Loyal travel Companions

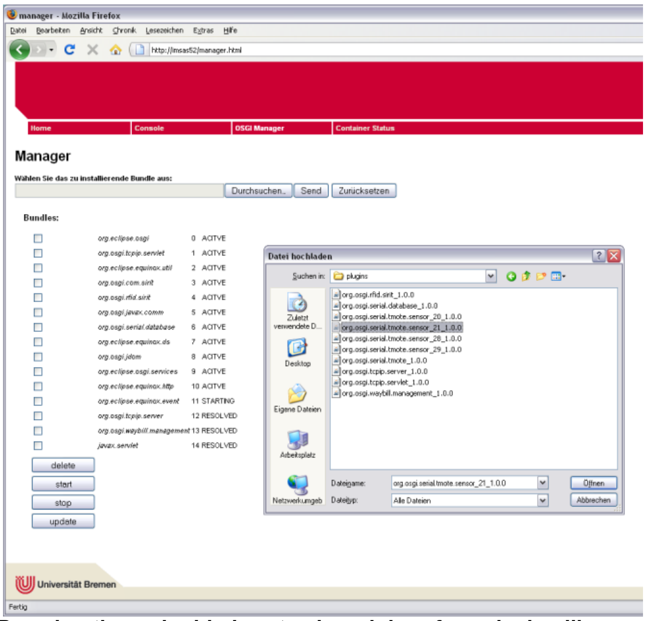
Seamless Transport Supervision Thanks to OSGi and RFID

Nowadays, supermarket customers are presented with a wide array of perishable goods coming from many different countries. These goods just completed a long journey, begging the questions: In what condition did the goods arrive? Did the transport go off without a hitch? Should the goods be sold right away, or can they stay on the shelves for a while? To help answer these questions, recent experiments have been performed on Dole shipping containers with bananas transported from Costa Rica to Hamburg. Temperature data is transferred via wireless sensor networks and satellite, all accessible with a web interface.

For this scenario, different models of shelf life were developed for use inside an "intelligent container". Using these models, the decrease in shelf life of individual goods inside containers can be calculated. Since the temperature inside a container can vary by up to five degrees Celsius, the local temperature of each shipping palette is also recorded. Taking these factors into account allows the remaining shelf life of the goods to be determined.

The Right Middleware

Presently, in order to determine the changes in quality of the goods, each container is shipped with a digital waybill that uses temperature records to track the loss in shelf life of the goods. These temperature records are collected from a network of radio sensors and transmitted to a base station. An embedded system gathers these records and subsequently assigns them to each digital waybill. These digital waybills are implemented as software agents in the Java-based JADE framework. Software agents are autonomous programs that are administered from the framework.



By using the embedded system's web interface, the intelligent container can be monitored and the software maintained.

OSGi and the "intelligent container"

However, the use of JADE involves a number of difficulties. Although JADE offers many features, the inefficient implementation of this middleware leads to long loading times for each agent. Experiments performed at the Institute for Microsensors, Actuators, and Systems (IMSAS) have shown that processing the digital waybill can last more than six seconds. In parallel and fast container loading, this duration is unacceptable. This situation called for new middleware to be developed. OSGi was the platform most suitable for this task. Originally, OSGi was developed through a partnership between IBM, Sun, and Ericsson. Due to its efficiency, OSGi has meanwhile developed into an industry standard of component-based programming. With OSGi, self-contained "programs" can be added during runtime. Using this technique, the so far existing system can be integrated with this new middleware. In addition, this framework offers all of Java's dynamic capabilities; in JADE, only one execution thread is available per agent, and communication between separate agents adheres to a fixed pattern. In contrast, OSGi supports multitasking as well as access to the classes and interfaces of other components.

