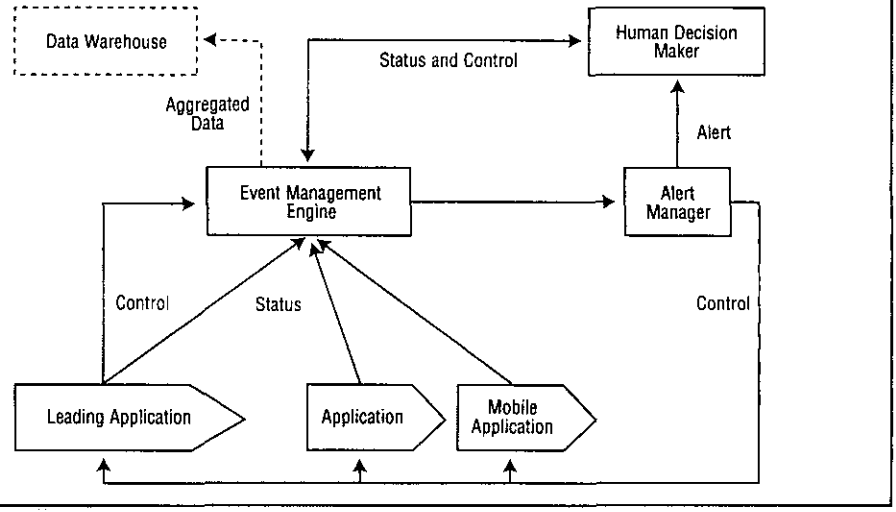
Data Warehouse. The historic event data will be frequently downloaded into a data warehouse, which allows for more sophisticated analysis. But this analysis will no longer address single event data, but aggregated data. Figure 5 shows a dotted line, since the data warehouse is not needed to manage an event in the narrow sense of the word. It is associated with the event management mode "learn", as introduced in Figure 2. Since learning takes past performance into consideration, a data pool (data warehouse) to hold the historical data is needed. The data warehouse also connects SCEM to another SCM solution, which is called Supply Chain Performance Management (SCPM), as defined by Lee und Amaral [36]. Whereas SCEM manages transactional events (a single delivery is late), SCPM focuses on key performance indicator events, which arise if aggregated performance indicators exceed tolerances (i.e. 30% late deliveries in the last quarter).

Summarizing, SCEM can be defined as a software solution, which enables companies to implement the management concept of SCEM. Its primary functions are to stabilize

Figure 5
The Structure of an SCEM Solution



and re-synchronize inter-organizational logistical processes. SCEM runs three processes (configure, trigger and manage single event) and employs a particular structure, which consists of seven components (event management engine, alert manager, human decision maker, leading application, application, mobile application, mobile device and data warehouse). Literature also supports the solution view [37].

SCEM as a Software Component

The majority of the contributions in literature view SCEM as a software component [38]. It then resembles the event management engine, as introduced above. The remainder of this paper describes the principle architecture of an event management engine.

Although a particular software product is not referenced in this paper [39], it can list the architectural components an event management engine can be bundled into three groups: mass interface, dialogue interface, and core (see Figure 6).

