SERVICE LEVEL AGREEMENT COMPLIANCE MONITORING BASED ON RFID EVENTS

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ABSTRACT

Cross-company gathering of information about physical goods using RFID increases the transparency in complex supply chains. The EPCIS specification represents a standard for RFID-based event data and corresponding interfaces to capture and exchange it. These technical premises enable the development of new approaches towards evaluating Service Level Agreement compliance of service providers. In this paper, this potential is envisioned using a scenario from transport logistics. It is investigated, which requirements a technical framework supporting the extraction of evaluation data and their inter-organizational exchange would have to reflect. Addressing these requirements a conceptual system architecture is proposed which enables compliance monitoring based on RFID events.

KEYWORDS

Logistics, RFID, EPCIS, Compliance Monitoring

1. INTRODUCTION

Today's supply chains have to be adapted to multilateral quality requirements originating e.g. from customers, competition or even legal restrictions. This does not only affect separate levels of value added but also logistics services in between. Therefore, it is crucial for Logistics Service Providers (LSPs) to ensure the propagation of high quality requirements to subcontracted Transportation Service Providers (TSPs) moving goods along the supply chain. This is usually ensured by negotiating so called Service Level Agreements (SLAs) stating the expected quality characteristics of transport services.

Unfortunately, these SLAs are not always met by TSPs. (Martin Strassner and Stephan Eisen, 2005) As a consequence time and money consuming regulation measures have to be applied, which negatively affect the efficiency of the whole supply chain. To overcome this drawback, the use of meaningful experiences derived from own business connections but also from those of cooperating partners could be a significant benefit: by preferably choosing TSPs that have proven SLA compliance in former situations, future compliance could be inferred and thus regulation measures reduced.

Nowadays, the selection of TSPs is mainly based on quantity or value contracts which were established beforehand. The inclusion of experiences is not common because reliable, fine-grained data giving insight in transport processes and allowing to evaluate them afterwards was not available or rather cumbersome to capture so far. (Alexander Mirow and Stephan Eisen, 2004) This situation is currently changing, driven by the increasing cross-company utilization of the RFID technology. It enables the automatic identification (Auto-ID) of goods equipped with transponder tags and therefore an increased visibility of goods along the whole supply chain.

In this paper, we point out how RFID can be applied in transport logistics scenarios to increase transparency (Section 2). Furthermore, we infer technical requirements which have to be reflected by a framework enabling the generation and exchange of experience data based on RFID events and SLA information. A corresponding conceptual architecture design is proposed as well (Section 3). A brief overview of existing related work is given in Section 4 and Section 5 completes this paper with a summarizing conclusion and an outline of future work.

2. RFID UTILIZATION IN TRANSPORT LOGISTICS

As shown in Figure 1, RFID readers can be applied along the complete supply chain considering goods issue and goods receipt stations and even transport vehicles in order to capture and transmit data related to charged, tagged goods. This facilitates the accumulation of time-and-space-snapshots of transport processes and the state of the transported objects.

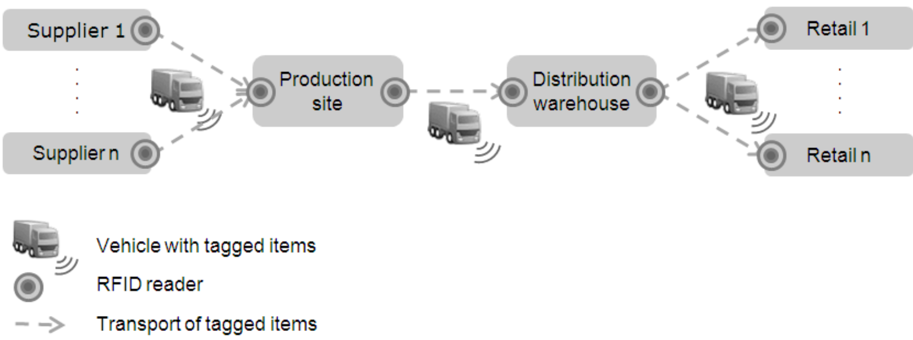

Figure 1. Supply chain scenario indicating the cross-company utilization of RFID tags and readers

