Data interchange between Web client based task controllers and management information systems using ISO and OGC standards

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ABSTRACT

Handling spatial data from sensors, farm management information systems (FMIS), local legislation, weather and many other data sources is becoming an increasingly challenging task for managers and stakeholders of arable farming. The amount of data, sources and on line services, heterogeneous group of data processers, and the complexity of agricultural practices calls for novel and common spatial data infrastructure. Automated process data acquisition and control is a reality in industry for online management of the production line. For farm machinery the use of sensor data and job files is restricted by hardware and software compatibility, different data formats, the lack of common concepts for interpretation of data, and the amount of data itself. This paper demonstrates an implementation of standard web feature services (WFS) defined by the ISO 19100 series, initiated by the open geospatial consortium (OGC) and ISO/TC211. Data are recorded by a novel web client based electronic control unit (ECU) and data is exchanged online with a web server offering WFS. The features in this study refer to field operations management data. Data are organized and stored on the server. It is demonstrated that data can easily be requested for further processing and use via the WFS.

Keywords: Web feature services, ISO 19100 series, spatial data, automated process data, Denmark.

1. INTRODUCTION

Farm Management Information Systems (FMIS) are developed to improve and ease the management decision making and compliance to agricultural production practice, legislation and task management by means of storing and processing of strategic, tactical, operational and evaluation data and services. Many of the agricultural production practices and legislation are hard-coded as e.g. look-up tables in many FMISs. This approach is unsuitable, due to i) limited validity, ii) limited accessibility,

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and iii) the dynamic and geospatial nature of agricultural production practice and environment, task management and not least legislations.

As derived from the results of the on-going ICT-AGRI GeoWebAgri project and similar studies (e.g. Steinberger et al., 2009) a web service based Spatial Data Infrastructure (SDI) can solve the stated drawbacks of current FMIS data exchange issues, since the data and services are accessible via standardized interfaces and formats. A collaboration of heterogeneous user groups with the need to access and update common data sets benefits from such an extensible, open structure, while the data can be created, processed and maintained throughout different systems, located either at local offices responsible for databases or being accessible through the Internet, for example on farm equipment. Consequently, interoperability becomes a key issue in efficient FMIS.

The dynamic and geospatial nature of agricultural production requires a rapid update for the optimization of the operational plan and adaption of the task in the field. The tasks for field operations can be quite complex (Sørensen et al., 2010). Dynamic and geospatial nature of field operations could for instance be concerned about current weather and weather forecast, pest alarms, changes to resources and dose rates, stock, working schedules, route plans, work applied by other working units, risk analysis, information from sensors, advisory recommendations and more. Thus, it would be desirable to update the operational and evaluation levels of field operations automatically in order to optimize the agricultural production practice locally and in real time.

Standardized information technology is the key component for such a system for automated data interchange, including FMIS and farm equipment. For example, with data acquisition as one element of the SDI and expert knowledge about processing of the acquired data in relation to agricultural practices decisions as a second element of the SDI, requires interoperability on the data and at the semantic level. SDI state of the art is typically operating at the fiel level involving data sharing, which requires special data integration techniques such as data translation and transformation due to differences in semantics, file type, and data format. The user can only request entire data sets, which for complex tasks can require time consuming data transmission, large storage capacity, and/or necessity of manual handling of files. Rather than constructing and evaluating a single complete task file, it would be better to evaluate separate decisions which are forming the task in real time. These decisions can be made based on available spatial data sets, incorporating the actual, local situation of the farm and down to the scale of current variations within each field as mentioned above. In this context, the standards for geospatial data exchange using web-services by applying a Service-Oriented Architecture (SOA) are regarded to be a key component, which in addition have the ability to make data available to a heterogeneous group of users and stakeholders independent of client or server platform.

The implementation of ISO 11783 part 10 by many vendors and the development of agroXML are successful examples of standardization in agriculture. The ICT-AGRI GeoWebAgri project found that the ISO 11783 part 10 and agroXML does not support the interoperability between the identified components of the SDI ranging from the levels of strategic and tactical planning, via task management and execution to the evaluation of field operations. The objective of the research presented in this paper is to demonstrate the applicability of the ISO 19100 series and open geospatial consortium (OGC) standards of spatial data communication for FMIS and in particular for field operations. The research results of the ICT-AGRI funded GeoWebAgri project indicate that the required integration of spatial information can be realised by building the FMIS on open GIS standards. This paper describes the initial steps of a SDI which combine the ISO 19100 and OGC series of standards to demonstrate a novel way that geospatial data is created, modified and exchanged via the Internet between the two SDI components; a commercial FMIS and a mobile implement control system (MICS).

