EPCIS-based tracking and tracing of returnable transport items in the food supply chain

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1. Motivation and research objectives

In recent years, food safety and quality issues have drawn more and more public attention worldwide. Food crisis und product recalls in the last decade have not only caused severe image damage and sales drop but also shaken the consumer confidence dramatically. In this context, traceability legislation and regulations are becoming more stringent (Mejia, Muth, et al. 2010). The European Union (EU) Regulation 178/2002 came into effect in January 2005, while the US Bioterrorism act has been in effect from December 2003 (Senneset, Forås, et al. 2007).

However, the regulations have not involved the implementation details of a tracking and tracing system. According to (Bechini, Cimino, et al. 2005), a large amount of traceability systems are still paper-based and not adequately equipped for timely and accurate tracing of products. Furthermore, the diversity of the systems also makes the integration difficult.

Nowadays, the development of Auto-ID technologies especially the RFID technology brings new opportunities for improving tracking and tracing process and thus increases the supply chain transparency (Kelepouris, Pramatari, et al. 2007). Since food chain safety and traceability demand an in-transit visibility of the returnable transport items and their carried products (Martínez-Sala, Egea-López, et al. 2009), an intelligent container as well as the IT-infrastructure will be developed in the 6th subproject of the integrated research Alliance "FORFood"[1]. RFID technology, temperature sensors and if necessary also the localisation module such as GPS will be integrated in this container to make it intelligent.

The main objective of the doctoral research is to apply the EPCIS (Electronic Product Code Information Services) standard for supporting the tracking and tracing process of intelligent containers in the food chain. EPCIS is an EPCglobal[2] standard designed to enable EPC-related data sharing within and across enterprises (EPCglobal Inc™ 2007). It is the crucial component of the EPCglobal-network (a global approach for internet of the things) and enables a useful semantic interpretation of Auto-ID data to improve supply chain visibility. Recently, some pilot projects have started to test and adapt EPCIS standard for tracking and tracing in various branches of industry, such as pharmaceutical industry (RFID Journal n.d.), automobile industry (Auto-RAN 2010), textile industry (GS1 Germany 2007) and so on. It is also reported that some countries have recently launched pilot projects using EPCIS in the food sector such as the fish industry (eTrace 2010). As a standard of EPCglobal, EPCIS is becoming the de facto standard for exchange of RFID/EPC events in the future (Myhre et al. 2009). However, despite the worldwide attention, the adoption level of EPCIS is still in its infancy (Kim et al. 2010). The implementation of EPCIS should be investigated and adapted for various application scenarios. Furthermore, how to integrate EPCIS into existing IT infrastructure still remains elusive. In addition, since EPCIS is becoming the most important standard for RFID data exchange, it's also important to analyse and interpret the EPCIS-based data to support high-level business applications such as Returnable Transport Items (RTI) management system.

2. Methodology

The doctoral research will be carried out in the following steps:

[1] FORFood is a Bavarian Research Foundation funded integrated research project addressing ways to optimize the usage of resources and to increase food quality and efficiency in food manufacture and distribution.

[2] EPCglobal is a subsidiary of GS1. It is an organization set up to achieve worldwide adoption and standardization of Electronic Product Code (EPC) technology. The main focus of the group currently is to create both a worldwide standard for RFID and the use of the Internet to share data via the EPCglobal Network.