The cool chain exhibits a good example, because usually, temperature settings have to meet strong restrictions and have to be relatively stable during the whole transport process. To ensure this, goods are equipped with small sensors capturing temperature data during discrete points in time and storing the measured values on associated RFID tags. These can then transmit the stored data to eligible readers. (Alexander Mirow and Stephan Eisen, 2004) The Auto-ID data collected across multiple companies is usually stored in databases for later access, exchange and evaluation. To support such scenarios and to overcome incompatibilities between companies' RFID-related IT infrastructures, EPCglobal has ratified several specifications which are already widely adopted by industries. The EPC Information Services specification (EPCglobal Inc., 2007) is of particular interest for our work, because it standardizes interfaces for capturing and querying EPC-related event and metadata. Software systems implementing these interfaces are called EPCIS Repositories that store RFID events represented in the form of EPCIS Events. The specification classifies four event types: ObjectEvent, AggregationEvent, QuantityEvent, and TransactionEvent. They represent object observations, object aggregations, object quantity observations, and connections of objects and business transactions. Additionally, the specification allows for user defined extensions of event types enabling the reflection of any conceivable state of tagged objects depending on respective use cases.

The data available in EPCIS Repositories and SLAs can be used to derive information and thus experiences about the compliance of TSPs. A technical framework supporting the generation of experiences and their exchange between cooperating LSPs has to meet several use case depending requirements which are outlined in the next section. Furthermore, a conceptual architecture design is shown in Figure 2, envisioning the reflection of the given requirements.

3. REQUIREMENTS AND CONCEPTUAL DESIGN

As described in Section 2 the EPCIS specification formalizes the representation of RFID events in EPCIS Repositories. To compare this data with the not yet unified data captured in SLAs, a schema has to be designed which enables the representation of quality information typical for transport processes like quantities, states, times and locations (Klaus Dorer and Monique Calisti, 2005). Once SLA data has been formalized, it can be compared to transport process monitoring data retrieved from EPCIS events. To allow for an automated comparison, a rule set has to be defined which represents dependencies between both available information sources and specifies the computation of variances, e.g. the duration of transport maps to the time difference of RFID events at goods issue of warehouse A (source) and at goods receipt of warehouse B (sink). The actual computation and interpretation of the rule set has to be performed by a

suitable rule engine, which has to extract data from the available information sources, combine it and return information about the compliance to negotiated quality requirements in an appropriate data format.
The data format has to be easy to interpret in a cross-company setting, which means that it has to instantiate a schema ensuring interoperability by its syntax and semantics, since the actual utilization of this experience data depends on the respective company's intentions. (Sylvia Encheva, 2007) This also implies the need to represent context information like applied units of measurement and metrics with the experience data, because these may vary between different usage scenarios but still have to be comparable.