OGC Web Services Suite (OWS) includes three principal types of geo-information services:
1) Map services: A WebMapServer (WMS) provides maps to the client in the form of raster data (e.g. PNG, GIF, and JPEG).
2) Coverage services: WebCoverageServer (WCS) provides spatial data optimized for detailed raster data information. Certain extents and data extracts are possible which makes WCS data suitable for further processing (e.g. using the Web Processing Services (WPS))
3) Feature services: WebFeatureServer (WFS) WFS can as a WMS supply maps. The difference is that a WFS delivers vector data (Geometry and attributes), while a WMS is delivering raster data in the form of a map.

WFS allow clients to receive spatial data while programming using the Geography Markup Language (GML) (others like KML are also supported) (ISO 19136). An important perspective by WFS is that the vector data format allows two-way communication where the client is able to edit, add and delete data. A WFS request is generated at the client and sent to the WFS via HTTP protocol. The server executes the query and the result is returned to the client via HTTP. OGC Web Services will allow for geo-processing systems can communicate with each other using standard technologies such as XML and HTTP. The research and development presented in this paper has focused specifically on WFS.

2. MATERIALS AND METHODS

The WFS specification defines two main WFS classes; basic and transaction (ISO 19142). The basic WFS can provide three read-only operations; *GetCapabilities, DescribeFeatureType* and *GetFeature*.

A Transaction WFS (WFS-T) comprise all operations as in basic WFS, with an additional *Transaction* operation. The following standardised WFS and WFS-T operations were supported by the Danish Knowledge Center for Agriculture (KCA) field database server used in this study: *GetCapabilities, DescribeFeature, GetFeature, Transaction*, which is four out of a total of eleven defined operations defined by the ISO19142 standard. The field database also supported SOAP operations for web services for the FMIS web clients. Figure 1 illustrates the SDI components of the researched and developed SOA within the ICT-AGRI GeoWebAgri project.
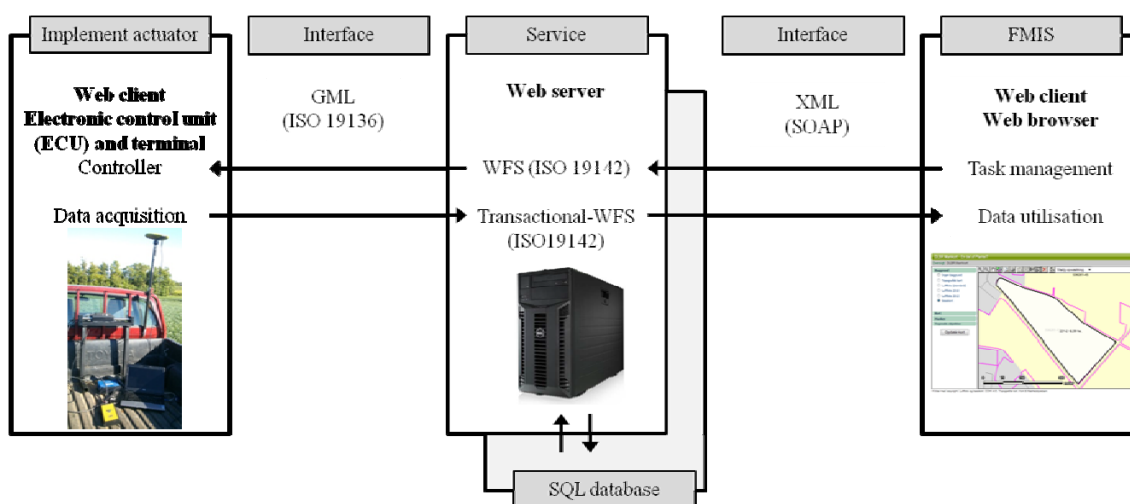

Figure 1. SDI components for the analysis of utilising WFS and WFS-T for novel agricultural process data services.

