RFID-based Supply Chain Event Management

Frank Straube, Stefan Vogeler, Philipp Bensel
Department of Logistics
Institute for Technology and Management
University of Technology Berlin
Straße des 17. Juni 135
10623 Berlin, Germany

Abstract- **Supply Chain Event Management (SCEM) systems aim at detecting the occurrence of negative events – such as a delayed shipment – and suggesting measures that help limiting negative implications. The main functions of such a system include process monitoring, proactive notification of process managers in case of deviations, simulation of the effects of the event on the process, providing options for action. By monitoring processes over a longer period SCEM generates measurement data that facilitates process improvement. The effectiveness and efficiency of a SCEM system depends on the quality of the available data, which in turn is related to the identification and data capture system used. Radio Frequency Identification (RFID) as an Automatic Identification and Data Capturing Technology (AIDC) is used to enhance visibility in supply chains. The paper provides an overview of the current state of research in the field of SCEM. In the following a RFID-effect-framework is developed, that explains how the technology leads to higher process efficiency and information quality or promotes new processes. The paper then analyses how RFID supports the functions of SCEM in various ways and enables shorter control cycles thus reducing costs resulting from the handling of deviations while improving overall service levels.**

I. INTRODUCTION

The reduction of the vertical integration and the ongoing diversification of products lead to complex supply chain structures with many partners involved. In addition partners are distributed all around the globe [1]. While supply chains are becoming more and more complex by integrating additional players and reducing buffers in time and resources the probability of the occurrence of unpredicted events keeps growing [2]. As a result of these trends the coordination of the supply chain becomes more challenging, aggravating the adverse effects of negative deviations from planned processes. In this context Supply Chain Event Management (SCEM) aims at detecting deviations and managing their consequences. Identifying deviations from planned processes at an early stage allows the management in charge to choose from a maximum of options to deal with the identified event and minimize consequences at reasonable costs. However the acquisition of cross company data, which is needed, is an even more challenging and extremely time consuming task [3]. Auto Identification and Data Capturing (AIDC) technologies – such as Radio Frequency Identification (RFID) – reduce the effort of collecting data and can therefore be seen as enablers of SCEM. The paper analyses the contributions of RFID to SCEM in detail based on two frameworks.

The requirements for the developed frameworks result from the analysis of supply chains in three different industries conducted by the authors. In the analysed cases RFID is expected to increase data quality and availability which creates the basis for an efficient SCEM.

II. SUPPLY CHAIN EVENT MANAGEMENT – PERSPECTIVES, DEFINITION AND FUNCTIONS

Even high-performance planning system cannot entirely predict the future. An often discussed concept to increase supply chain visibility – thus enabling instantaneous reaction in case of deviations from defined processes – is known as SCEM.

The concept is mainly founded on two theories namely "management by exception" and "event based planning". Reference [4] first introduced the term management by exception in 1964 and defines it as "… a system of identification and communication that signals the manager when his attention is needed; conversely, it remains silent when his attention is not required". Thus the control function of management is reduced to the management of unexpected events, allowing it to fully concentrate on those issues. The event is only escalated to higher management levels if the process owners fail to fix the problem.

The second theory influencing the concept of SCEM is event based planning. Once existing plans become insufficient due to certain events a new planning cycle is started, taking into account altered restrictions and environment conditions [5].

A. Perspectives

SCEM is a management concept in the truest sense of the word since it is all about decision making. Reference [6] differentiates the following perspectives of SCEM: SCEM as a management concept, as a software solution or as a software component. Those perspectives are closely linked since the software component is part of the software solution which in turn enables the management concept.

SCEM fills the gap between supply chain planning and supply chain execution. Supply chain planning develops plans for complex supply chains taking into account all relevant restrictions, whereas supply chain execution fulfils those plans [7]. Re-planning – in the supply chain planning sense – in order to respond to a deviation is seldom possible due to the complexity of the supply chain. Addressing such near-term shortcomings is the mission of SCEM.

