NEW GEOSPATIAL TECHNOLOGIES FOR PRECISION FARMING

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ABSTRACT

The system of Precision farming guarantees a detail monitoring of data and information, which are necessary for successful decision in crop production. The system is designed for data collection from several sources. The data are collected by Service Company and farmers mainly Paper also analyse economical efficiency on the base of Medlov Farm. Next development is currently running under projects Prezem, Future Farm, AgriExchange, COIN EEU and AgriSensor

Keywords: Precision Agriculture, SDI, eCollaboration, Open Agriculture Services

INTRODUCTION

Current agri-food economy focuses on consumers and their food supply. The consumer should be enabled to make choices, based on aspects such as food safety, quality and sustainability. This means that the business environment of agri-food production is very dynamic, driven by various and changing needs of consumers and society. Production is becoming more demand-driven, has to be transparent and must meet quality and environmental standards. Besides, agricultural markets in Europe are under pressure because of high land and labor prices in combination with intensified competition due to globalization. We can mention several external driving forces, outside the direct control of industry, retail and consumer product companies, which can be grouped into five areas:

- **Economic issues**, including the reshuffling of the world's top economies, the growing gap between industrialized and developing countries, as well as a focus on social responsibility among the more developed countries in areas such as fair trading.
- **Ecological issues**, including water, energy and fuel scarcity and efficiency, sustainability and waste management.
- **Changing demographics**, such as the shift in global population, urbanization and cross-border migration.
- **New technologies**, such as virtual reality, quantum computers and information networks, have the potential to make data, people and objects accessible everywhere and immediately.
- **Regulatory forces**, including extended legislation on health and wellness (for example, labelling of products) and privacy standards.

The developers' principle emphasizes interaction among technological components developed by different partners for agrifood applications. Collaborative tools (i.e. tools, which have the ability to interact with other SW tools and together create new services) can operate separately, but also can be integrated into new applications. **The process of designing applications hat to covers analyses of SW architecture and the definition of available data sources, services and other existing components.** As example we could mention system development of data transfer from sensors and the publication of the data on the web through open web services. Independent tools developed in different institutes are integrated into one web application supporting monitoring of production. These tools could be integrated with food traceability products or e commerce systems.

At the same time, there will be key industry trends that will affect the future value chain, particularly in the areas of consumer behavior, information flow and product flow. In contrast to the external driving forces, it is possible to shape these internal forces. A convergence of these external forces and industry trends will drive the evolution of the value chain. **Information sharing** is the most interesting in the context of this project. About information sharing they state the following: Companies must be prepared to share standards-based data free of charge. Sharing information (such as supply chain events) between trading partners will result in an improved information flow and, as a consequence, improved collaboration to better serve the consumer. A resulting collaborative information platform could become the basis for further supply chain solutions, like demand-driven ordering and collaborative promotion planning.

As main testing use case we plan implement **Open Agriculture Service** solutions for Latvian Agri sector connecting farmers, service provides, advisory services and data holders. The main objective of an Open Agriculture Service (OAS) Platform for eCollaboration in agriculture has to support more effective access of farmers, farming service organisation, advisory service organisations to services based on spatial data. There will be focus on two conflicting issues:

- On one side, there is relatively low cost per hectare,
- On the other side, the current model of spatial data ordering is very expensive for final users, as they have to buy full scenes even if they will use only a small portion of them: this data policy is almost out of reach for small users.

As possible solution for these constraints it was proposed to establish a collaborative solution, where the final users will not directly access all data, but only the results = knowledge, which are generated on the base of the analysis of selected parts of field observation data in combination with other data sources.

The prototype will aim to demonstrate the feasibility of creating a subset of complete supply chains up to final user access, by linking and connecting different data suppliers, service and consultancy companies, in the farming domain. The focus of the proposed work is on models that can improve the interoperability of the whole production chain, on collaborative support tools to introduce a new interoperability concept to vertical chains. This model will also support a more effective utilisation of agriculture data and is expected to foster the market of agriculture services.