Open Source Implementation

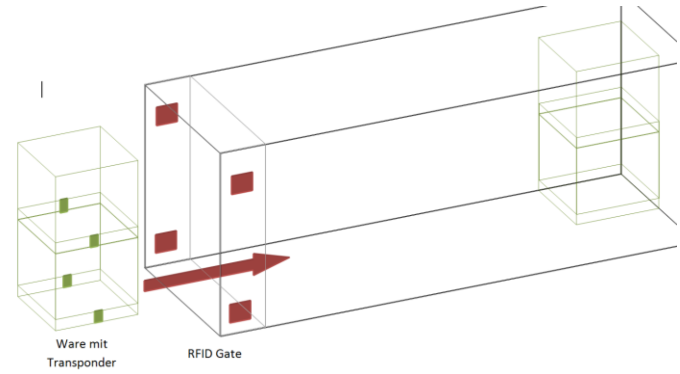
The interfaces found in OSGi are defined in a standard. Different commercial and freely available implementations of the OSGi framework exist. In this project, the widely used, open source Equinox implementation was selected for use. The entire framework as well as the integration of the interfaces and Java libraries was aided by an AICAS Jamaica installed on an embedded system. The XScale processor with a clock speed of 400 MHz and 32 megabytes of memory offers sufficient performance to operate the OSGi framework.

Optional System Update

In contrast, the remaining software is made up of OSGi components called bundles. Using bundles unleashes the fully dynamic capabilities of this platform for use. This means that individual software components can be installed and uninstalled on the fly during runtime. Thus, the entire container control software can be modified afterwards. A central component of this new software is the HTML interface. Using this, any computer on the network can control the embedded system. In addition to providing updated system condition information, the website allows the addition and removal of new bundles. An Internet connection affords the ability to execute a system update from any place on earth. The digital waybills are also realized as bundles in this framework. After a waybill is installed, it is then registered in the system and thereafter receives individual environmental information in the form of an event. The foundation of these records is the sensor network, whose data is interpolated based on the position of the goods.

Localization through RFID

In order to assign the waybills to the goods, RFID tags are attached to each palette. Four Deqtron antennas, placed in the entrance of the container, provide a secure detection of the transponders. Despite their small size of 5x5 cm, the antennas are strong enough to transmit from up to three meters away. The Sirit Infinity UHF-RFID reader from Meshed Systems is connected by TCP/IP to the XScale processor and signals when a transponder passes through the container entrance. The reader is then assigned to a waybill, which is eventually sent over a local network. The waybill, implemented as a bundle, is responsible for examining the individual goods. When the goods pass through a gate, the current status of the waybill is written to the transponder and can be read out by any UHF-RFID reader. However, a reliable registration onto the RFID transponder cannot be guaranteed for all conditions. Therefore, the current status is additionally transferred via a local network. When the goods are loaded again, the latest status is transferred along with the bundle. By doing so, the legally mandated supervision of perishable foodstuffs is made possible, and the waybill becomes a loyal travel companion of the goods.



During loading, RFID gates identify the goods, and simultaneously, the position of the goods is transmitted.

Additional Position Identification

The role of the RFID gate extends beyond simply coordinating goods and digital waybills. It also serves to provide a rough estimation of the position of the goods. The four antennas employ RSSI values to determine of the palette is placed high or low, or whether it entered the container to the left or right side of the entrance. In addition, the specific arrangement of the transponders allows a determination of the side of the palette that is loaded into the container. When the palette is stored on the same side as it was loaded, the exact position of the palette in the container can be determined. This position information forms the basis for retrieving temperature records for each individual waybill.

A 1:1 Scale RFID Gate

Experimental scenarios involving an RFID gate the size of a refrigerated container verified the effectiveness of the new software. Results showed that using the new middleware significantly reduces the time needed to register the waybills. The time needed from recognizing a transponder to complete installation and the initialization of the bundles now takes less than one second. The use of OSGi allows RFID event

A test run at the RFID-Gate

processing middleware to be implemented with improved system performance on embedded systems. Because of the bundle structure, individual system components can be subsequently modified, simplifying software development and maintenance. Using OSGi as middleware affords increasingly improved integration with practical applications. By employing RFID readers, OSGi offers the necessary infrastructure to fuse temperature records, the status of transported goods, and shelf life models.

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