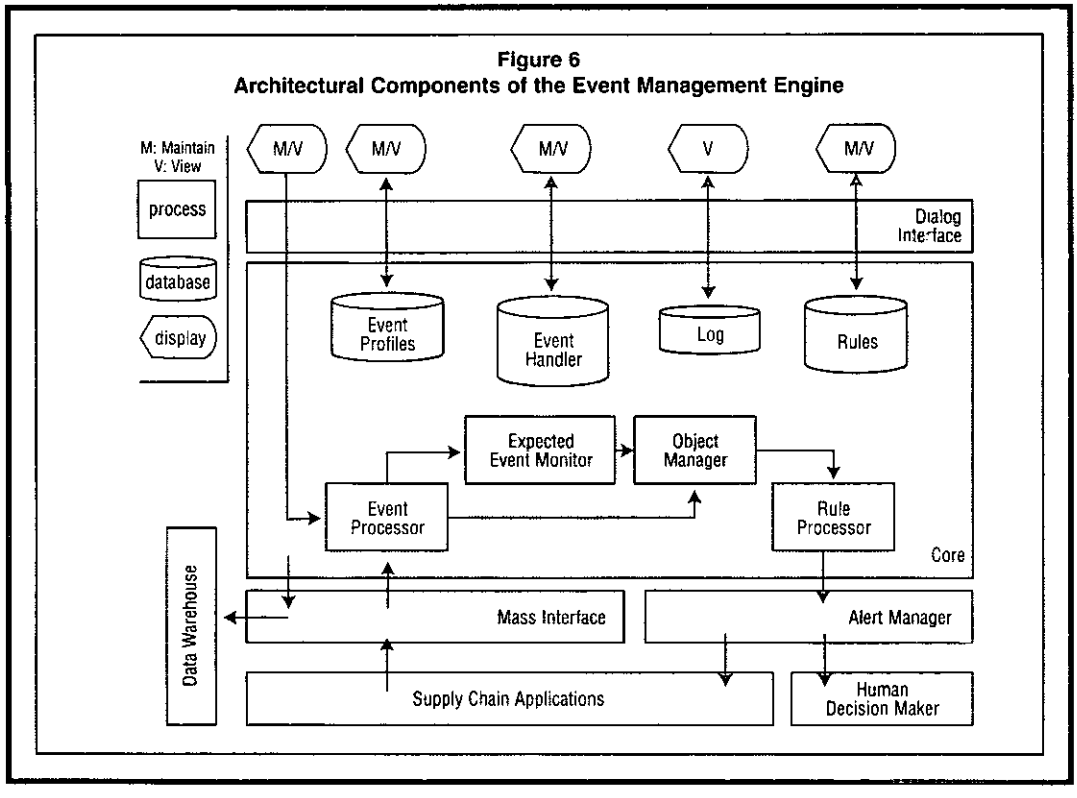
Mass Interface

The event management engine is not a stand alone application [40], but works in close cooperation with the other parts of the SCEM solution and therefore, communication is of pivotal importance. The mass interface handles the in- and outbound machine to machine-communication. The inbound flow represents the control flow out of the leading application. This triggers the creation of event handlers as well as the message flow. The message flow populates the event handlers with the operational feedback created by the supply chain applications while the object processes are executed. The mass interface may possess parsing capabilities to handle XML-based data feeds and other structured inbound flows [41]. It may also contain mapping capabilities to semantically translate the received data structure into the required internal structure. Furthermore, it will also support the export of the SCEM data into a data warehouse for offline analysis.

Dialog Interface

The dialog interface enables the users to maintain the event profiles and the rules as well as to retrieve event data interactively. In addition, the dialog interface can be used to enter event data manually. For example, smaller logistics service providers will be required to feed event data into the system,

Figure 6
Architectural Components of the Event Management Engine



but may lack the capabilities to communicate via the mass interface.

Core

The core again has an inner structure, of which some parts have already been mentioned. Four components run the process inside the engine [42]: The event processor reads all incoming data, does semantic and syntactical mappings to convert the message into the needed format, and associates the content to the landscape of existing event handlers. The object manager creates and maintains the event handlers, which represent the SCEM objects. The expected event monitor creates expected events according to the predefined event profiles and compares them against the reported events. Finally, the rule processor applies predefined rules to deviations, triggers alerts, and communicates the rule evaluation results into the data warehouse for further analysis. If the rule processor identifies a need to act, it will communicate with the appropriate actors in the supply chain via the connected alert manager, either creating textual alerts or executable function calls into supply chain applications. The result of the rule processing will be fed into a log to enable a subsequent analysis of the decision making process.

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SCEM can be defined as a software component that represents the core of an SCEM software solution. Its function is to trigger the process of resolving identified problems (deviations) according to predefined rules. It consists of three components: dialog interface, mass interface and a core.

Outlook and Fields of Research

In this paper SCEM was introduced from three perspectives. Upcoming contributions can be expected to shift the research attention more towards normative issues. This paper enumerated some starting points to do so.

- Distribution of Functionalities within the SCEM System: The intermediate functions (collect, document, analyze, decide, implement and learn) need to be placed somewhere in the system, which creates a variety of design issues. For example, should the SCEM solution be furnished with capabilities to actively collect data out of the application systems? Should the SCEM solution hold simulation capabilities for better decision making? In both cases, other solutions in the SCM area are already equipped with similar capabilities.
- Quality Management: Researchers in quality management will find similarities between managing quality "intra-company" and "intra-supply chain". SCEM will furnish a rich data pool to apply proven quality management concepts.
- Risk Management: Risk management concepts may be applied for a more sophisticated analysis of a single event. The current rule based evaluation of the event situation will certainly see risk oriented approaches.
- Data Collections: The growing field of intelligent sensors [43] and Radio Frequency Identification (RFID) will increase both the quantity and the quality of the available event data and will furnish a richer informational context for analysis. Whereas the traditional barcode scan supplies only an object identification, intelligent tags may additionally report facts of the object "history", like the amount of time a shipment already spent in the supply chain, or the number of days before a product exceeds the date of expiry.

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[32] This architectural restriction can be made, even without referring to a particular SCEM vendor since SCEM can hardly work different. An alternative to a message based integration would be a database based integration. Since SCEM, by default, has to communicate with a plurality of heterogeneous systems (supplier, manufacturer, logistics service provider, carrier and retailer), a database integration is hardly an option.

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