B. Definition

Even though SCEM is a highly discussed concept it still lacks a generally accepted definition [8][9].

Reference [8] provides a rather technical definition of SCEM: "The application of statistical, process and technology identification and control solutions to standard and non-standard supply chain events".

SCEM is a concept to track, monitor and assess events occurring within a company or in supply networks according to reference [10].

Reference [11] perceives SCEM as an extension of existing tracking & tracing systems for it translates status reports into events based on information about the standard process.

All authors stress the proactive character – automatically notifying users of an event – as the main attribute of SCEM.

C. Functions

Several categorizations for the functions of SCEM can be found in literature. Most authors agree upon the following five functions or have them included into their classifications (see Figure 1) [9][11][12].

Tracking and tracing solutions "monitor" supply chain processes, but they just deliver monitoring data or status information. SCEM systems "notify" the process owners once a deviation between a defined standard process and the current state is identified. The system provides management with decision support based on defined rules or the simulation of possible outcomes ("simulate" function).

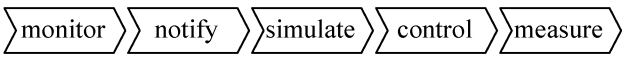

Figure 1. SCEM functions (see [9][11][12])

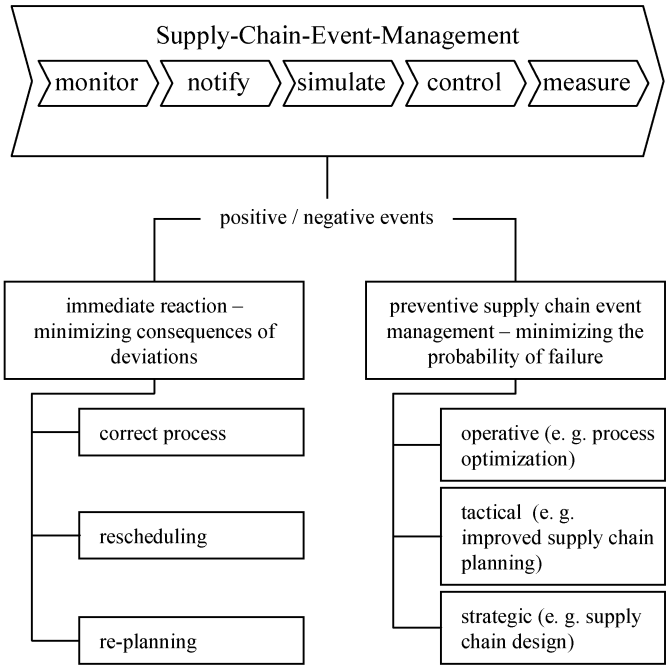

Figure 2. SCEM framework

Once an alternative process has been defined the "control" function assists with its execution. Process performance data is gathered through the "measure" function [11].

Most of the functions support the handling of events with the aim to reduce negative consequences in the short term, while the system itself remains unchanged. But SCEM also features a long-term component. The data gathered by the "measure" function empowers the management to improve the existing system thus reducing the probability of the occurrence of events in the future [11].

D. An extended supply chain event management framework

By synthesizing the present literature on SCEM an extended framework is developed as illustrated in Figure 2. The five functions introduced above are at the core of the framework and enable both short-term effects namely the immediate handling of events and long-term learning thus preventing future deviations.

The two branches of the framework can be further detailed. Three levels of escalation can be distinguished, when an immediate response to a sensed deviation is needed. First of all the defective process can be corrected based on encoded rules. If a process cannot be fixed consecutive processes need to be rescheduled. In case of major deviations SCEM enables immediate re-planning [6]. Long-term learning – also known as preventive SCEM – is the key to improve processes on operative, tactical and strategic levels. An example for enhancements on the operative level is the continuous improvement of material handling processes. Increased visibility of supply chain processes supports the quality of planning on a tactical level, while the knowledge gained over time supports strategic issues such as supply chain design.