1. AgriXchange project

Within the knowledge-based bio-economy, information sharing is an important issue. In agrifood business, this is a complex issue because many aspects and dimensions play a role. An installed base of information systems lack standardization, which hampers efficient exchange of information. This leads to inefficient business processes and hampers adoption of new knowledge and technology. Especially, the exchange of information at whole chain or network level is poorly organized. Although arable and livestock farming have their own specific needs, there are many similarities in the need for an integrated approach. Spatial data increasingly plays an important role in agriculture.

The overall objective of AgriXchange is to coordinate and support the setting up of sustainable network for developing a system for common data exchange in agriculture. This will be achieved by:

- establishing a platform on data exchange in agriculture in the EU;
- developing a reference framework for interoperability of data exchange;
- identifying the main challenges for harmonizing data exchange.

First, an in-depth analysis and investigation of the state-of-the art in EU member states will be carried out. A platform is built up that facilitates communication and collaborative working groups, that work on several, representative use cases, guided by an integrative reference framework. The framework consists of a sound architecture and infrastructure based on a business process modelling approach integrating existing standards and services.

The development is done in close interaction with relevant stakeholders through the platform and international workshops. The results converge into a strategic research agenda that contains a roadmap for future developments. The project consortium consists of 14 partners from 11 countries covering different disciplines, stakeholder views and experiences with information management and standardization.

2. Precision farming platform - Prefarm

Technology of Precision farming guarantees a success of this system in the market. Difficulties of technologies, which are currently and continually involved in this system, argue against its practical using by farmers. In this case, Service Company wants to offer a suitable environment not only for data collection, data processing, but also for the high quality of other information related with farm management and crop production. The practical distribution of result to customers helps them ensure a variable application of result on the field. The most important part of services is a technology of data collection, system of data processing. Remote sensing, crop scanning and soil sampling for management zones classification means presentation for farmers or other users the simplification of the difficult operations and recommendations including economic calculations.
Professional service on the market in this area using a follow tools:

- navigation system GPS with or without Differential GPS
- environment of Geographic information system (GIS)
- internet as a tool for data transport, data presentation,
- map server technology, web mapping services (wms / raster)

The complex advisory and service system on the market is based on results of field trials in different crops and locations. The data for WEB processing are prepared and stored by service organization and farmers. Central database store data as follow:

- soil measuring (EM 38 data, soil type data)
- soil sampling (lab analysis for Phosphor, Potash, Magnesium, Calcium, soil pH….)
- crop scanning (NDVI data created from satellite or airborne pictures)
- yield data from yield monitor created during harvest
- other remote sensing data (N-sensor scanning)
- agronomies, field management data (crop rotation, variety, data of applications, weather conditions…..)

The main point of system is to collect different data the easiest way on the field and on the farm, and then use collected data for data processing via web tools.

Open source solution MapServer. Inside of services was developed mobile interface for this Open Source solution and also there were implemented OGC standards (WMS) for utilization of data in distributed system. Connection with another open source systems (GRASS, etc), was established. Current solutions are Internet Mobile Systems, including analytical tools. The most successful and currently used application from service system is „GIS server for precision farming application with mobile access“. It is focused on to increase the agricultural profitability and to reduce the fertilizer and chemical bad influence on surround environment.

3. Technological solutions

SWE

The concept of sensor web was introduced by NASA. The sensor web enables autonomous collaborative observation collections via a variety of sources. Typically, scientific events of interest trigger observation campaigns in an ad hoc sensor constellation and supply multiple data acquisitions as rapidly and to such extent as possible in a given time period. This is accomplished through a seamless set of software and communication interactions in a system of linked sensors.

As the critical management is becoming more up to date, regarding communication with GIS tools, the OGC begins to release the Sensor Web Enablement (SWE) that should become a standard in integrating various kinds of sensors into one communication language and well defined web environment. Open geospatial consortium SWE is intended to be a revolutionary approach for exploiting Web-connected sensors such as flood gauges, air pollution monitors, satellite-borne Earth imaging devices, etc. The goal of SWE is the creation of web-based sensor networks. That is, to make all sensors and repositories of sensor data discoverable, accessible and where applicable, controllable via the Internet. Open geospatial consortium defines a set of specifications and services for this goal. Short descriptions of these services are shown below.

