Remote Assisted Task Management for ISOBUS Equipped Tractor-Implement Combination

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ABSTRACT

Efficient task management is a key to profitable use of an automated tractor-implement combination in the field. The information management system which is used to operate automation of the tractor-implement combination can be used to manage the external information such as to the task or surrounded environment related information, as well. User-friendly open operation environment that provides possibilities for intelligent on-line functions in the field and remote support via internet connections is introduced. The system utilizes open system interfaces and ICT standards, such as ISOBUS, to enable compatibility between different system parts. Wireless communication enables information exchange between off-road automation machines and external operators like support services, databases or clients. Maintaining the wireless internet based remote support system is cost efficient, since it can be used for communication between several parties. Disadvantage is that internet connection exposes the system to malicious programs and variable quality of service. The experiences from the case study concerning remote assisted task management of ISOBUS compatible tractor-implement combination were encouraging. The importance and possibilities of internet will increase further. Still there is a need for further research and development work in the areas of openness, dependability as well as user and task specific optimization of the calculation and data transfer capacity. Additional, but unavoidable challenge will be the integration of site-specific data and GIS to the other information systems.

Keywords: Database, GIS, information management, ISOBUS, mobile, openness, usability

1. INTRODUCTION

Sophisticated automation systems require advanced information management. Intelligent functions such as fault diagnostics, assisted user interfaces and location dependent control are typical for a novel automation also in off-road machinery like tractor-implement combinations (Suomi et al., 2006). The information management system, which is used to operate automation, can be used to manage the external information like to the task or surrounded environment related information, as well. Efficient task management is a key to profitable use of an automated tractor-implement combination in the field. Wireless communication enables information exchange between off-road automation machines and external operators like support services, databases or clients. This brings great possibilities to improve quality and profitability of businesses like machinery contracting. However, there are several challenges to meet before all benefits of information management of off-road automation systems are gained. The main challenges are discussed in this study.

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2. CASE STUDY

The aim of the case study was to investigate remote assisted task management of a tractor–implement combination. The system consisted of the ISOBUS compatible Agrix system (fig. 1) as a platform and an information management system provided by Bitcomp Oy (fig. 2) that was attached to it.

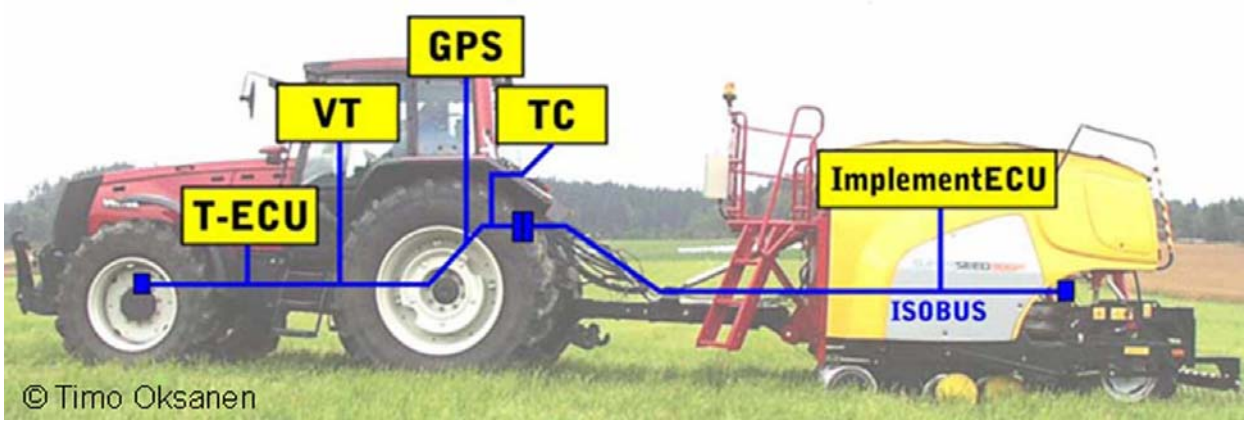

Figure 1. ISOBUS compatible Agrix system, a plant production automation system.