E. Data quality

SCEM aims at minimizing the delay between the occurrence and the identification of an event respectively the time that elapses before a reaction to the event is initialized. SCEM thus relays heavily on process data. Data can be characterized by its accuracy, quality and timeliness [13]. The four dimensions of data quality introduced by reference [14] already incorporate timeliness in the dimension time, which includes the granularity of the time axis and the time elapsed between generation of the data and the action taken. The other dimensions include content about a supply chain object, granularity of position data and granularity of object classes.

III. RFID – PROPERTIES AND IMPACT OF THE TECHNOLOGY ON BUSINESS PROCESSES

By the use of Automatic Identification and Data Capture (AIDC) technologies data about physical objects can be collected automatically and processed without change of format.

A. Definition

Radio Frequency Identification is a technology to uniquely identify all types of objects without contact making use of electromagnetic or inductive coupling. It allows data written on tags to be acquired and processed without any change of format. Unlike bar-coding, RFID technology enables the reading, writing and recording of data on the applied tag [15][16] Thus RFID opens up new opportunities in the areas of logistics, production and service. In the following section a conceptual framework is presented which helps to understand the impact of RFID on operational processes – such as receipt of goods or material handling – and on management processes – such as supply chain control or planning – in logistics and supply chain management.

B. Development of a RFID-effect-framework

In 1995 reference [17] developed a conceptual framework for the assessment of IT value for business processes, which was adapted to RFID by reference [18]. The framework distinguishes between "three separate but complementary effects"[17]. In the following section the authors deduct an extended model for assessing the value of RFID regarding process performance based on the effect categories automational, informational and transformational. According to reference [17] processes are on the one hand distinguished between operational and management processes and on the other hand between existing and new processes. The latter is based on findings by reference [19] who argues that RFID either increases the efficiency of existing processes or enables "new games".

The automational and informational effects have a direct impact on the existing processes and an indirect impact on new processes via the transformational effect.

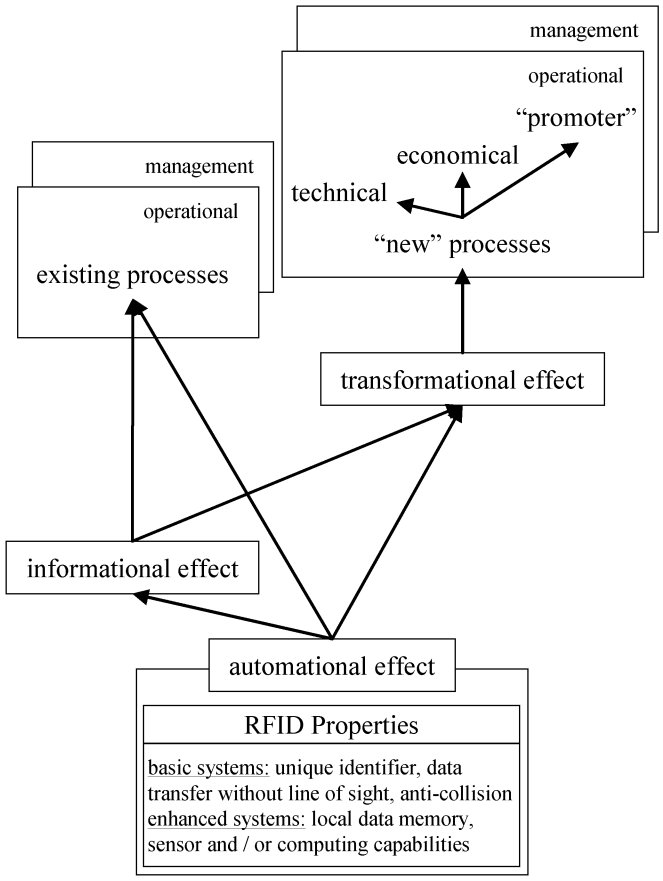

Figure 3. RFID Framework

The automational effect applies when RFID improves the performance of existing operational processes by lowering the data capturing effort through automation of data capturing. As a result human interaction and changes of format can be avoided. Since RFID is an AIDC technology the automational effect is always present and for this reason creates the basis for the other two effects.