Sensor Observation Service

The SOS is an OGC standard that defines a web service interface for discovery and retrieval of real time or archived data. Data are produced by many sensors, including mobile, stationary, in-situ or remote sensors. Data can be observations or descriptions of the sensor (calibration information, positions, etc.). Observations return encoded as an O&M Observation and the information about the sensor returns encoded in SensorML or TML.

The operations of the SOS are separated in four profiles:

- core profile – three basic operations, provided by every SOS implementation
- transactional profile – operations to register sensors and insert observations into SOS
- enhanced profile – additional optional operations
- entire profile – implements all operations

Core profile has three mandatory core operations which provide its basic functionality:

- GetCapabilities – returns a service description containing information about the service interface and the available sensor data.
- DescribeSensor – returns a description of one specific sensor, sensor system or data producing procedure. The response returns information like position of sensor, calibration, in- and outputs encoded in SensorML or in TML.

- GetObservation – provides access to sensor observations and measurement-data.

Our recent work was focused on creating an SOS implementation which contains core operations. Communication between consumer and implementation is based on xml documents.

An XML schema describes the structure of an XML document. An XML Schema:

- Defines elements that can appear in a document;
- Defines attributes that can appear in a document;
- Defines which elements are child elements;
- Defines the order of child elements;
- Defines the number of child elements;
- Defines whether an element is empty or can include text;
- Defines data types for elements and attributes;
- Defines default and fixed values for elements and attributes.

For reading and parsing XML document, JAXB utilities that are a core part of JAVA are used. JAXB constitutes a framework for processing XML documents. JAXB accesses the XML document from a Java program by presenting the XML document to the program in Java format. The first step in this process is to bind the schema for the XML document. Binding a schema means generating a set of Java classes that represents the schema. All JAXB implementations provide a tool called binding compiler to bind a schema. We have successfully generated all required classes, so now we can handle all SOS related XML documents. Next work is to add a convenient API to deal with specific requirements of SOS more comfortably. This lets us publish the position or the track of the sensor and some of the measurements. To publish the measurements in a better way, we can access the data by SOS service (still in development). We have also implemented web service that generates charts from database query.

The OpenGIS® Web Processing Service (WPS) Interface Standard provides rules for standardizing inputs and outputs for geospatial processing services. The standard describes the way of distributing geospatial operations (referred as “processes”) across networks. WPS server can be configured to offer any sort of GIS functionality to clients across network. The process can be simple calculation, like putting raster maps together or making buffer around vector feature, as well as complicated models, as for example climate change model. The main goal of WPS is that computational high-demanded operations are moved from client stations (general desktop PC) to server.

Three types of request-response pairs are defined. Request can be in Key-Value-Pairs (KVP) encoding, as well as XML document. Server response is always formatted as XML document.

- GetCapabilities - Server returns Capabilities document. First part of the document includes metadata about server provider and other server features. Second part of the document includes a list of processes available on server.

- DescribeProcess - Server returns ProcessDescription document. Apart from process identifier, title and abstract, process in- and outputs are defined.
- Execute - Client overhands necessary inputs for partial process, the server provides geospatial calculations and returns document with all process outputs.

Three basic types of in- and output data are defined:

- LiteralData -- Character strings as well as integer or double numbers.
- BoundingBoxData -- Two pairs of coordinates
- ComplexValue and ComplexValueReference -- Input and output vector and/or raster data. Vector data (e.g. GML files) can be directly part of request/response execute document (then the input is of type ComplexValue). Client can specify only URL to input data (e.g. address to Web Coveradge Server (WCS)). In this case, the data are of type ComplexValueReference.

PyWPS

PyWPS is a project which has been developed since 2006 and which tries to implement OGC WPS standard in its 1.0.0 version. It is written in Python programming language. The main goal of PyWPS is that, from the beginning, it has been written with direct support for GRASS GIS. Consequently, PyWPS can be conceived, as a kind of translation library which translates requests complain to WPS standard, overhands them to GRASS GIS or other command line tool (such as GDAL/OGR, PROJ.4 or R statistical package), monitors the calculation progress and informs the user and after the calculation is completed, it returns its result. PyWPS released under terms of GNU/GPL licence. Currently, version 3.1.0 is available.

