The intelligent container: Combining RFID with sensor networks, dynamic quality models and software agents

Reiner Jedermann[1], Dieter Uckelmann[2], Adam Sklorz, Walter Lang[1]

[1]Institute for Microsensors, -Actuators and -Systems (IMSAS), University of Bremen

[2] LogDynamics Lab, University of Bremen

Motivation

The evolving trend to shift logistical planning to automated systems demands for improved monitoring of supply chains. Advanced tracking and tracing has to include information about current temperature and other environmental conditions. The prediction of changes in freight quality is very valuable additional information for optimization of transport processes and warehouse keeping. The *Intelligent Container* implements an autonomous transport monitoring system that goes beyond nowadays telemetric solutions for remote supervision.

System concept

The *Intelligent Container* adapts automatically to the supervision requirements of the loaded commodities. A dynamic quality model calculates the repercussions of suboptimal transport conditions. This software representation of the freight item is realized as mobile process by concepts from the field of intelligent agents. The freight items only have to be equipped with passive RFID-Tags containing address information to indicate which system currently holds the freight representation. After being transferred to the local system the agent collects data from the internal wireless sensor network and links them to the dynamic model. If the system foresees a risk that the quality will drop below an acceptance limit before the destination is reached, the agent contacts the route and transport planning instances to initiate necessary reactions.

Sensor supervision and dynamic quality modelling

As example for quality modelling we applied the well-known concept of keeping quality or shelf life for a dynamic course of the temperature[1]. Other factors, e.g. humidity or composition of the atmosphere, will be considered in near future. Especially the gaseous hormone ethylene has an important impact on the ripening process of agricultural products. A miniaturized gas sensor system that was developed by our institute for the detection of volatile aromatic components in ppb-concentrations will be adapted for the ethylene measurement.

Dynamic linking of the system components

Our concept removes the need to equip freight items with expensive components like sensors, processing power or large memory. Based on data stored on a standard RFID-Label the transport items dynamically link themselves to the facilities provided by the surrounding environments. Information that accompanies the fright is transferred through the communication infrastructure. By shifting all costs to long term investments into transport vehicle and warehouse equipment our concept allows extensive supervision at minimum costs per transport unit.

Technical implementation

Within the research of the Collaborative Research Centre 637 „Autonomous Cooperating Logistic Processes“ funded by the Deutsche Forschungsgemeinschaft (DFG) the *Intelligent Container* was developed as a core element for an autonomous supply chain. The software agents representing the quality models are executed on a check card sized processor module. Our reduced scale prototype is associated with a dynamic route and transport planning system.

Contact

Dipl.-Ing. R. Jedermann, University of Bremen (FB1 / IMSAS), Otto-Hahn-Allee NW1, D-28359 Bremen, GERMANY, rjedermann@imsas.uni-bremen.de, Phone ++49/421/218-4908, Fax -4774

[1] Cooperation with Wageningen University, Horticultural Production Chains

Fig. 1: Prototype of the intelligent container.
Loaded freight items are scanned by the RFID-Reader on the left. Sensor nodes supervise the environmental conditions (middle). A credit card sized processor module on the right side executes a software agent containing specific transport instructions and quality modelling. The module for external mobile communication is placed on the right side panel.

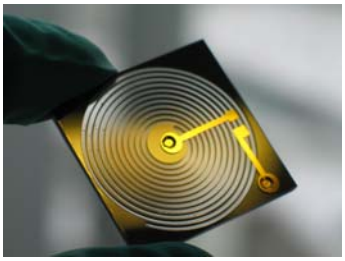

Fig. 2: Besides temperature controlled atmospheric conditions are used to extend product lifetime. The picture shows a micromechanical fabricated gas chromatography column that will be adapted for ethylene detection.

Fig. 3: Sensor node for wireless transmission of measurement values inside the means of transport. Modules for temperature, humidity, light and vibrations are available.

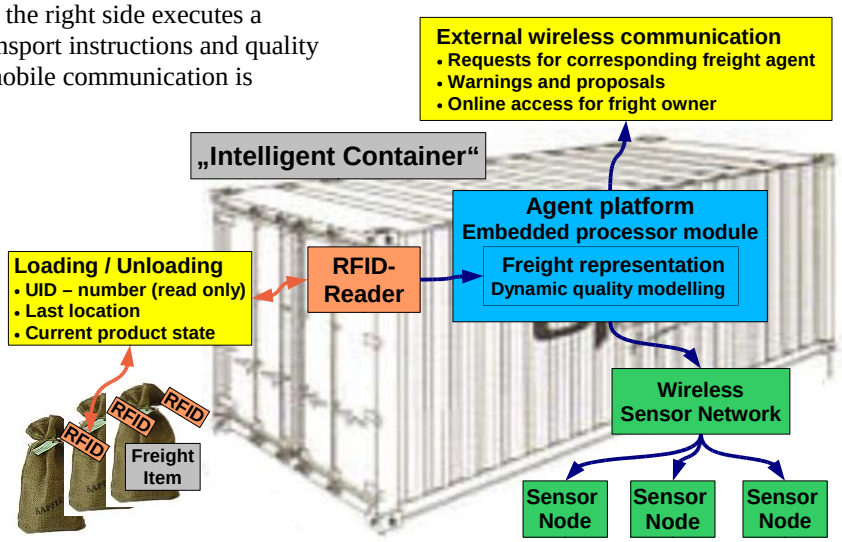

Fig. 4: Loading and supervision process: After reading the identification number and address of the preceding host system from the tag the transfer of the mobile agent is initiated. After being started on the local platform the agent accesses the wireless sensor network, predicts quality changes and sends warnings over external communication if a potential risk is detected.

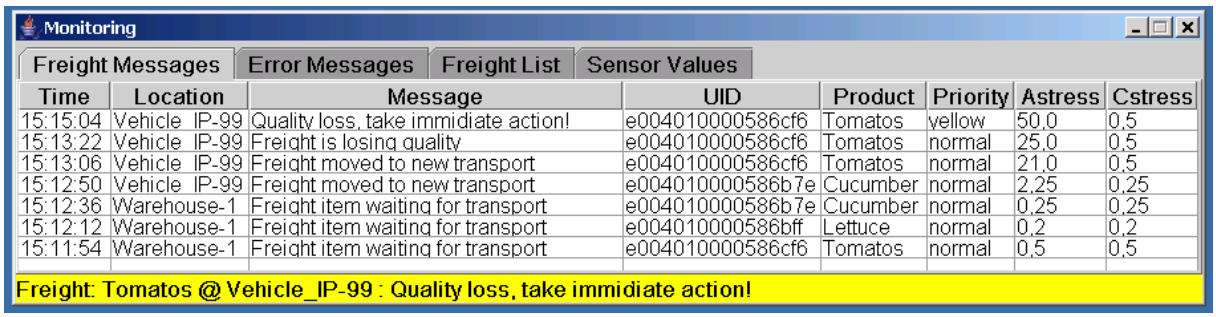

Fig. 5: Detail from the graphical user interface for the freight owner: The window lists all warning messages for selected items including time stamp (time-lapse mode) and current location. The embedded unit calculates stress resulting from deviations of the optimal transport conditions. The current and the accumulated stress are displayed as percentage value.