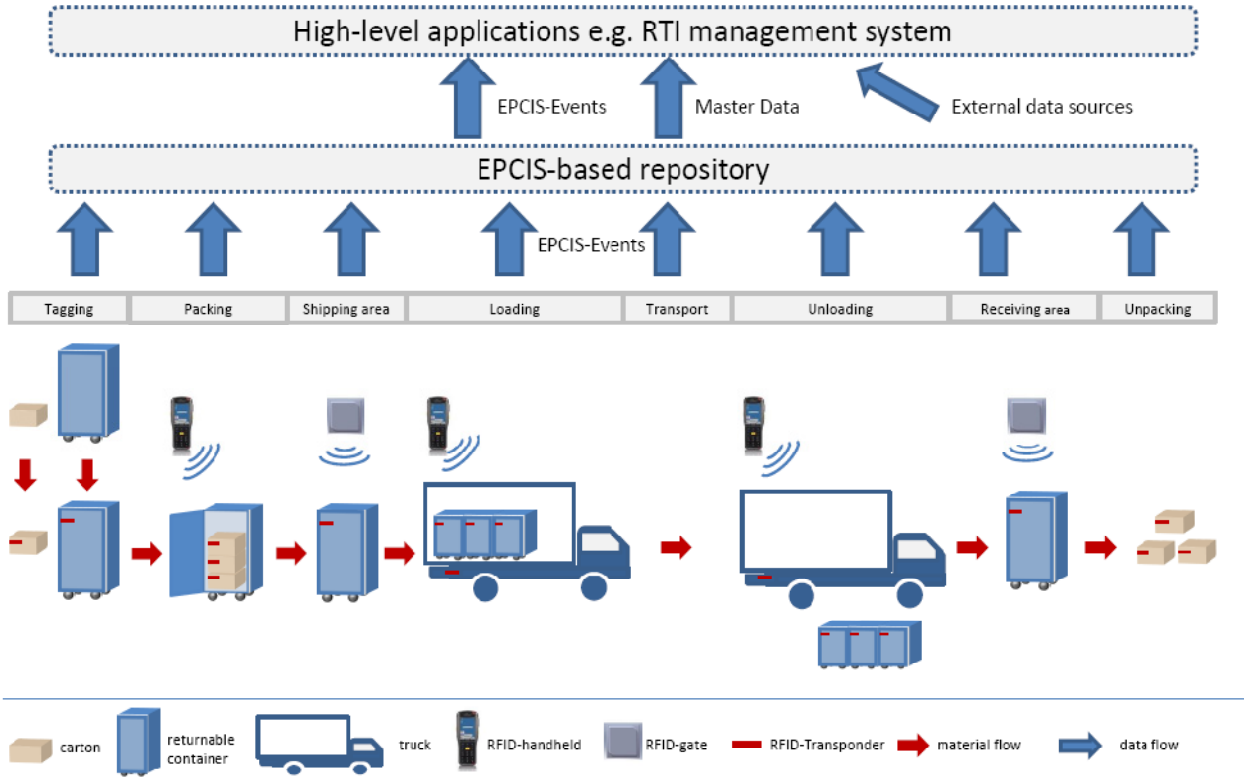

Fig.1 A framework for EPCIS-based tracking and tracing

2.1 Identification of key data elements for supporting the tracking and tracing process

Any trade item and location, which need to be tracked or traced, should be uniquely identified (ECR Europe 2003). The EPC coding system is expected to become a standard for open, global RFID usage, and a core element of EPCglobal network. EPC identifiers are provided by GS1 (EPCglobal Inc™ 2008) and accommodate the currently in industry widely used GS1 EAN.UCC system (Bechini et al. 2008). In this research, the key data elements for tracking and tracing of returnable transport items and also their contents will be discussed and identified. Besides the identification of RTI and business location, the integration of product batch number, expiry dates, temperature and GPS data as well as the extension of EPCIS-vocabulary will also be investigated.

2.2 Simulation of EPCIS-Event driven food supply chain

In the area of supply chain management, simulation methods are widely adopted (Kleijnen 2005). Recently, with the development of RFID technology simulation of RFID-based supply chain are discussed in several papers (S. J. Wang et al. 2008)(Y. M. Lee et al. 2004). However, in these papers simulation models are modelled mainly to examine and determine ways in which RFID could improve the current supply chain efficiency and accuracy. In this research, a simulation model will be developed for simulating material flow of returnable transport items as well as their information flow namely the EPCIS events in the food supply chain. Another way for generating the EPCIS events is using data generators, which is common in software engineering, e.g. for database tests (Stephens & Poess 2004). However, Data generators cannot represent the process interdependencies in the supply chain, e.g., a returnable container has to be filled with products at distributor at first, then loaded into the truck and not until then transported to the retailer. Therefore, in our study the process simulation will be used. The Events will be generated according to the EPCIS 1.0.1 specification and forwarded into the EPCIS-repository for further analysis. A framework for EPCIS-based tracking and tracing is illustrated in Fig.1. In this figure a simple supply chain scenario is shown. For complicated process more identification points would be established.

2.3 Rule-based analysis of EPCIS-events for supporting tracking and tracing & RTI management

An example of EPCIS events with XML binding looks like the following:

```
<ObjectEvent>
  <eventTime>2010-10-14T10:20:25</eventTime>
  <epcList>
    <epc>urn:epc:id:grai:0123456.12345.1234</epc>
  </epcList>
  <action>OBSERVE</action>
  <readPoint>
    <id>urn:epc:id:sgln:0123456.01234.1234</id>
  </readPoint>
  <bizStep>urn:epcglobal:epcis:bizstep:fmcg:shipped</bizStep>
  <bizLocation>
    <id>urn:epc:id:sgln:0123456.12345.0</id>
  </bizLocation>
</ObjectEvent>
```

This event indicates that the container identified by EPC number (GRAI: Global Reusable Asset Identifier) with URI format *urn:epc:id:grai:0123456.12345.1234* has been read (action=OBSERVE) by an RFID Reader at 10:20:25 on 14.10.2010. The business step bizStep indicates that the container was shipped by a supply chain partner and read at a specific location defined by Serialized global location number (SGLN) with URI *urn:epc:id:sgln:0123456.12345.0.*

As mentioned in 2.2, the EPCIS-Events will be stored in EPCIS-based repository. High-level systems and tools can resolve the events not only for tracking and tracing issues, but also for deducing Key Performance Indicators (KPI) as well as finding out hot spots in the supply chain using rule-based analysis. In the scenario of RTI management, using the tracking and tracing data, KPI such as RTI stock level, average cycle times and average transport times (Bowman, Ng, et al. 2009) could be determined. Moreover, Supply Chain Event Management (SCEM) applications can also be supported based on EPCIS-events analysis. SCEM refers to monitoring, prioritizing and reacting to events that occur pertaining to the flow of goods in the supply chain (Otto 2003). In the context of RTI management, the monitoring of RTI conditions and the alarming in case of injury of predefined rules all belongs to SCEM applications (Hofmann & Bachmann 2006). For this purpose, external data sources (e.g. predefined conditions, EDI) should be connected to the analysis to detect differences between physical observations based on EPCIS-Events (as-is-situation) and expectations (to-be-situation).

3. Expected results

This doctoral research aims to contribute to building a framework of EPCIS-based tracking and tracing of RTI in the food supply chain. For this purpose, the key data elements related to RTI tracking and tracing will be identified and their integration into EPCIS will be discussed. Moreover, a process simulation model will be developed for simulating EPCIS-Event driven RTI flow in the supply chain. The simulation model should be flexible to extent for adapting to various application scenarios. Furthermore, the rule-based analysis of the generated EPCIS-Events will be carried out for supporting the high-level RTI management system.

Further results will be the recommendations of integration of EPCIS with currently in industry widely used EDI systems and the procedures for product-level (contents of RTI) tracking and tracing in the food supply chain.

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