QUALITY TRACEABILITY FROM PRODUCTION TO RETAIL SHELF CASE STUDY AND SOFTWARE TOOLS FOR MEAT TRANSPORT

Patrick Dittmer, Marius Veigt (both Bremer Institut für Produktion und Logistik GmbH – BIBA), Markus Becker (ComNets (University of Bremen)), Alexander Dannies (IMSAS (University of Bremen)), Ulfert Nehmiz (OTARIS Interactive Services GmbH), Martin Hosse (Seeburger AG)

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Bremer Institut für Produktion und Logistik GmbH
Hochschulring 20
28359 Bremen
Germany
Phone: +49 421 218 50090
E-Mail: dit@biba.uni-bremen.de

1. Introduction

Almost one third of food produced for human consumption is wasted globally [1]. For this reason, the joint industry research project “The Intelligent Container” developed a container that enables – through combination of technology and software – quality monitoring of distribution processes for perishables to optimize logistics processes and consequently reduce wasting food [2].

A lot of various actors work along the supply chain of perishable goods. Thus, the management of cold chains needs flexibility in logistics as well as technical and software solutions for communication and coordination. A cold chain network from producer to retail shelf involves different actors as producer, logistics service partners and distributors with production, transport, storage, handling and distribution processes. Between these process steps goods are consolidated to shipments, deconsolidated and distributed as retail units; quality tracing of these goods means to interact with this complexity. Therefore, technical and software systems have to be developed.

In this paper a concept for flexible quality traceability for meat is shown. The first part of this work describes a method to analyze business processes for logistics and the integration of data transfer in these processes. In the second part of the paper the technical solution is depicted. Its content involves the necessary hardware as well as the required software which enable the implementation/realization. In conclusion, the impacts of the “Intelligent Container” on cold chain logistics will be shown.

2. Cold chain logistics

Optimization of supply chain is necessary to stay competitive in business. A method for optimization is the SCOR model, especially for strategic optimization along the entire supply chain with all actors. SCOR is an acronym for Supply Chain Operations Reference. The SCOR model includes all important processes for supply chains, e. g. planning, sourcing, making, delivering and returning. Furthermore, it combines the concepts of business process reengineering, benchmarking and best practice analysis to a cross-functional, standardized model. [3]

For strategic orientation of supply chains, supply strategies, e.g. make-to-order or deliver-to-order, can be defined according to the customer order decoupling point (CODP). The CODP is defined by the synchronization of pushed operations of the supply (forecast-driven) and pulled operations by the market (driven by customer order). [4]

Especially for food supply chains two supply strategies are common: deliver-to-order for nonperishables with forecast-driven processes and make-to-order for perishables with customer order driven processes. The success of the make-to-order strategy depends on the effectiveness of logistics. To meet this effectiveness depot networks are very common in logistics with handling and storage of objects in depots. Fig. 1 illustrates a typical depot network with vendors, depots, a centralized warehouse and customers. This depot network is very common for cold chain logistics for meat. Within this example of a network four transport processes and three handling and storage processes take place. At a change from transport to storage processes potential risks for rise of temperature of perishable goods occur. [5]

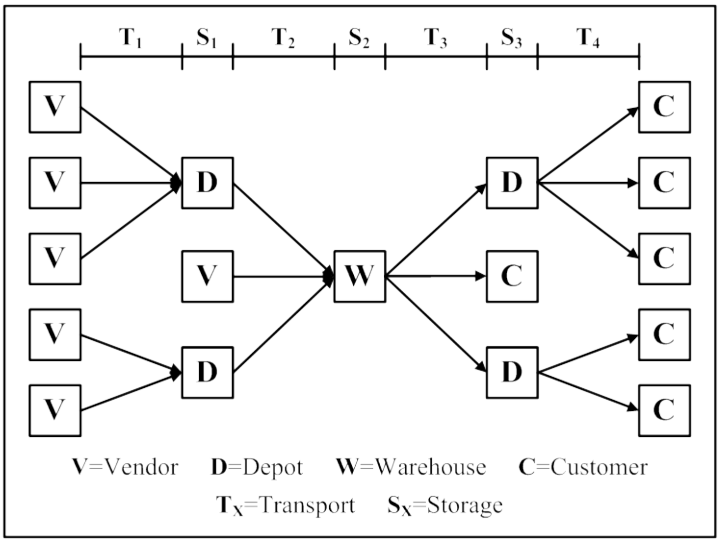

Figure 1: Logistics via a depot network [5]

“Intelligent Containers” can be used for transport processes to avoid incorrect conditions during the transport of perishable goods. These “Intelligent Containers” are equipped with technologies that enable online monitoring of the condition of perishable goods and changing settings autonomously during transport. Changes in the condition of the perishables are sent to the user via a middleware. These technologies are described in detail in chapter three. In brief the “Intelligent Container” consists of a Wireless Sensor Network (WSN), a Freight Supervision Unit (FSU) and a telematics gateway. The middleware provides the data of the “Intelligent Container” to the customers via a customer defined data interface, see fig. 2. So customers can integrate the information of the “Intelligent Container” in their own IT systems. This also allows using the information of the “Intelligent Container” along the entire supply chain.