The system utilizes open system interfaces and ICT standards, such as ISOBUS, to enable compatibility between different system parts. ISOBUS compatible Agrix system, a plant production automation system (Oksanen et al., 2005), consists of five operational parts, connected together with ISOBUS CAN. The parts are: Virtual Terminal (VT), Tractor Electronic Control Unit (T-ECU), Implement Electronic Control Unit (Implement ECU), Task Controller (TC) and external sensors like GPS. VT is used to provide a user interface. A virtual terminal has a graphic display, soft keys and some means to enter data. An implement ECU uploads its user interface to the terminal. T-ECU is responsible for transmitting the tractor's status information to the ISO 11783 network. All the controllers on a single implement (Implement ECUs) form a working set. In a working set, one controller functions as a working set master. The working set master is responsible for transmitting the user interface to the VT. The communication between modules, e.g. VT and TC, is standardized. The planned tasks are imported to the TC. The TC is used for the execution of work tasks and the results of the tasks are sent back to a Farm Management Information System (FMIS), e.g. a stationary farm computer of the farmer or the contractor. A FMIS computer is used for planning and evaluation of field work. Interaction between user and TC may be realized through a VT or other interface.

In this study, the remote assistance was made possible by centralizing the data to an internet database. The task management can be supported by several actors joining the system. The system developed by Bitcomp Oy is devised open so that it can be easily connected with other systems using XML (eXtensible Markup Language) or SMS alerts. It is possible to log in to the system from internet via authentication mechanism. Two kinds of user interfaces are offered, one for the farmers and one for the advisors. The system is based on WebWisu Farm Management Information system (FMIS) so, that when the normal cultivation plans are done in the office application of the WebWisu, the task files are created automatically by adding only the positioning data.

