Herd, Daniel

Network Systems and Cloud Applications in Livestock Farming

The use of sensors for animal monitoring and automation grows, and thus the amount of data from animal husbandry. Data analysis is challenging and the reduction of information for decision support is getting harder. The examples from research and practice show possible solutions. In scientific and practice-oriented projects the systems of different manufacturers are linked together and data are analysed. In scientifically oriented projects there are usually many manufacturers involved in order to answer complex scientific questions and to strengthen communication and cooperation between the participants. Within company projects the focus is on the concrete user advantage. The presented examples show mobile applications implemented as early warning systems for health changes in stocks or for machine control. Overall, it can be clearly seen that the data evaluation and utilization shifts to the cloud. With these cloud systems, data analysis is improved and methods like complex algorithms and mobile services (APPs, Webberatung or Social networks) are implemented

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Abstract
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Technologisation and automation in agricultural operations is steadily increasing, driven above all by the requirement to improve labour productivity. With the growing number of sensors and systems, the amount of data is increasing and therefore also presenting greater challenges to data analysis and decision support systems. It has often been necessary to create a network within a business and for data to be exchanged between manufacturers [1]. However there have been no major changes observed in improving on farm networks in recent years. On the other hand, information and communication technology (ICT) to improve the exchange of data, particularly beyond the boundaries of a farm, has become more important [2]. This technology is particularly significant for the implementation of methods and algorithms in precision livestock farming as only this will allow complex approaches to monitoring the behaviour and health of livestock to be developed and successfully realised in practice. The widespread use of mobile devices in particular is seen to offer opportunities nowadays. Hoffmann et al. [3] report on the great potential for the mobile business in farming. However, the manufacturers of these applications should continue to drive forward the development of services and apps.

The following article describes the applications currently available and their options and limitations. Examples of network solutions and of the use of mobile applications for the most important types of livestock drawn from scientific applications and from practice are given.

Applications from science

In a science environment, the networking of devices and systems with a central data storage facility is essential to allow work on complex research projects. An IT infrastructure is required particularly for interdisciplinary projects and equally for precision livestock farming. The following examples describe solutions from dairy and pig farming.

Projects at the University of Bonn

At the University of Bonn, Büscher et al. [4] are investigating issues in the recognition of patterns of behaviour and changes in these patterns in dairy farming at Frankenforst research farm. Various systems are networked here, including feed and water consumption, rumination, activity, the location of the animal in the barn, body weight and milking data. The large amount of data for each animal thus generated is recorded at the farm in separate systems and then collected and sent to the “KuhDaM” database system which was developed at the University of Kiel. The data is checked for plausibility, stored and made available

for analysis. This complex network with shared storage of data from different sources represents a major challenge for the farm and the operator of the KuhDaM database. There are various working hypotheses in the projects. The linking of activity with other animal-specific characteristics in order to identify sickness earlier is one of them. Results show that animals react individually to environmental influences and that the recognition of patterns of activity is a promising approach [5]. However, more interdisciplinary research on the integrated approaches must follow to realise the concept of precision livestock farming.

PigWise research project

The PigWise research project examined issues and ICT methods in pig farming. The aim was to record and analyse the output and welfare of pigs raised for meat. High Frequency Radio Frequency Identification (HF RFID) was used to record how much feed was consumed by 236 pigs and how long it took them to do so. The study confirmed that the actual feeding duration correlated strongly with the data from the HF RFID antennae. With the concept of synergistic control, the amount of feed consumed by each animal was monitored and a distinction made between normal and abnormal behaviour. This was accomplished by sending the data to a server for processing. One experiment tested online an early warning system which sends a message if the feeding habits of an individual animal change. XMPP messages were automatically sent to a suitable end device (a smartphone or a tablet) to do this [6; 7].

Applications already used in practice

Networks of devices, sensors, systems, barns and complete farms are already used in practice and are steadily increasing with the first Cloud solutions now available. These networked systems are focussed on providing a benefit to users with the overarching objectives of economic efficiency and labour productivity. Two areas are of significant benefit here:

1. Central system management and monitoring including logging and alarm systems.
2. A system providing centralised management (mobile and static) of livestock with data capture, data input, analysis and decision support.

Three examples from different animal husbandry systems are shown below.