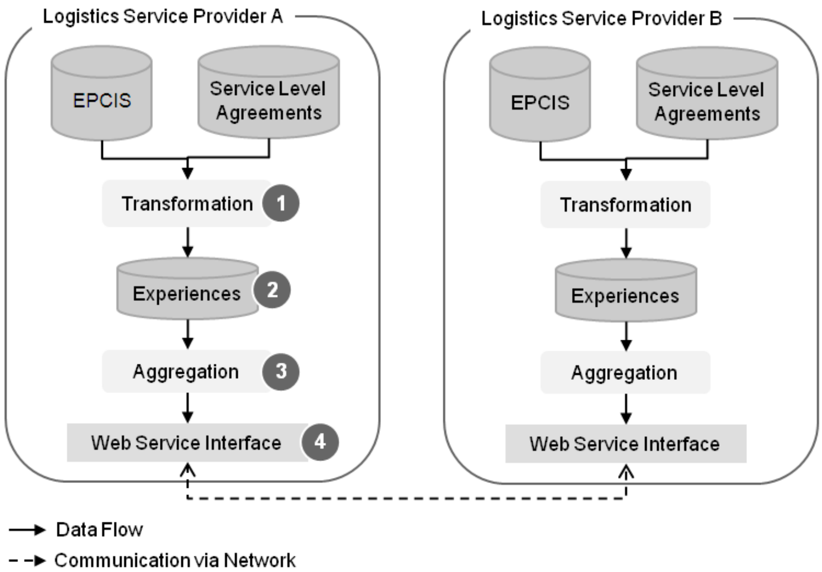

Figure 2. Conceptual architecture design

The computed experience data is designated for an exchange between cooperating LSPs but still has to meet their confidentiality requirements. Instead of simply exchanging „raw“ experience data with any interested partner, operators allowing for the reflection of diverse trust relationships between cooperating LSPs and thus allow data to be exchanged in different abstraction and aggregation levels should be applied. Appropriate access control mechanisms have to be utilized in addition to limit access to only authorized partners. To technically enable the exchange of experience data, easy to implement interfaces have to be provided which could be accessed via a network.
To allow for later extensions, any applied interface or schema should provide easy to use extension points because it can be foreseen that reflected data or user interests vary over time since technologies improve and influences on supply chains change.
In general, typical system requirements like robustness, scalability and efficiency have to be considered as well but will not be of particular interest in our work.
Table 1 summarizes the above given requirements and indicates their reflection in specific system components (see Figure 2) by numbers in brackets.

Table 1. Summary of key requirements (numbers indicate connections to system components depicted in Figure 2)

Real world requirements	**Reflection in conceptual design**
Computation of experiences	Extensible SLA schema (1)
	Extensible and parameterized rule set reflecting dependencies between EPCIS data and data captured in SLA schema (1)
	Rule interpreter (1)
Easy to interpret and compare representation of experiences	Extensible schema and unified data format integrating context information like applied units of measurement or metrics (2)
Mechanisms to access experiences while still taking account of confidentiality requirements	Operators that allow to exchange experience data in different abstraction and aggregation levels (3)
	Unified and easy to implement interfaces (4)

4. RELATED WORK

The fine-grained monitoring of contractual specified quality parameters during transport processes is almost exclusively practically performed in the cool chain so far. (Alexander Mirow and Stephan Eisen, 2004; Ruud Riem-Vis, 2004) This is why research in this area is mainly focused on this specific use case. While it is examined how data could be gathered using sensor and Auto-ID technologies and stored in rather proprietary software systems, the derivation of experience data and the support of cross-company usage scenarios is usually not considered at all.
Already well established approaches to the determination of long term experiences are supported by Data Mining mechanisms on data stored in huge Data Warehouses (William H. Immon, 1992). These mechanisms can be applied to RFID based event data. They differ from our approach in their potentially redundant representation of stored data and in their long term character by allowing high response times due to very complex computations. Furthermore, a cooperative exchange of the computed data is not intended.

5. CONCLUSION AND FUTURE WORK

In this paper, we showed that experience data about the SLA compliance of TSPs can support LSPs during the carrier selection process. The therefore required information is already available in EPCIS Repositories and SLAs. What is currently missing and not yet addressed is a technical framework enabling the processing, representation and inter-company exchange of this data. To promote the development of such a framework, we outlined several requirements and introduced a conceptual architecture design showing how they could be addressed by specific system components.
Our future work will be guided by these requirements. In a first step we are going to analyze SLAs in the transport logistics setting to later define a generic schema representing the comprised information. Based on such a schema the available information can be mapped to the transport process monitoring data stored in EPCIS Repositories which drives the development of a corresponding rule set and an interpreting engine. This will give insights on the actual range of quality data which can be derived from the available information sources. Furthermore, it has to be decided on an appropriate evaluation mechanism which reveals the quality of derived experience data. This presumes the definition of a proper quality measurement. One approach we have in mind is to chose a dedicated simulation environment and run TSP selections with and without the influence of experience data. The SLA compliance information gained from monitoring data from later on simulated transport processes could then be compared. High compliance rates should preferably be performed by TSPs chosen due to good experiences to support our assumptions and the quality of experience data.

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