For demonstration purposes of the WFS and WFS-T based agricultural process date services (with specific focus on the on-line communication between field database server and mobile field machinery) a standard computer running Linux was programmed in C++ to function as a web client for actuator control (simulating ag-implement control). A TopCon Legacy E GPS (Topcon Inc., USA) was providing positional data to the web client via serial communication. A XTB2508 Servotube permanent magnet rod actuator module and Xenus XTL-230-18 servo controller from Copley was used to simulate a variable dose rate actuator on agricultural implements. Communication between the controller and the web client computer was done by a manufacturer specified ASCII formatted serial protocol. A mobile internet connection was used for web client ECU data communication to the Internet.

The selected exchange format between web client and server was the Geographic Markup Language (GML) specified by the OGC and ISO 19136. The software for the web client ECU was developed in this project. The initial step for the web client ECU software was to request the service metadata, which is a description of the feature types it can service and what operations are supported on each feature type. The service metadata were prepared for demonstration purposes only by KCA and available for web

clients by requesting the *GetCapabilities* operation of the WFS via 'HTTP GET'. In the URL a user ID and password is required. The next step was to activate a *GetFeature* request via HTTP POST of a XML code. The *GetFeature* operation returns a selection of features from a data store that the client has access to (limited by user ID and password). The WFS processes a *GetFeature* request and returns a response XML code to the client that contains the feature instances that satisfy the query expressions specified in the request. As an example, once the farm id was entered at the web client, the software requested the geographic information for all field polygons linked to the farm (Figure 2).
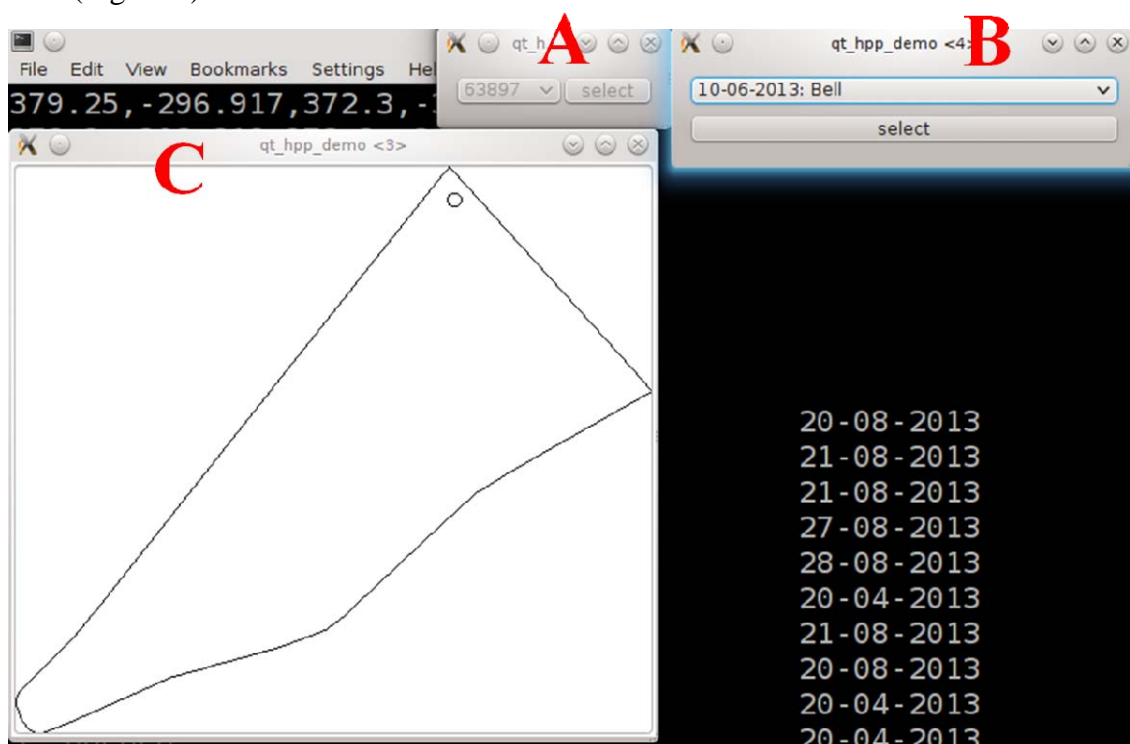

Figure 2. The Web client ECU software showing the graphical user interface on the terminal when the software have recognised that the current position is inside one of the field polygons of the Research Centre Foulum farm. A: Selection of farm, B: Selection of task of field operation, C: Map and current position on field.