Pig farming – Big Dutchman

The Big Dutchman company has developed BigFarmNet [8], a concept which combines all the controllers, computers, sensors and machinery in one system. It is used to configure and manage applications in a single stall or throughout the farm and data is exchanged between the systems. If animals are regrouped in sections all the systems affected are informed and the number of animals is updated. Master data, temperature and feeding curves only need to be entered once.

The individual components are visualised in three dimensions on a single user interface which provides users with a central management system with which, aided by an alarm system, they can monitor the most important processes from a static computer or with a smartphone. A module for monitoring health has been implemented, and has been validated by Hinrichs et al. [9]. The software recognises sows which come later than usually to a feeding station so that sick animals can be identified and actions put in place. A contribution is thus made to the overarching aim of improving economic efficiency and labour productivity.

Egg Production – Porphyrio

Porphyrio has developed "Lay Insight" for egg production, an early warning system which automatically monitors production and issues. Alerts are given if significant changes occur. The system controls and monitors the consumption of feed and water, egg production, average egg weight, hen weight, mortality and climate data (temperature and relative humidity). The data is collected in the sheds, aggregated and sent either directly or via a PC to a cloud server where algorithms are used to analyse it. The early warning system developed by the company uses the data in the cloud server and reports changes in the flock. The information is sent by email to mobile devices so that the operator is informed in good time of any changes. There is also a management system in the form of a browser application that can be used at a static PC [10;11].

Dairy farming – Lely

For dairy farming, Lely has developed the stationary management system TC4, the mobile management system T4C InHerd [12] and the Benchmark [13] application for interfarm use.

The static management system T4C is the central farm management system. It networks and manages the communication of all the devices via a background database (milking robots, feeding robots, concentrated feed stations, ID stations and cleaning systems) and calculates and analyses key figures. The T4C PC is linked to the Internet, allowing the provision of various services.

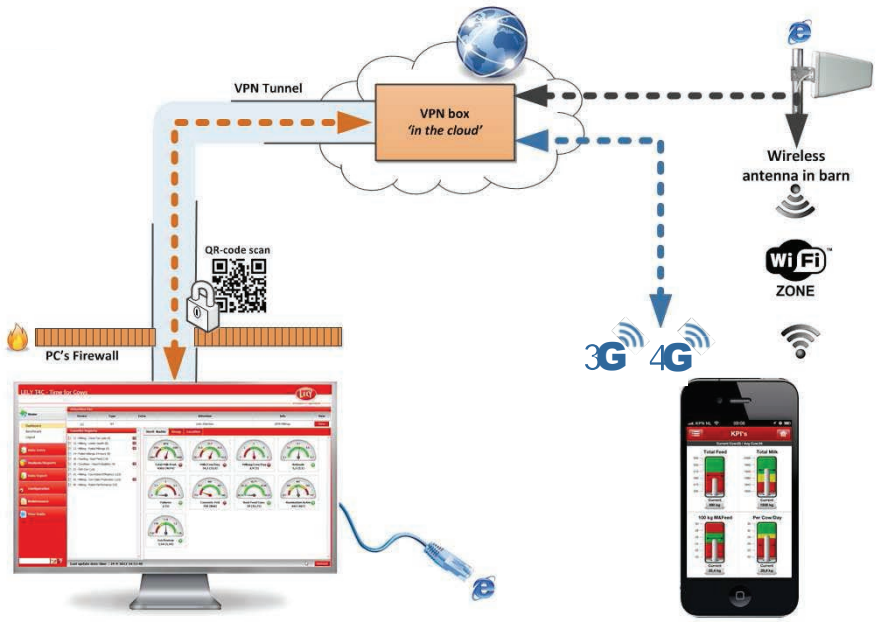
The T4C InHerd mobile management system integrates nine different tools (apps) in one platform to support the daily management of a dairy herd. It allows animal data to be reviewed and changed from anywhere online. Where required, a cow can be given milking permission and selected into an area. At its next visit to the robot, it is milked and automatically selected. Medication can be added to treat health problems and the milk from treated cows is separated from the rest.

An overview of daily tasks with a display of to-do lists helps staff with routine work. Communication between the mobile device and the static management system is encrypted and proceeds via a cloud server (**Figure 1**).