Map Viewer

The HSLayers system is used as a Map Viewer. This application has been developed by HSRS Company. Core of HSLayers system is the OpenLayers, a JavaScript web map client. Big difference from OpenLayers is in the appearance, as the OpenLayers has much more functions but very simple design. The Ext JS – JavaScript framework – is used here for design in HSLayers. This allows more complex designing. The source of HSLayers consists of two main parts, patches and add-ons. Patches are small modifications of OpenLayers original code. As OpenLayers developer style has big demands on developers, it is always very difficult to get these patches to source code; these patches must be hold outside the source code. Add-ons are new functions which are written by using "pure" OpenLayers or ExtJS. Big emphasis has been put here on its translations lately; versions in Latvian and Spanish have been made available recently.

One of the new functions which is very well visible on the screen is a side panel enabling for example map prints, adding new service by OWS Manager, etc. Projection switcher is available as well. If the service which is added by OWS Manager is in projection that is not supported by a map application, using the transformation service which is also part of INSPIRE draft is possible.

Teredit

The Teredit system facilitates mutual communication and data transfer between a mobile device (e.g., PDA) and the central server (Fig. 7). Teredit was developed in collaboration with the European Space Agency ESA/ESRIN in Frascati within the framework of the AMI4FOR project and was tested in collaboration with the Forest Management Institute in Brandys nad Labem (CZ). The system includes the server part Teredit – Broker and the client part installed on a PDA:

The server part of the system for mobile data collection

- Teredit Broker – a server part of the transaction system that facilitates saving data transferred from mobile devices on the server by means of open protocols
- Teredit Editor – a component which facilitates preparation of projects for updating of data in situ. By means of this component it is possible to prepare a project on the server using users' data, or possibly data accessible through web services. This project is then accessible from a PDA with the help of the Teredit Mobile component.
- Data Validator – an optional control component facilitating checking of data correctness and completeness before they are saved in the target database, the component does not have to be included in the system.

The PDA part of the system for mobile data collection

- Teredit Mobile – it provides communication between the server and a mapping application, data transfer is provided in the transaction mode.
- A mapping application – one of the commonly available commercial applications, modified for the purposes of a specific project. For this project we propose using the ArcPad software, or possibly TopolCE. Requirements for a PDA – operating system Windows Mobile.

Data collected *in situ* are saved on the server in the database, and at the same time interconnection with a web application is worked out. It is therefore possible to send data collected *in situ* to the server (via GPRS, WiFi, etc.), and these are displayed in the web client immediately after validation (in case validation is switched off, data are displayed immediately).

CONCLUSION

The Prefarm system is used more than 12 years in Czech Republic. The new version based on OGC standards is currently deployed for Latvia

The research to these results has received following funding:
FUTUREFARM - the solution was achieved with financial co-funding by the European Commission within the Seventh Framework Programme with registration number 212117 and name "Integration of Farm Management Information Systems to support real-time management decisions and compliance of management standards".
AgriXchange - the solution was achieved with financial co-funding by the European Commission within the Seventh Framework Programme with registration number 244957 and name "A common data exchange system for agricultural systems“

REFERENCES

Cepicky et al. 2008, Geospatial data management and integration of geospatial web services(p.175-190), conference proceeding book, *IAALD AFITA WCCA2008*, Tokyo , Japan.

Charvat et al.2007, Uniform Resource Management, *Naturnet Redime Newsletter vol 6,December 2007.*

Charvat et al. 2009, *INSPIRE, GMES and GEOSS Activities, Methods and Tools towards a Single Information Space in Europe for the Environment* Riga, Latvia.

Gnip et al. 2008, In situ sensors and Prefarm system(p.255-262), conference proceeding book, *IAALD AFITA WCCA2008*, Tokyo , Japan.

Gnip et al. 2008, Prefarm Solution - MapServer as a Services Support Tool for Farmers to Make a Fast Decision in Crop Production (p.423-428), conference proceeding book, *IAALD AFITA WCCA2008*, Tokyo , Japan.

Horak et al. 2009, Web tools for Geospatial Data Management, *Information Systems Development, Towards a Service Provision Society*, Springer 2009.