The selection of features was requested during the web client software development by a *DescribeFeatureType* operation request which returns a schema description of feature types offered by the WFS instance. The schema descriptions define how a WFS expects feature instances to be encoded on input (via Insert, Update and Replace actions) and how feature instances shall be encoded on output.

Positional data from the GPS was used by the software to determine in which field the vehicle was operating (Figure 2). The web client for machine control was then requesting the planned tasks from the field data base via a *GetFeature* request for the

2013 Conference

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TORINO, ITALY

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actual field. Once the specific task has been selected at the terminal (Figure 2), the software controls the actuator to achieve the dose rate. The update rate of *GetFeature* requests was 0.2 Hz, in order to check for any changes to e.g. the planned dose rate done via the FMIS while operating in the field. After the completion of a job, a command was entered in order to transfer and updating the total dose applied, date and time. The command activated the *Transactions* operations of the WFS-T. Requesting the *Transaction* operation clients can create, modify, replace and delete features in the WFS data store. When the *Transaction* request has been completed, the WFS generates an XML response document as described in the ISO 19142 standard indicating the completion status of the request.

2. RESULTS AND DISCUSSION

An evaluation of the proposed automated process data interchange in its most simplified version was done at the fields of Aarhus University, Research Centre Foulum. The developed software for the web client ECU exchange data directly and in real time from the server storing field operational data by requesting and following WFS standardized SOA operations. The demonstration of the implementation of standard WFS data and the succession of the requests is illustrated by the screen shots from both the FMIS and the graphical user interface of the web client ECU in Figure 3 and 4. The result of the evaluation was that the planned field task for June 10th 2013 was selected and automatically executed on the field number 221-2 illustrated by the 'Planned task' with and 'Executed task' screen shot of the FMIS user interface (Web browser) in Figure 3. The planned dose rate of the fungicide Bell was 0.35 l/ha. Due to software problems calculating the covered area from the registered GPS positions in the field, the applied dose rate was zero. Nevertheless, it was shown that after ending the field operation and activating the *Transaction* WFS operation, the data on the field data server was updated in real time with actual data from the client. The *Transaction* WFS operation also updated the checkmark indicating the task has been executed and the date of task execution.