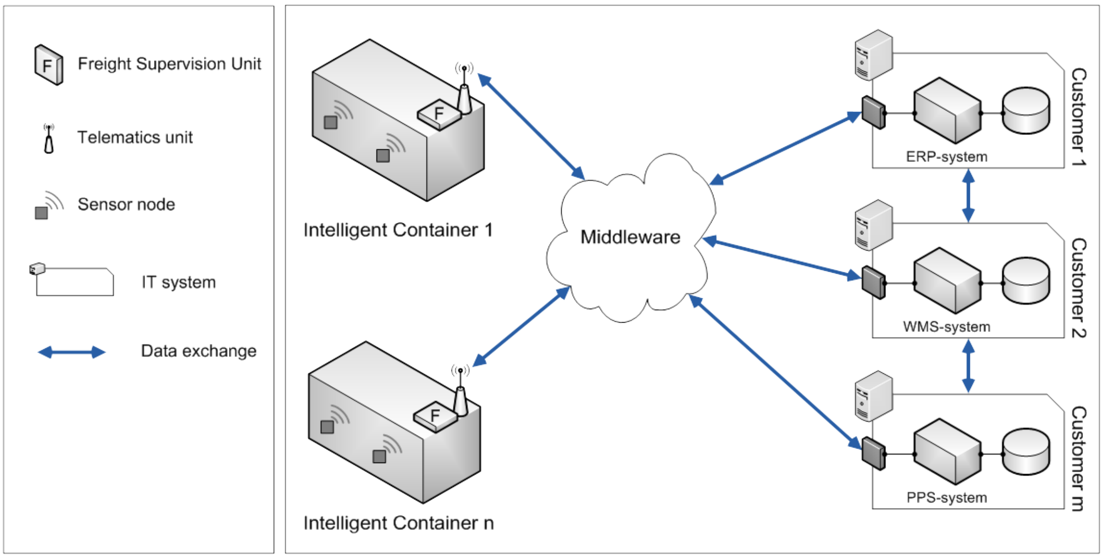

Figure 2: “Intelligent Container” and IT-infrastructure

As seen in fig. 1, changes from transport to handling/storage take place. To use online monitoring of perishables by the “Intelligent Container” every container or trailer and every depot has to be equipped with particular hardware which is connected to the middleware. However, in the near future there will be also containers and trailers without this particular hardware. To monitor the entire supply chain continuously we had to develop a concept of offline monitoring as well. For this concept the wireless sensor nodes have to be integrated in the perishable goods, e. g. sensor nodes in boxes or on a pallet. During transport or storage processes without connection to a FSU the sensor nodes must be able to log relevant data offline. When a FSU is available these sensor nodes have to be switched to the regular online mode while handling the pallets concerned. As usual in logistics scanning of these goods take place at handling processes. A software application installed on a handheld or a tablet computer and a FSU enable configuring the sensor nodes when scanning is performed. A detailed introduction to the software application can be found in chapter four.

A forwarding label was invented to provide all important information machine-readable to execute the processes of the “Intelligent Container”. This forwarding label was created according to GS1-standard GS1-128 and EDI-standard DESADV meeting specifications for electronic data interchange [6]. Furthermore, this data was extended by relevant information to use the “Intelligent Container”. Information according to GS1- and EDI-standard are serial shipping container code (SSCC), master SSCC, global trade item number (GTIN), consignee, consignor, load, number of pallets and date of manufacture. Further relevant data for the “Intelligent Container” are minimum and maximum temperature for transport, handling and storage in degree Celsius and degree Fahrenheit. All this information is provided machine-readable in two GS1-128-codes or just one QR-code on the forwarding label. To use the “Intelligent Container” every pallet has to be equipped with this forwarding label.

3. Technology of the “Intelligent Container”

The traceability of the individual legs of the transport is performed by using WSNs. When no means of communication to the Internet is available (e.g. because of no cellular network coverage or no telematics device being present), those nodes can work in a regular offline logging mode, where measurements are stored to non-volatile memory. At the end of one leg of a transport the nodes can be read out to provide the data for the middleware and the customer IT systems. Contrary to regular passive RFIDs, the nodes do not need to pass a reader, but only need to be in distances comparable to WLAN covered areas of around 30-50 m to a static Freight Supervision Unit (FSU) in the warehouse. Additionally, when the transport device (ISO container for shipments, or trailer for road transport) is equipped with a mobile FSU, the nodes can work in an online mode and transmit the measured data to the FSU during the transport (unlike passive RFIDs). The data can then be processed according to specific quality models of the goods in transport. The hardware system enabling tracing of quality consists of a network of sensor nodes, a Freight Supervision Unit, a telematics unit and a back-end middleware server, see fig. 3.

