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LaSeKo – Agricultural self-configuring communication system for process optimization

To fulfill the high expectations of consumers and the legislator regarding modern agriculture, an autonomous documentation system of the crop harvesting process is necessary. In the research project LaSeKo a technical solution is developed and tested for its practical feasibility. For this purpose electronic communication units have been developed which can record all process related machinery and harvesting data using the CAN-bus. Afterwards this data is transmitted via radio (IEEE 802.15.4) between the members of the process chain. Subprocesses can be better adjusted by data transfer. At the same time this data can be used for the documentation of the process, monitoring and optimization.

Keywords
Documentation system, 2,4 GHz radio, IEEE 802.15.4, Embedded Linux, data exchange, LaSeKo

Abstract
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A flexible data exchange between agricultural machines allows the use of new methods in documenting procedures to improve quality and efficiency of agricultural production processes. An additional important aspect is the traceability of food to improve consumer protection. Since mobile working machines are mainly used in areas with neither broadband nor cell phone networks a direct application of existing technologies is not possible. New methods of data exchange between the machines and other participants have to be developed. The center of the research project LaSeKo is the development and testing of the system-hardware and the software which is adapted to agricultural needs. The goal is to develop a communication system which does not cause additional costs for transmitting and processing machinery and process data.

Description of the LaSeKo-Project

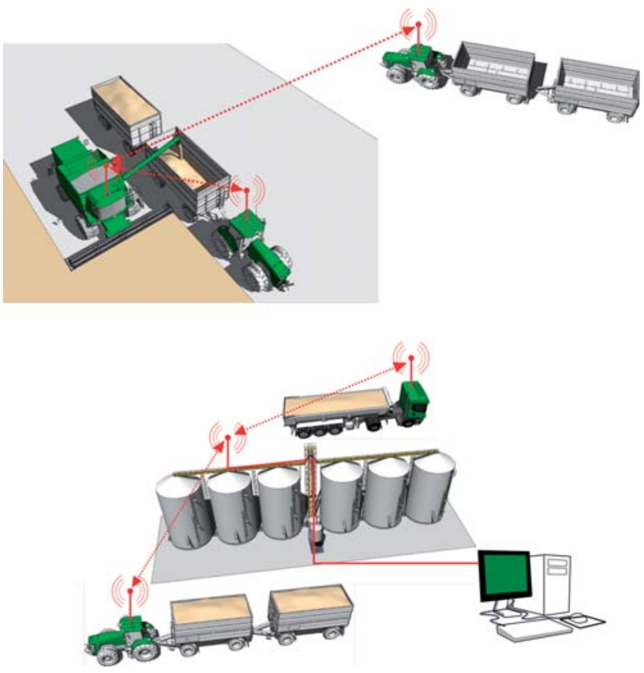
To develop an autonomous documentation system an interdisciplinary project team is necessary to carry out the database programming, field tests and hardware development as well as software development. On that account the TU Dresden, the Karlsruhe Institute for Technology (KIT), the John Deere European Technology Innovation Center, the Simplan AG, the LogicWay GmbH, the Arkade GmbH and the TU Berlin are participating in the project. The project funded by the Federal Ministry of Food, Agriculture and Consumer Protection (BMELV). Project executing organization is the Federal Institute of Agriculture and Food (BLE).

The core of the LaSeKo-Documentation-System consists of electronic communication units, so called LaSeKo-Boxes. Every harvesting and transporting machine is equipped with a LaSeKo-Box. This Box itself is equipped with numerous interfaces. All relevant data is acquired via the CAN-Bus and a data record is created in a predetermined time interval. These records are saved in a XML-file. Depending on the application this file can be closed after either a predetermined time or by the trigger signal of an event e.g. the end of the unloading process. Subsequently the file is compressed.

How data transfer works

A direct transmission of the data between the combine and the data-server is due to the low range of 300 m not possible. For this reason the data is passed on like a baton. The acquired combine data is transmitted via radio, as shown in **figure 1** during the crop unloading process from the combine to the tractor. While unloading the crop at the farm, the mill or the granary the data is passed on via radio to a data server.
To ensure that the data can reach the data server autonomously and is not transmitted between combines a priority model has been developed. A defined priority was given to every machinery type. Combines possess a higher priority than transportation vehicles, the data server itself was given the lowest priority in the network. A transfer of data is only conducted to a member

Fig. 1



LaSeKo-Radio-Network

with a lower priority. Every network member can be a sender or a recipient. The determination of its role is only negotiated after the initial contact of the two members. During the data exchange between a combine and a tractor on the field the combine represents the sender and the tractor is the recipient. As soon as the tractor transfers the data to the server at the granary the tractor changes its role and becomes the sender.

How the units communicate with each other

The initialization of contact starts through a BEACON_REQUEST_COMMAND which is used by the network member which has to send data to the server to search for members within radio range. This call using the BEACON_REQUEST_COMAND is answered by all members within range with a BEACON. The received BEACONS are evaluated according to their priority, Pan-ID and LQI (Link Quality Indication) so that a contact is only established with a member that fulfils all criteria. The essential criteria are that the recipient has to be registered in the same network (PAN-ID), that it has a lower priority and that the quality of the signal (LQI) is not below a certain limit. If those criteria are fulfilled the data is transmitted [1].