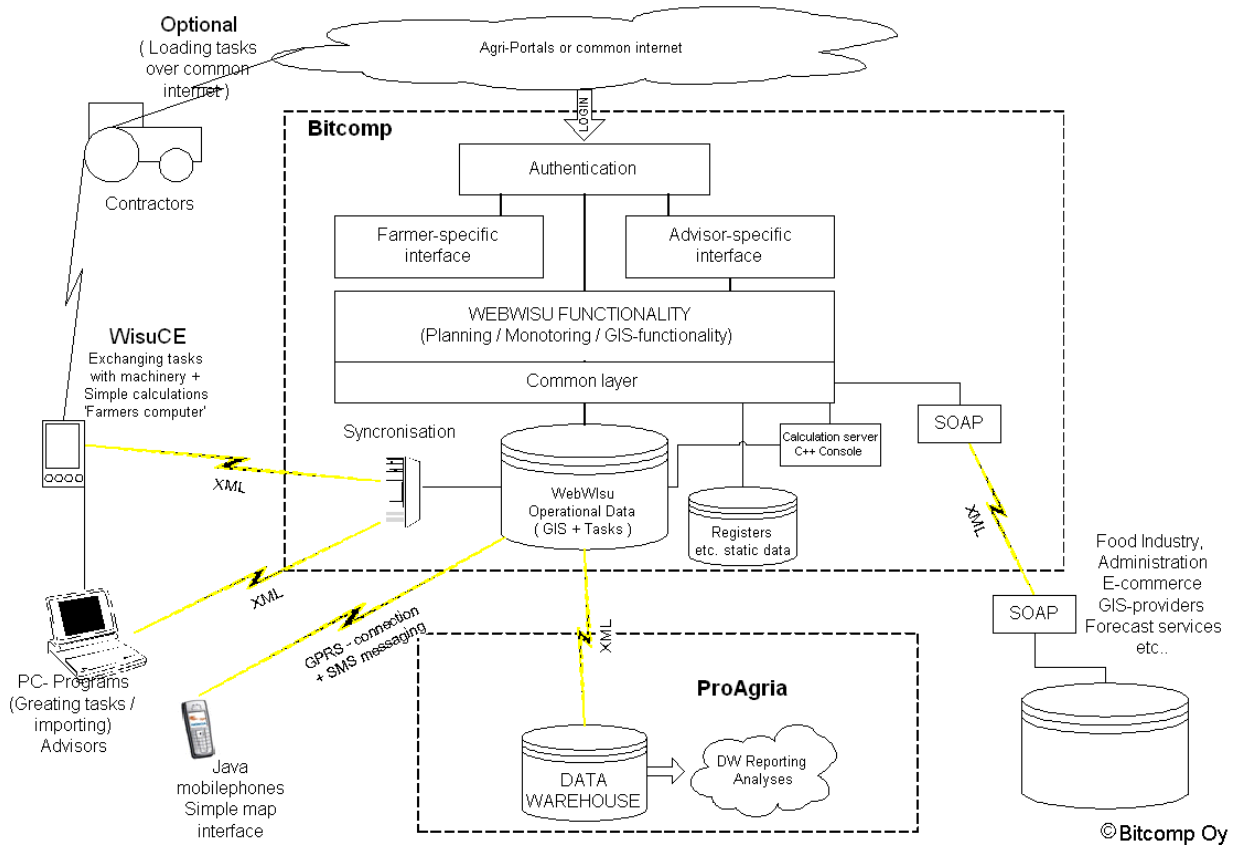

Figure 2. Open interface centralized data management system by Bitcomp Oy.

The task can be downloaded and updated in the field, and realized task can be reported straight to the customer via wireless internet connection. It is possible to send recorded field data files immediately after work to a centralized database, where it is stored and saved, thus being available for authorized re-users. Farmer's data is placed straight to the book keeping system in the office WebWisu. The Agrix system includes VRA (Variable Rate Application) features, so it operates with site-specific data. External site-specific task data such as application maps are imported to the system's database from farmer's PC as shape files. The tasks can be downloaded from the database to the Agrix TC via GPRS connection as an XML. Pocket PC acts as Agrix TC, which offers benefits of portability. Data format in the TC is adapted to follow the draft of ISO 11783-10 standard. Tasks can be created or imported with PC. Mobile phone can be used to supply SMS alerts with the system.

Centralized task management provides better quality control and traceability. Finnish agricultural advisory organization ProAgria, implements data warehouse services and makes necessary reports from the data. Food industry, administration, logistics, GIS-providers, forecast services etc. can connect to the Bitcomp's system using XML. Wireless internet connection provides possibility to on-line support during the task. The updated task plan can be downloaded to the TC just before executing the task from the support service or from the client. And when adjustment or advice are needed during the work, e.g. changed weather conditions, new instructions can be downloaded rapidly, thus avoiding long downtimes. When the task is done, to the TC recorded document of realized work can be uploaded to support service (central database)

or to the client immediately from the field. In this way, the client can check and accept the done work at the time the machinery is still located on the working site, in case there is something in performed task that requires still additional attention.

3. REQUIREMENTS AND CONCERNS

Wireless remote assistance is an important feature when system usability of mobile working unit is considered. It enables availability of information just on time independent on the location. Centralized databases and controlled open interfaces (COI) of the systems enable compatibility between different information systems. This creates possibilities for new kinds of services, where several information producers may provide support to the same user. Utilizing common internet makes it possible for working unit to connect to the information society and its' services. However, there are several concerns and requirements to consider when applying remote support systems to mobile working units.

3.1 Openness

Openness in the above mentioned case study means data transfer through controlled open interfaces including diversified authorization (fig. 3).