The Benchmark product [13] serves as a platform for various services, which are described below.

In the background is a database which stores the operating data, robot data and alarms and alerts. Various services are set up based on this database, such as the Lely Benchmark Social

Fig. 1



Encoded communication between the stationairy management system T4C and the mobile management system T4C InHerd

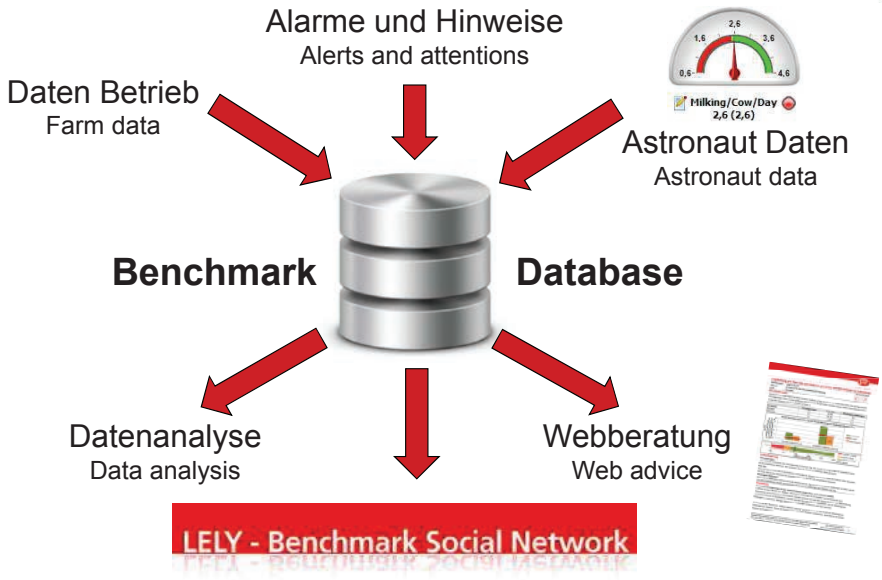
Network and web consultancy (**Figure 2**). Farms can be compared with others on the basis of key figures and thus systematically reviewed for weaknesses. Direct comparison is only possible where the participants are "friends" and authorise the release of data. Milk robot customers can access anonymous advice on pre-defined subjects with the web consultancy service, and thus optimise their production process and save time with the recommendations made there. Lely also uses the Benchmark application to perform anonymised analyses to support product development and to plan robot services.

Conclusions

The two scientific projects are very different. The project at the University of Bonn focuses on basic research and has implemented a permanent network of different systems and data storage. There are still technical problems with compatibility. A central control system such as the one realised by BigDutchman is technically very sophisticated, innovative and offers great benefit to customers and companies.

The examples show that mobile applications on smartphones or tablets with the necessary servers and services on

Fig. 2



The Benchmark Database as central system for different services

the Internet are increasing. The benefit to farmers lies in management support and particularly in the early identification of changes in the operation. This has been implemented for pig farming in the PigWise project. Porphyrio has realised this on a practical level by analysing data in the cloud and sending alerts about changes to the customers. Lely's mobile management system T4C InHerd offers efficient herd management support by displaying changes to the operation online so that action can be taken immediately. The web-based application Lely Benchmark allows comparison between farms, offers web-based consultancy and internal analyses.

Networks of machines, sensors and systems offer many advantages, such as improving economic efficiency and labour productivity for customers and companies and will continue to increase. The challenge is to process the large amounts of data automatically and make it available to users as a basis for decision-making and to fully automate processes. Cloud applications with integrated algorithms which allow data to be merged present an opportunity in this respect and will become more widely used. Central servers have the advantage of storing larger quantities of data and with superior processing power can apply very complex computational algorithms. It is also possible to use them to develop a wide range of different (mobile) services such as apps. Data security must be ensured in this environment.

The solutions offer many options for implementing software and algorithms for precision livestock farming technologies, encouraging the development of mobile applications and promoting the use of the "Internet of Things" in farming.

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Author

Dr. agr. Daniel Herd is head of the Farm Management Support department at Lely Deutschland GmbH, Industriestr. 8-10, 89367 Waldstetten, e-mail: dherd@lely.com