The impact of RFID on information quality is referred to as informational effect. As mentioned above information quality is dependent on data accuracy and quality. The informational effect of automated identification via RFID affects all dimensions of information quality. First the automation of identification increases the data collection rate, which leads to more timely information. Moreover the accuracy of planning, scheduling and controlling data – e. g. of planning fundamentals or invoices – is improved by preventing input data errors. Finally automation leads to higher operation efficiency making a higher density of read points cost-effective. Through this improved data base existing processes – mainly on the management side – can be supported.

The two effects described above enable the transformational effect. A transformational effect can be identified if the new technology leads to process innovation. Therefore transformational effects only occur in combination with new process steps or processes. These new processes can

be divided into three categories. The processes of first category become technical feasible through the implementation of RFID, e. g. the identification and control of skits in the paint shop in the automotive industry. A characteristic of the processes of the second category is that RFID makes these processes cost effective. These processes are technical feasible using alternate technologies but only with prohibitive high costs. This is true for the identification of empty containers in an analysed case from the automotive industry enabling an efficient container management. The third category includes processes which are promoted in the course of the RFID-implementation – e. g. the creation of new shopping experience by giving customers additional product information via RFID on the shop floor.

Figure 3 shows the relations between the effects and their impact on the different processes. In the next section these effects will be applied on the SCEM-framework to show how SCEM benefits from RFID.

IV. THE CONTRIBUTION OF RFID TO SCEM

Different supporting technologies – such as Auto-ID, Mobile Computing and Agent Technology – are crucial for realizing SCEM [9]. In the following the impact of RFID in supply chain management will be analysed based on the developed SCEM framework and the RFID framework.

RFID supports the "monitor" function by reducing costs of data acquisition (automational effect). This effect allows users to implement additional data acquisition points thus enhancing the granularity of the data in the dimensions time and position. Decreasing tag prices will allow users to tag more and less valuable objects increasing the object granularity. Tags usually feature a unique identifier sometimes local memory or even sensing capabilities contributing to the content dimension of data quality. As a result RFID provides a deeper insight into the supply chain (informational effect).

The "notify" function profits from the automational effect of RFID which guarantees faster data acquisition and the informational effect with RFID providing data of higher quality.

"Simulate": the quality of a simulation increases if a more detailed model of the system exists and its actual states are known. RFID provides that level of detail through the informational effect.

In addition to the effects listed above the "control" of supply chain processes can be enhanced by RFID once data on the tag assist controlling operations. Some researchers are working on passive tags that even feature computing capabilities that would empower tags to control basic processes locally [20].

The four functions above are part of the "immediate reaction branch" in the SCEM framework (see Figure 2). "Measure" – the function associated with the "preventive branch" – does profit from the increased supply chain visibility and data quality (informational effect) helping management solve operational, tactical and strategic supply chain issues [3].

Transformational effects of RFID advance SCEM as a whole. RFID serves as an integrating technology supporting cooperation among supply chain partners [21]. Global standards are about to gain worldwide acceptance making RFID the preferred Auto-ID technology when it comes to tracking objects in global supply chains. The technology itself transforms SCEM by adding new features such as additional sensing capabilities. More efficient data capture enables shorter control loops – a precondition for effective SCEM. At last software needed to exchange RFID-data among supply chain partners usually contains some basic SCEM functions bringing SCEM in range of sight for many companies.

V. CONCLUSION

Many views of SCEM can be found in the current literature. This paper synthesized the findings into an extended framework. In order to analyze the impact of RFID on SCEM a framework providing an insight into the effects of the technology was developed. A detailed analysis shows various fields where SCEM can benefit from the implementation of RFID. The findings will contribute to projects with partners from different industries. In turn the insights gained from those projects will enrich the presented frameworks. Ultimately, we hope that this paper may give rise to an improved understanding of the impact of RFID on SCEM.

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