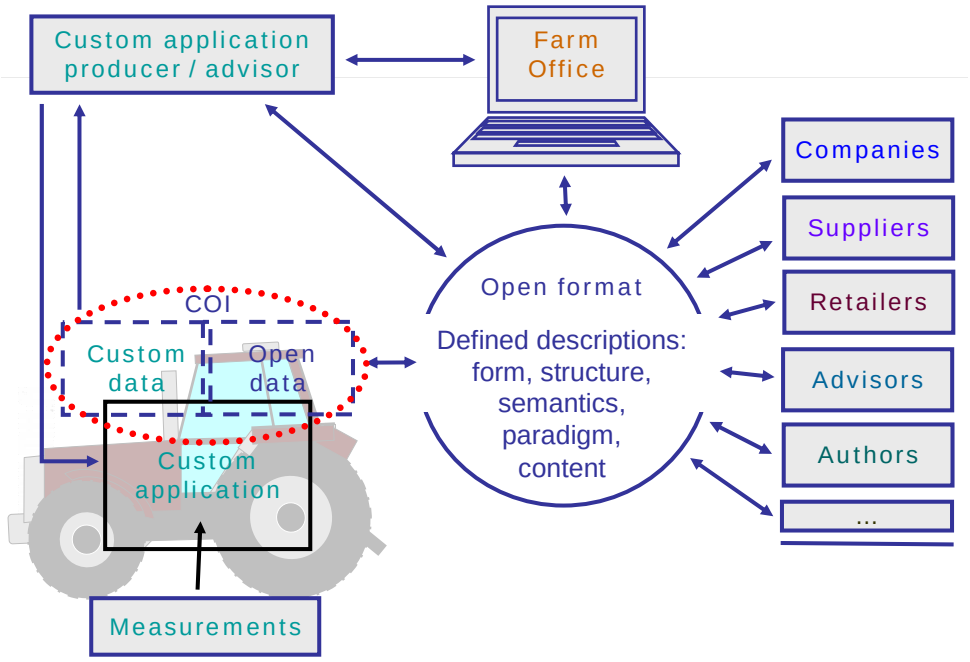

Figure 3. Diversified authorization and communication interfaces.

The interface is determined by the software provider. However, it is not always the case, that software providers are willing to offer the open interfaces. Also, there is a lack of common practices how to obey the mentioned controlled open interfaces. The definition of the interfaces cannot be the lowest criteria. The development of internet technology together with the rapid adoption of the XML standard is revolutionizing data exchange within and between organizations (Meneghello, 2001). Thus, XML based systems seems most promising also in

agricultural applications. However, there is no reason which prevents the use of both an optimized native application specific format, and interchange format like XML (Shrestha, 2004). For agricultural use aimed XMLs such as ISOBUS-XML, AgroXML and FODM™ (Field Operation Data Model) are under development at the moment.

The meaning for XML grammar is to bring the independence of data and programs to the information exchange. Information from different sources could be brought to the system in a same format. XML itself is not a file format. Instead, the file formats could be built on top of XML. Software can access to the data through various data models built by the parser where items of interest are defined by the associated XML schema. This means that such software is independent of the physical arrangement of the data.

More challenge is faced when site-specific data is in question. Within identical GIS platforms and database paradigm, the systems might have different conceptual database schema, different data collection schemes, or different quality parameters (Bishr, 1997). Among others, to improve data exchange and to enable interoperability of independently developed applications, the OGC (Open Geospatial Consortium) (OGC, 2003) has established the XML based standard known as GML (Geography Markup Language). GML is an XML grammar written in XML schema. It is for the modeling, transport, and storage of geographic information. GML is defined as an XML encoding of geographic information, including both spatial and non-spatial properties of geographic features and it is designed to represent arbitrary data structures. This might induce a lot of work when converting data between GML format and other formats.

A question about sharing information sets a challenge for the data management. The authors and number of databases can be limitless. The transferred data can have parallel but differently authorized users. For example, data that are essential for a support service provider may be desired to protect from competitors. Finding reasonable limits for the information allowance and still keeping the system open and avoiding confrontation needs effort. In a fully functioning concept, the data can be distributed to several databases but the communication interfaces, however, should be constructed so, that the efficient use of information is possible and profitable for the end-user as well as service provider.

3.2 Data Transfer Capacity, Distributed Calculation and Backup

The amount of collected sensor data a can vary from few kB/ha to GB/ha (machine vision). It may not be feasible to send all the data to central databases through wireless internet or GPRS connection. Average transfer speed of GPRS is as low as 30-80 kb/s, and also wireless internet may be slow. Only urgent data, such as data used for remote fault diagnoses, are reasonable to send straight from the field to central databases, where data are available to for example remote support providers. Also the data that are supposed to be stored centralized, like refined documentation data for FMIS, are usable to upload straight from the tractor. However, it is necessary to record all the logged data in order to be able to trace and analyze possible fault functions afterwards. Even tough there are fault diagnostics built in to the system it would not cover all possible malfunction cases. The faulty functions can become visible after a certain time, and in that case backup data would be valuable when improving the system. Backup data bring also legal support in cases where the quality of a contractor's work is under speculation. The backup data can be saved to memory cards or hard drives in the tractor and be uploaded to the backup system for instance during the breaks at office yard via WLAN.

