Motivation

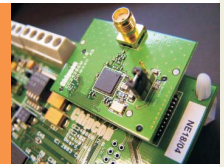
The evolving trend to shift logistical planning to automated systems demands the improved monitoring of supply chains. Advanced tracking and tracing of goods and containers has to include information about current temperature and other environmental conditions. This information is used for both prediction of changes in freight quality and as additional information for optimization of transport processes and warehouse keeping. By applying novel information and communication technologies the Intelligent Container implements an autonomous transport monitoring system that goes beyond current telemetric solutions for remote supervision.

Intelligent container demonstrator (Scale 1:8)

System Concept

The Intelligent Container adapts automatically to the supervision requirements of the loaded freight. A dynamic quality model calculates the effects of sub-optimal transport conditions. This software representation of the freight item is realized as mobile process by concepts from the field of intelligent software agents. The freight items are equipped with passive RFID-Tags containing the address of the system that currently holds the virtual freight representation. After being transferred to the local system the agent continues the freight supervision within the transport hold. 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 actions.

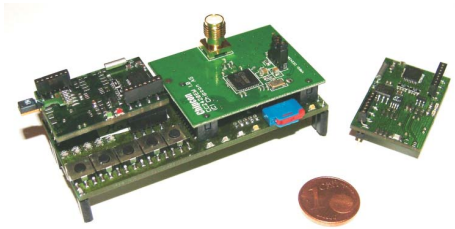
Wireless Sensor Networks



The agent collects data from the surroundings using wireless sensor networks that organize themselves autonomously. New nodes are automatically identified and added to the network in an ad hoc manner. Failure of one or more nodes (due to e.g. empty batteries, out-of-range) is automatically compensated by reorganizing the topology.

Communication security in the sensor network is a major concern and unauthorized access to the data must be prevented. This is done by using state-of-the-art encryption and authentication methods. In order to improve reliability built-in self-tests for sensors and methods for cross-network plausibility observation are integrated into the system.

Since the nodes of the wireless sensor network are battery-operated, particular attention has been put into energy efficiency. Network nodes that are not needed may be deactivated by an intelligent power management system in order to conserve energy and thereby increase the system lifetime.

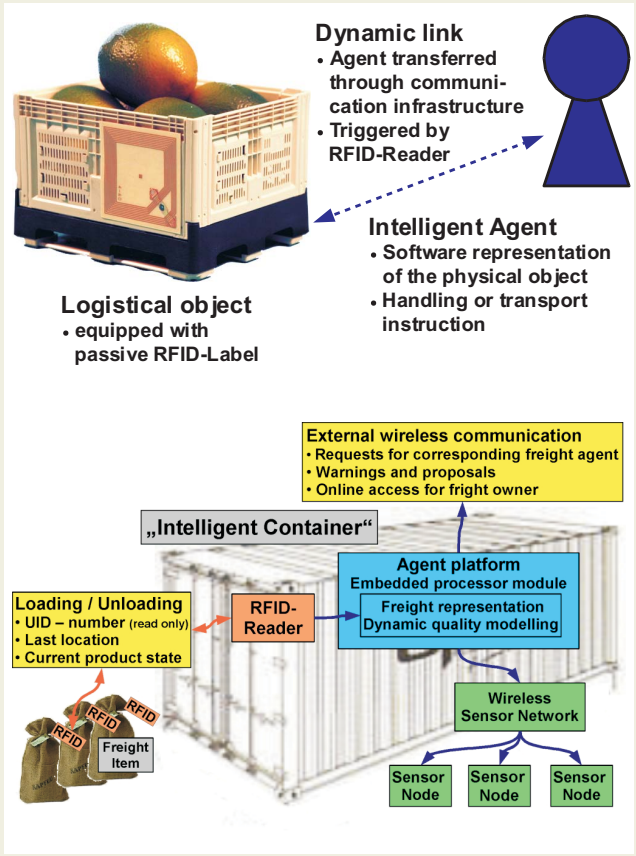


Sensor Supervision and Dynamic Quality Modelling

As an example for quality modelling, we applied the well-known concept of '*shelf life*' for dynamic temperature changes. Other factors, e.g. humidity or composition of the atmosphere, will be considered in near future. The gaseous hormone ethylene especially has an important impact on the ripening process of agricultural products. Commercially available sensor systems are not sensitive enough for consistently monitoring the degree of ripeness during transportation. In this domain advanced research and development is needed.

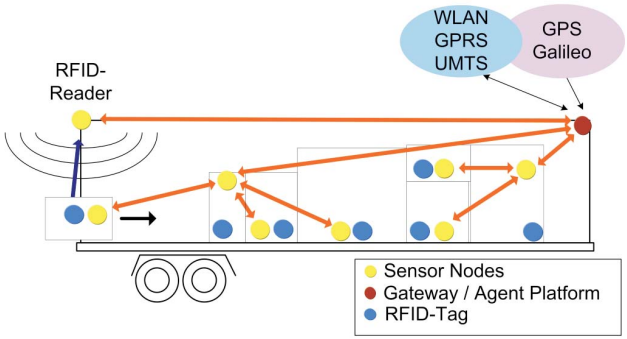
Dynamic Linking of the System

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



Technical Implementation

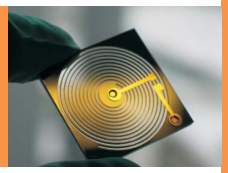
The Intelligent Container was developed as a core element for an autonomous supply chain through the Collaborative Research Centre 637 "Autonomous Cooperating Logistic Processes“ that is funded by the Deutsche Forschungsgemeinschaft (DFG). The software agents representing the quality models are executed on a check-card-sized processor module. Our reduced scale prototype is associated with a dynamic route and transport planning system. The external communication is carried out using different mobile networks (e.g. WLAN, GPRS or UMTS) depending on availability.



Application of Autonomous Cooperation

The Intelligent Container allows for fully automated transport planning. Decisions are made based on assessment of the outer world (traffic and market information) and the inner world (environmental condition affecting the freight). Local pre-processing within the transport vehicle reduces data volume and the costs for mobile communication. Central control instances and their processes were displaced by autonomous local processes which makes the proposed system very robust against failure of communication links or remote processing units. All these factors guarantee a permanent monitoring of food transports as required by EU regulations.

People



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SFB 637

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