Only when combined with customized software the supervision system becomes alive. The software for the resource-limited sensor nodes enables the collection and transmission of data in a way that the battery-life is maximized. Standard compliant protocols are used by the WSN where appropriate [7]. The FSU offers a software platform in form of an OSGi-framework. In this way it becomes possible to install or update software modules for each specific task that is needed in the application – so called bundles – during runtime and also remotely. Bundles for more complex algorithms – the so called Decision Support Tool (DST) – as well as communication with the base station of the WSN or the telematics unit are running in parallel. During the operation in online mode or the transition from offline to online mode the algorithms for quality estimation calculate the current status of the goods based on the collected sensor data. Based on the calculated status of the transported goods notifications can be send via the telematics unit to the back-end.

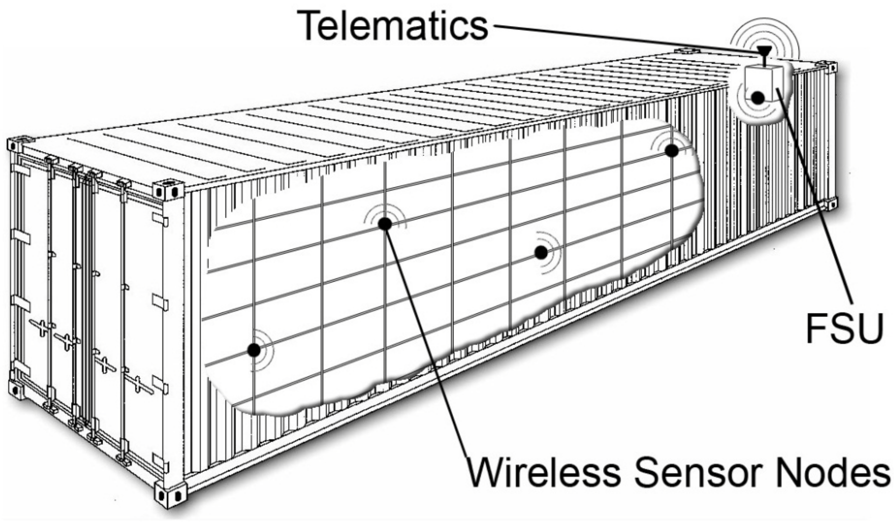

Figure 3: Hardware of the “Intelligent Container” [8]

4. User interface

The development of an interface for using the “Intelligent Container” system is very important for a successful integration into the logistic processes. The users will operate the system with a web-based service for configuration and monitoring of the traceability system. To represent logistics processes such as consolidation of shipments and deconsolidation of the shipment to retail units a handheld application has been implemented. It allows the online/offline initialization of the sensor nodes with the appropriate quality model based on the type of goods. The application for a handheld shown in Figure 4 allows the initialisation, reinitialisation and deinitialisation of the transport process as well as the involved technology components.

Figure 4: The process support application running on a handheld device

The user of the handheld (e.g. the producer in Figure 5) scans the QR code contained in the label on the good generated from the web-based service, which includes information on the appropriate transport and surveillance conditions. The QR code of the sensor node is scanned as well to connect the device with the good to be monitored and to initialize the sensor node, e.g. with an offline logging mode. At the distribution center the handheld application can be used to read out the logged data and reinitialise the sensor node for online logging, where the measured data is sent to the Freight Supervision Unit (FSU) and to the middleware. At the customer the handheld application is used to stop the logging and de-initialise the transport process.