Remote support service can execute most of demanding, to the task related, calculations and send them to mobile unit. Especially, semantic web provide assisted help to find needed information easier. Automation system in mobile working unit such as tractor-implement combination can provide sensor data that can be used to provide to a sensor fusion based intelligent assistance for the driver. Intelligent functions can be intensified by external, via internet received up-to-date data, like weather data. However, sensor fusion based assistive functions and automated task updates require on-board calculation capacity. If only filtered and refined data are sent to be stored and maintained, the refining process needs calculation capacity, as well.

Present technology enables high precision site-specific data collection in crop production. This set new requirement also to FMIS. Managing into field specific accuracy refined originally site-specific output data reduces the benefits that could be achieved from intelligent implements. The larger the fields and the in-field variations are the bigger is the benefit from the more precise data management. More precise data can also improve data analysis, online support, implement calibration and reliability.

3.3 Dependability

There are also to dependability related concerns like availability, reliability, safety, integrity and maintainability of the support data or service. Work interruptions caused by unstable data management are not acceptable. Security is composition of integrity, availability and confidentiality, which means the absence of unauthorized disclosure of information (Avizienis et al., 2004). In rural areas, especially the availability of the internet connection may be a problem. The tendency is to provide fast internet connections to all users. In Finland, the goal is to cover the whole country with wireless broadband network by the end of year 2009.

The situation in telecommunications is changing rapidly. NGN (Next Generation Network) concept has been developed (ITU, 2004), and it is assumed to become to common use in the near future. NGN is a packet-based network, which is able to provide services including telecommunication services, and it is able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies. It offers unrestricted access by users to different service providers. It supports generalized mobility which will allow consistent and ubiquitous provision of services to users.

Mobile unit with unprotected wireless communication may cause safety problems by interfering to other wireless networks. Disabling the SSID broadcast, using WEP and configuring the network to allow only known IP and MAC address usage make more difficult to disturb the network (Dunham, 2005). If the system is not protected with virus protection and other specific programs, malicious programs may cause malfunctions in operation of the working unit. Thus, unprotected networks and systems will create a risk of severe environmental and economical damages.

3.4 Awareness of the User over the Information Flow

It is important that the driver is aware of data and information flows that are taking place. Simple and natural dialogue in this case between ISOBUS VT and the user is needed. The system has to speak the user's language and the system status has to be visible providing necessary feedback data (Haapala et al., 2006). The driver has to be able to control the data flow. In case of remote

service by automation or equipment manufacturers to guarantee optimal working efficiency, the driver has to be aware of when connection to support service is active.

Availability and timing of information and data has to be fitted to drivers working habits, working culture and to the working process defined by the task. The system interface has to be pleasant and easy to use, and the driver has to be able to trust the reliability of the information received and produced by the system.

Saliba et al. (2005) have studied user-perceived quality of service (QoS) in wireless data networks. Network engineers have been trying to dimension wireless networks to run in most efficient way by concentrating in QoS. Nowadays user perceptions are used in dimensioning. Reliability, efficiency, predictability and satisfaction are the main factors in users view. The main result of Saliba et al. (2005) was that QoS is application specific. Various applications require different level of network performance to satisfy users.

4. CONCLUSIONS

Remote just-on-time support intensifies task management and working efficiency of mobile working units like tractor-implement combinations. Remote assistance requires access to data. Use of centralized databases as data storages, enables a data management system where data is saved only once, but it is yet available to different re-users. Centralized database based task management can be supported by several actors joining the system. The system developed by Bitcomp Oy is devised open so that it can be easily connected with other systems using XML. The system concept could be a pioneering way of thinking the architecture of field information management. The autocracy of an individual database author should be avoided by providing open interfaces for the other service providers.

Maintaining the wireless internet based remote support system is cost efficient, since it can be used for communication between several parties. Disadvantage is that internet connection exposes the system to malicious programs and variable quality of service. So far, the inadequate wireless communication methods have been limiting the possibilities, but now the situation is changing rapidly. Especially, NGN is a very promising new technology. Still there is a need for further research and development work in the areas of openness, usability, dependability as well as user and task specific optimization of the calculation and data transfer capacity. Also the challenge will be to have the whole data management in a geographically oriented environment.

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