Smart jacket as a computing system for automobile warehouse logistics

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1 Introduction

Up to several thousand vehicles are shipped or delivered by trucks at terminal gates of automobile warehouses at once. In order to manage the warehouse, the vehicles are identified by a specific code. During the initial detection phase, this code is read and attached to each car on a tag. Equipped with that tag, the cars are relocated to pre storage places. From there they are sequentially processed at a technical station, where they are processed and checked for damages as well as set up if necessary. Small damages can also be repaired at the technical station. After leaving the technical station they are driven to temporary storage places, from there they can be delivered to the customer or stored in long-term storage places.
The primary aim of the automobile warehouse is to reduce time to market. This can be done properly by an efficient storage management of the cars as well as a self controlled order placement. The task of the handling employee is to drive the cars to the temporary storage places. To have access to the distant cars they are driven by bus shuttles and get their job description orally.
In this research project, handling employees are to be outfitted in a “smart jacket”. With this technology they will have the ability to identify the cars automatically, to locate the storage place of the cars and to receive order information wirelessly. The smart jacket must be comfortable to wear, have low power consumption and encrypted wireless data transmission. Furthermore radiation protection and robustness are important required properties for the smart jacket.

2 Hardware of the smart jacket

The smart jacket includes a Ultra High Frequency (UHF) RFID module for tag identification, a combined GPRS (General Packet Radio Service) / GPS (Global Positioning System) module for communication and localisation, a Thin-film Transistor (TFT) display with touch screen, hand free audio hardware for user interaction and a proximity sensor for detection. All components are handled by a central software platform integrated in an embedded microcontroller.

2.1 The main board

The core of the smart jacket is an embedded microcontroller with TFT support and a large range of connection slots with a PCB area of 53 x 38 mm. An operating system is integrated. This module is mounted on an adapter board which singles out the connection pins of the microcontroller and supports a Local Area Network (LAN) communication port for fast and secure software development. A developed power supply board fits directly into the adapter board, so that the microcontroller and bigger electrical components, which are necessary for the power supply, lie between the boards. In this way the microcontroller is protected. The size of this robust board combination, which will be referred to here as the main board, is 95 x 70 x 18 mm. The main board supports directly the hardware interfaces to all other modules and provides their power supply by using only one accumulator. Each connected component has its own required power supply. To reduce energy consumption, the power supply of the intermittently used components, such as the identification module or the touch screen display, is managed by GPIO (General Purpose Input Output) pins of the microcontroller for activation. Furthermore the activation hardware of the proximity sensor such as a resistive touch screen controller for user inputs and a flash card holder for additional memory is integrated.

2.2 Hardware modules

The UHF RFID module is used for identification of RFID Tags inside the car. The tag lies on the inner side of the windshield and the external reader antenna is integrated in the shoulder region of the smart jacket. By using a ceramic UHF antenna with high efficiency the RFID module is able to read the tag from a distance of 1.5 meters under ideal and 1.2 meters under normal conditions, whereas 80 centimetres are acceptable for this application. Because the energy consumption of the RFID UHF-Reader is high, this module is only activated when it is required.

If the handling employee equipped with the smart jacket gets into a car, a proximity sensor is used to find out his status. It is an infrared sensor and placed into the back area of the smart jacket. If the handling employee takes a seat the sensor gives a positive output. The microcontroller then activates the power supply of the identification module. Then the identification module starts to read the RFID tag automatically. The microcontroller interrupts the power supply, if valid tag data is received via a serial interface.

To get order information from a server and to receive global position data, a combined GPRS/GPS module is used inside the smart jacket. The GPRS supports the class 10 technology and is able to communicate with a Secure Shell (SSH) server by using the M2M (machine to machine) technology. The GPS receiver works with the latest Satellite Based Augmentation System (SBAS) technology and provides high sensitivity with an accuracy of 2.5 metres in location determination and

an update data time of one second. Both, GPS and GPRS data have the same instruction sets and use different serial interfaces to the microcontroller.
As a standard mobile phone this module includes an audio part. A Loudspeaker and a microphone are integrated in the collar of the smart jacket. The output- / input signals are amplified by an audio part, which is placed on a separate audio board. To increase robustness, this board is mounted on the GPRS/GPS module directly. The size of this combination is 47 x 47 x 12 mm.

2.3 User interaction

A comfortable user interaction is an important task of the smart jacket. Therefore a combined usage of a touch screen display with an audio interface will be used. If the handling employee is sitting in the bus shuttle or if he observes not previously listed damages on cars, he can use the touch screen to read and write. The touch screen is used only if necessary; therefore it shuts down automatically if no interaction is received. If the handling driver is driving a car or underway, the order information are admitted audible and hand free by using TTS (Text To Speech).

3 Communication and localisation methods

Several handling employees equipped with the smart jacket are working at the same time. As figure 1 show, each jacket makes a connection to the public internet by using the GPRS module. The first step is a network registration of each jacket by loading an identification file to the SSH server. This server verifies this file and registers the IP address. By using the IP address every smart jacket is able to receive or transmit data over point to point protocols (PPP) to the SSH server or among themselves. An order is started by broadcasting a job description from the SSH server to available smart jackets. Each jacket knows what to do by using an implemented self-controlled procedure over PPP.