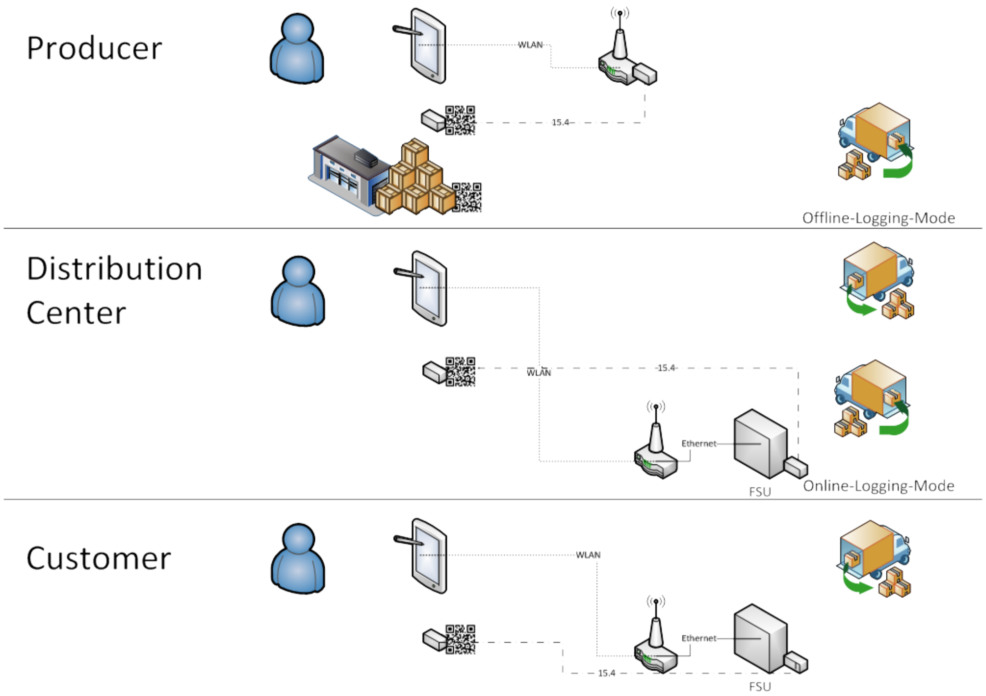

Figure 5: User Interaction and Communication for initialisation, reinitialisation and deinitialisation

5. Impacts on cold chain logistics

The concept of the “Intelligent Container” enables an early reaction to events that change the logistics process. Fig. 6 illustrates exemplarily a quality model that calculates changes in the shelf life of the product. The reduction of the remaining shelf life affects subsequent logistics processes directly.

It is possible to predict the remaining shelf life of food by using a quality model. In the target logistics process, a defined shelf life for distribution Q_d is reached at the time t_{dT}. If the remaining shelf life decreases during the transport, the distribution has to be brought forward to an earlier time t_{dA}. By using the quality model, the event of change t_i initiates an actual logistics process that includes the time displacement of the distribution to t_{dA}. The implementation of the autonomous coordinating system requires flexible logistics processes, which allow temporal adjustments for the distribution.

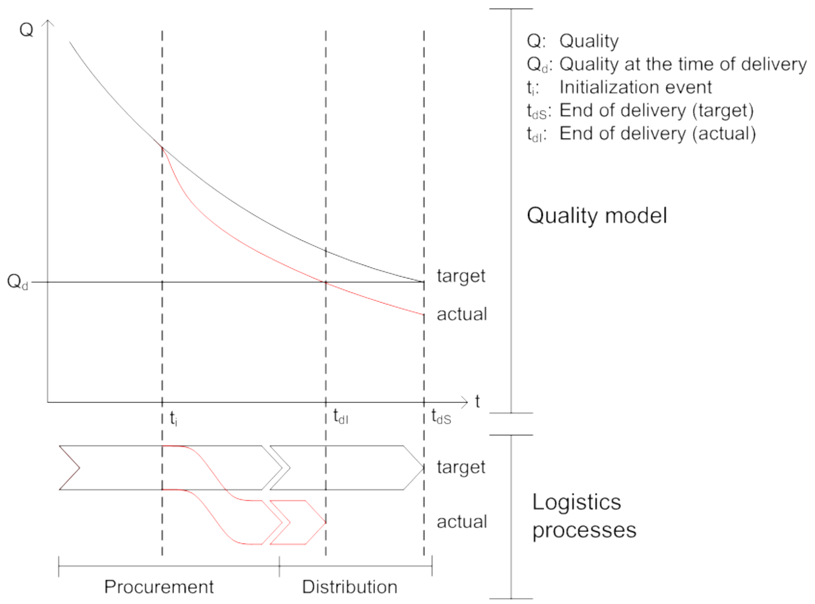

Figure 6: Impacts of the “Intelligent Container” on cold chain logistics [9]

Furthermore, the concept impacts upstream processes in the supply chain. If the “Intelligent Container” detects a decreasing shelf life which is not caused by a change of the logistical environment, the collected data can be used to influence the production of perishables and thus to detect eventual deficits in quality in the production process. An early identification of the deficits results in a decrease of spoilt products within the logistics system.

6. Conclusion

The “Intelligent Container” enables online monitoring of distribution processes in cold chain logistics. With the detailed information of the quality of perishables new logistics processes can be designed to raise the effectiveness of logistics for perishables and thus reduce waste of food. To meet the requirements of a flexible logistics network a new concept for partly offline tracing of perishables like meat was developed. In cooperation of technologies, e.g. WSN or FSU with telematics, and software, e.g. quality models for shelf life prediction or mobile applications to support logistics processes with the “Intelligent Container”, even offline tracing allow to use the advantages of the “Intelligent Container”.

7. Acknowledgment

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