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.

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.

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.

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[Image of RFID and Sensor Technology for Autonomous Transport Monitoring]