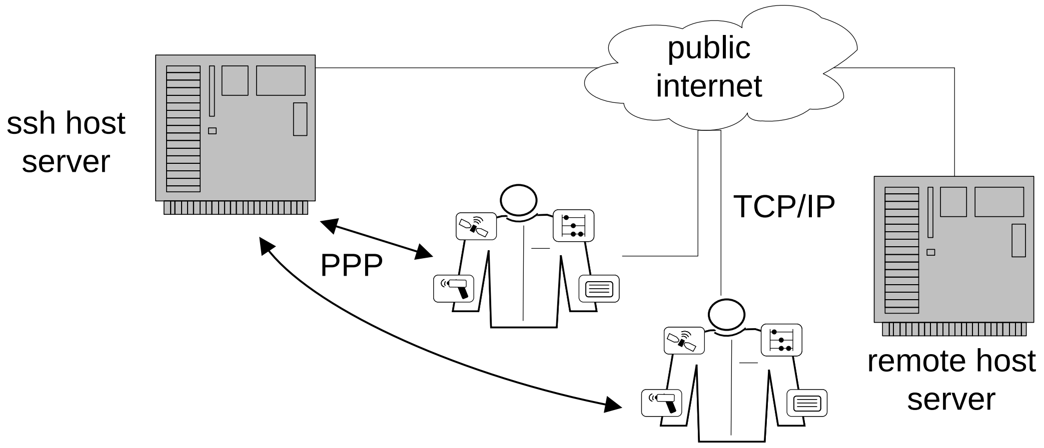

Figure 1: M2M communication of smart jackets

For example there is an order to drive some delivered cars from a terminal gate. Handling employees are taken to the gate by the bus shuttle and have to drive the cars in sequence. If a car is identified, encoded information is transmitted to the SSH server. The server verifies and sends information about where to drive this car. If the temporary storage destination is reached, the proximity sensor finds out the status of the handling employee. Then, the global positioning data is collected to identify the destination place. The order is completed by sending this data to the SSH server.

For correctly locating storage place of the vehicle, an accuracy of 2.5 meters is not always sufficient. Therefore two different storage methods are used to improve the localisation accuracy. If the storage parking places are structured, their area information is gathered in storage areas while using corners GPS data as positioning reference points. This area will be mapped to find out the correct storage points and saved as reference data which is used, if the smart jacket receives the order to reach this area. Figure 2 shows an example of this structural localisation method. On the other way there are not just structured storage places on the automobile terminal. The chaotically storage method is used to locate storage places of cars for short time at any areas by lower accuracy. The cars are stored behind one another in rows of four to five cars. As seen in figure 3 all cars are close together, so it's only possible to evacuate vice versa beginning by the last car. In this method, only the directly measured GPS data is used. They are collected after the handling employee gets out of the car. Data of the first car in a row and of the last car over all are the most important. To find out where every car is located, the time of storing process is noted too. By using this time in combination with the received global position data, the cars' location are found.

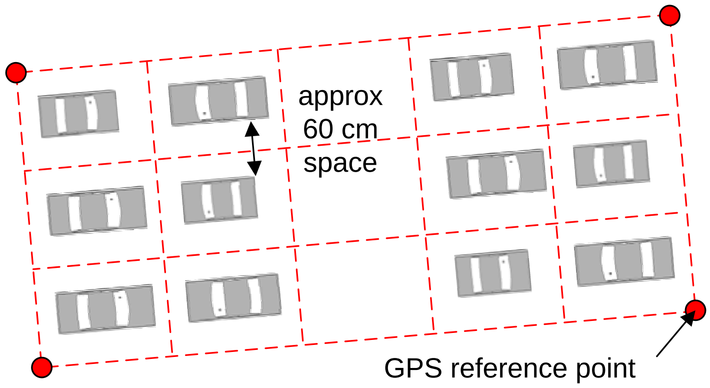

Figure 2: structural GPS localisation

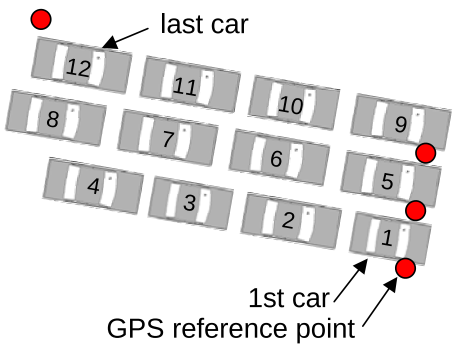

Figure 3: chaotically GPS localisation

4 Acknowledgement

The smart jacket is a part of a consortium project of BIBA (Bremer Institut für Produktion und Logistik) and IMSAS (Institute of microsensors, -actors and -systems) and the industry partners E. H. Harms Autotec as automobile warehouse company and FEIG Electronic as distributor of the implemented RFID (radio frequency identification) module. This research is funded by the German Research Foundation (DFG) as part of the Collaborative Research Centre 637 “Autonomous Cooperating Logistic Processes - A Paradigm Shift and its Limitations” (SFB 637) at the University of Bremen.