At every unloading process it is documented between which process members the crop is transferred. By that a complete traceability of the crop is possible. As soon as the unloading auger of the combine is switched on meaning that the unloading process is starting the combine sends a BEACON_REQUEST_COMAND. As a result all machines within radio range answer with a BEACON and the combine detects the tractor with the highest signal strength. This process is repeated every 4 seconds during the entire unloading process. The tractor that has the highest signal strength most frequently is saved as the transportation vehicle.

Components of the hardware of LaSeKo-Box

In **figure 2** the main board and interface circuit board developed especially for mobile applications by the LogicWay GmbH are shown. The AP7000 was chosen as microcontroller. This is a 32 bit processor by Atmel. The installed operating system is an Embedded Linux. On the main board the processor and the memory are installed, the interface circuit board has the following interfaces integrated:

- 2 × CAN-Bus according toISO 11783 or SAE 1939
- GPS
- 2 × 2,4 GHz radio according to IEEE 802.15.4 Standard
- GSM/GPRS-Modem
- SD-board up to 32 GB
- Real Time Clock (RTC)
- USB-Client
- Ethernet (100 Mbit/s)
- Serial interface (RS232)

Apart from the radio all interfaces are integrated as a driver in the Linux kernel. This makes the development of additional applications much easier. The Linux-ZigBee Open Source Project is currently working on the development of a kernel driver for the used radio chip.

Results of field tests

In the harvest period 2010 field test at the Seydaer Landwirtschafts GmbH in Seyda have been carried out. Five combines, five tractors and the scale have been equipped with a LaSeKo-Box. **Figure 3** shows the LaSeKo-Box installed in the cabin with the John-Deere Gateway. The Gateway provides chosen CAN-bus-data of the combine. For two reasons the LaSeKo-Box is not directly connected to the machine CAN bus. First the CAN bus does not have to be disclosed by John Deere and second it guarantees a secure bus communication because John Deere hardware and communication driver software is used. In case of a failure of the LaSeKo-Box the functionality of the combine is under no circumstances affected.

The tests have shown that net transfer rate of 18 Kbytes/s and the time during the unloading processes is more than sufficient for the transfer of the recorded machinery data. Although the LaSeKo-Boxes were installed inside the cabins a range of 150–200 m was measured. Furthermore it was tested if the correct transportation vehicles have been detected. This was the case in all tested scenarios.

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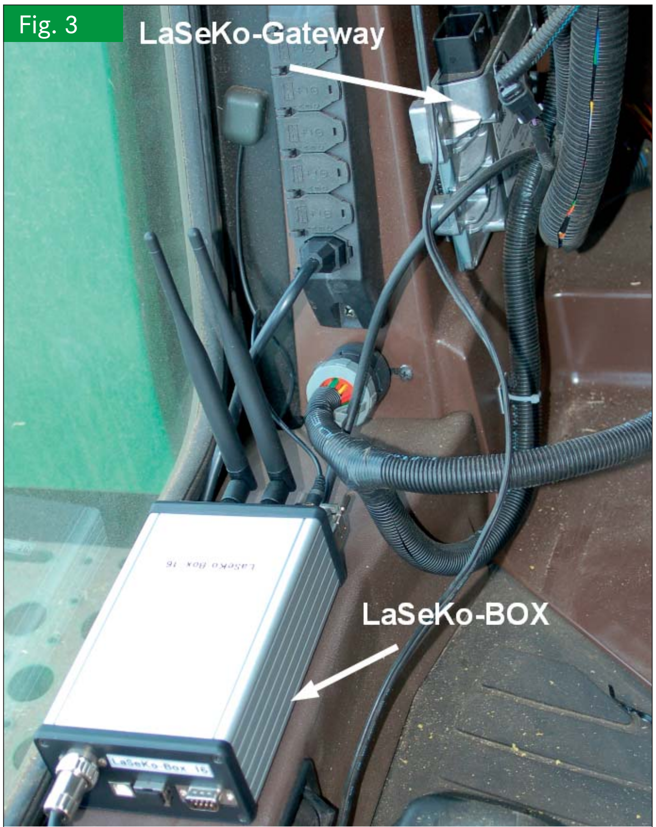
Fig. 2

LaSeKo-Box main board and interface circuit board [2]

Fig. 3



Gateway and LaSeKo-Box assembled in combine cabin

Conclusions

To achieve acceptance by the farmers it has to be made sure that all data is transferred without exemption autonomously to the data server and no data is lost. In case of a network breakdown all data is saved on the machine and will be deleted only after being saved on the server. Furthermore it should not be possible that data can be read or manipulated by a third party. This can be guaranteed by encrypting the data and by an additional encryption of the radio traffic.

Literature

[1] Voigt, G. (2010): Untersuchung und Entwicklung eines Embedded Linux Gerätetreibers für den AT86RF231 Funkchip von Atmel. Bachelorarbeit, TU Berlin

[2] LogicWay GmbH (2010): DIMM-CPU09 CPU Modul Handbuch, http://www.logicway.de/pages/mde-hardware.dimm-cpu09.shtml, Zugriff am 24.08.2010

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