A system that could potentially integrate external data from different SDI components with electronic control units on mobile vehicles and implement was demonstrated. The integration of the essential WFS operations (*GetCapabilities, GetFeatureType, GetFeature and Transaction*) with the presented web client ECU solution for task management worked flawlessly and the transferred amount of data was rather small and the update rate of 0.2 Hz was high.
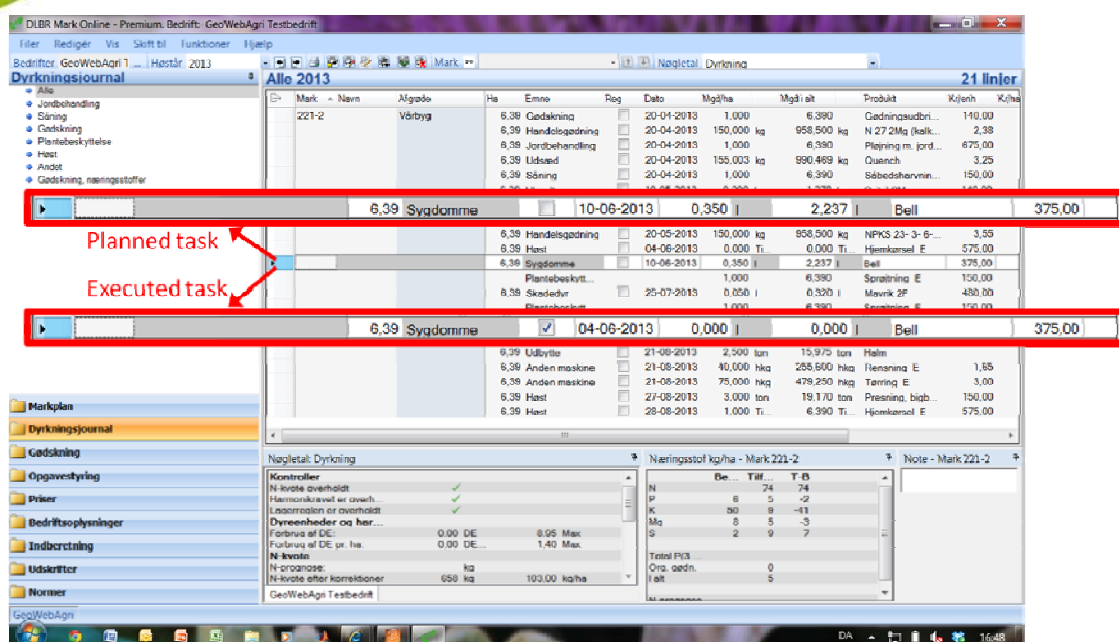
Figure 3. The FMIS user interface (Web browser) showing the planned field operational task for field number 221-2. On the Web client ECU, the fungicide spraying task planned at June 10th 2013 was selected, executed and updated the FMIS data store as shown by the change of the check mark, dose rate and date.
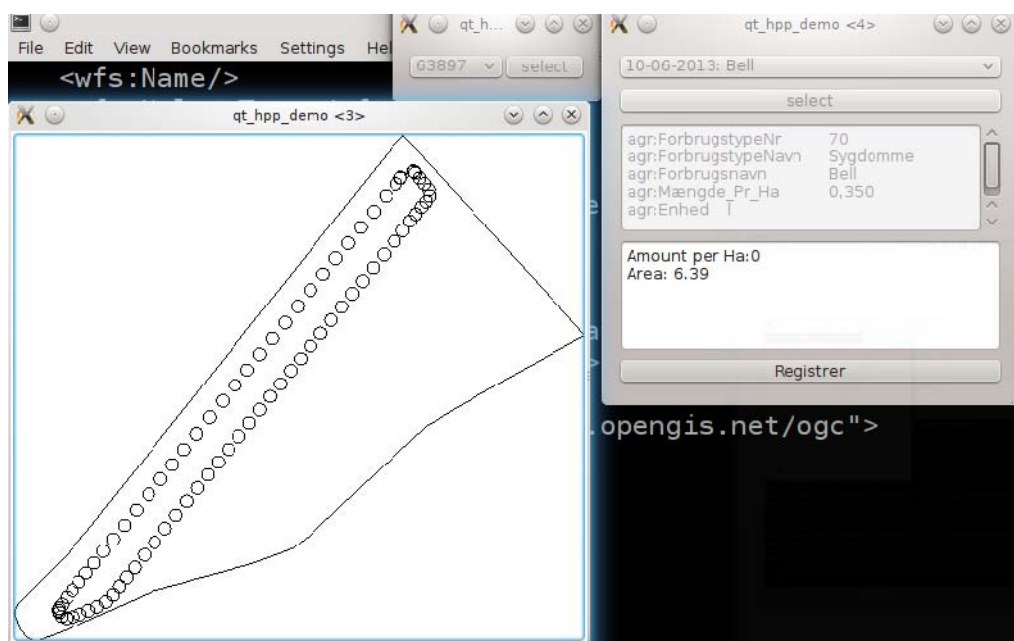

Figure 4. The graphical user interface of the Web client ECU, showing the situation when the *Transaction* WFS operation has been activated in order to update the FMIS data store about the actual dose rate, date of task execution and indication of the task has been executed.

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Access to the database behind the WFS was in this study provided by a simple username and password system. WFS supports the use of HTTPS, which is HTTP encapsulated in SSL/TLS, but it was not implemented in the presented proof of concept. The WFS itself also provides a security. Part of the server response to the *GetCapabilities* request, is an URL containing a time limited ticket, valid for approximately an hour. After the *GetCapabilites* request, the client utilize the URL with the ticket, thus avoiding transmission of user name and password for every communication with the server.

3. CONCLUSION

A novel communication interoperability between two SDI components; a novel web client ECU and a commercial FMIS has been established based on real farm data exchange via WFS and WFS-T (ISO 19142). The evaluation proved that agricultural machines can request and update field operational data on-line, in real time and at high update rate using open GIS communication standards.

Agricultural machinery supporting a web client platform can potential use several services simultaneously. For instance such machinery platform can be prepared for several services and when the services are available locally, value is added to the agricultural machine automatically.

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