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Alert System in Case of Excess Drawing of Ground Water

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Abstract: The paper describes the implementation of sensor observation services for sensor networks. The development is done by Czech and Latvian scientists and developers. The implementation is currently tested as a part of the EnviroGRIDS@BlackSee infrastructure. The technological solution is demonstrated on the protected area Litovelské Pomoraví. The solution is integrated with EnviroGrids portal using a new client solution.

Keywords: GEOSS, sensor networks, underground water, SWE SOS

1. Introduction

The paper is focused on the description of the implementation interfaces supporting the integration of sensors. It is performed as a part of the EnviroGRIDS@BlackSee infrastructure. The paper describes tools to access sensor measurements in a standardised form. The collected data are stored in the EnviroGRIDS@BlackSee repositories. The integration of data generated by active sensors within the EnviroGRIDS@BlackSee environment is a prerequisite for handling of these data inside of the Black See catchment. The solution is generic and experience could be transferred into other areas. The solution is currently extended by Czech and Latvian scientist and developers and important parts of the software solution are available as open sources.

The pilots take place in the Pnovice locality, on the basis of measured changes of the ground water level, and in the the Natural Conservation Area Litovelské Pomoraví, pumping area Pnovice, measurement line “Pnovice – Tri Dvory.“

2. Objectives

The objective of the EnviroGrids Black See project is to create a system, which would independently monitor the ground water level. This will enable the optimisation of drawing the ground water from individual pump wells in order to comply with demand of consumers and at the same time to ensure the protection of the bottomland forest.

For the integration of the sensor environment in the Web environment Web Interface defined by Open Geospatial Consortium (OGC) initiative is used. The standard used is Sensor Web Enablement (SWE), mainly Sensor Observation Services (SOS). This allows:

- to describe the sensors in a standardised way;
- to standardise the access to the observed data;
- building a framework and encoding for measurements and observations.

The paper demonstrates how SOS can be integrated in the spatial infrastructure. The document describes pilot use cases, different sensors, integration of sensor mesurements with Web environment, possibilities of analysing the measurements and tools for visualisation of measurements.

3. Methodology

The main focus in the EnviroGrids@BlackSee sensor development was on the implementation of Sensor Observation Services (SOS) accessing data stored in a database. A modular and scalable architecture was defined in order to understand and implement full chain of actions needed for utilisation of sensor observation into SDI. The architecture can be easily modified or extended.

This description includes not only the components directly related to the SOS implementation, but also sensor and analytical technologies. Some parts of the solution including VLIT sensor network technology, Mort Gateway, Software daemon on server, Catalogue and WPS server were developed as part of other projects, but currently implemented as part of this modular solution. It can be used for concrete tasks.

The basic architectural components are depicted in Figure 1.

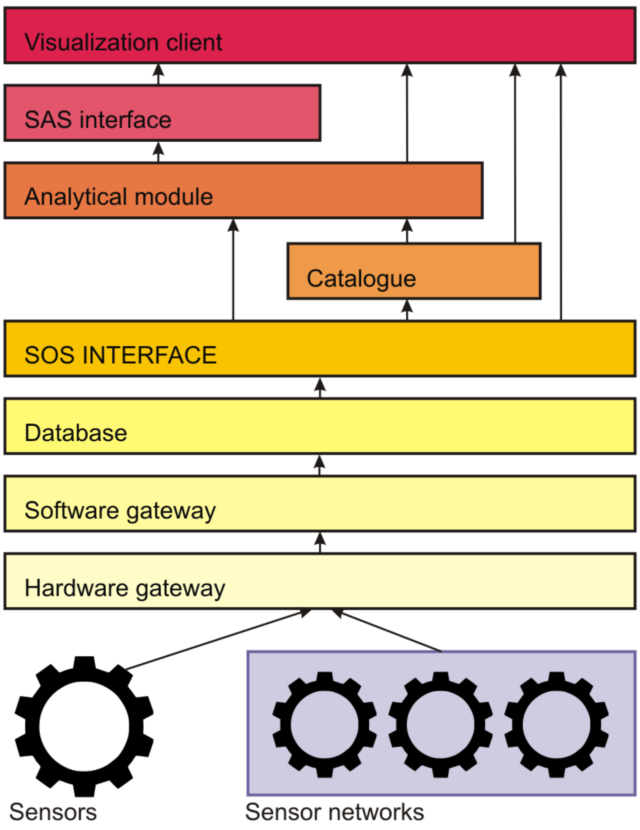

Figure 1. EnviroGrids@BlackSee sensor architecture.

4. Technology Description

In the EnviroGRIDS@BlackSee project we are providing test with two types of sensor technology. The first type is a specific solution developed directly for the purpose of the pilot Litovelské Pomoraví. It is supporting measurements of height of water column. The second technology is more generic and it is new generation of Wireless Sensors Network technology called VLITE node. This technological solution was developed as part of the VLIT Node project. The project was funded by the Ministry of Industry and Trade of the Czech Republic (programme "TIP-2009" with registration number FR—TI1/523). This technology was integrated in the EnviroGrids@BlackSee infrastructure. Both technologies are tested in the pilot implementation area Litovelske Pomoravi. [5]

The VLIT Node project built an extensive network of wireless sensors communicating with the MESH topology. The MESH topology enables connection of nodes to any other node in the network. As part of the MESH topology it is provided an automatic configuration of network structure, reliable routing between nodes and automatic access to new nodes in the network via the existing nodes. Hop identifies the network segment, where all participants can communicate to each other without the need for routing. Multi-hop network is a network composed of several such segments, where information could be routed among the nodes. In the area of wireless networks AH-HOC is used. AH-HOC is a network where actors do not require any pre-created infrastructure to be able to communicate with each other and it provides the necessary functionality for the network management.

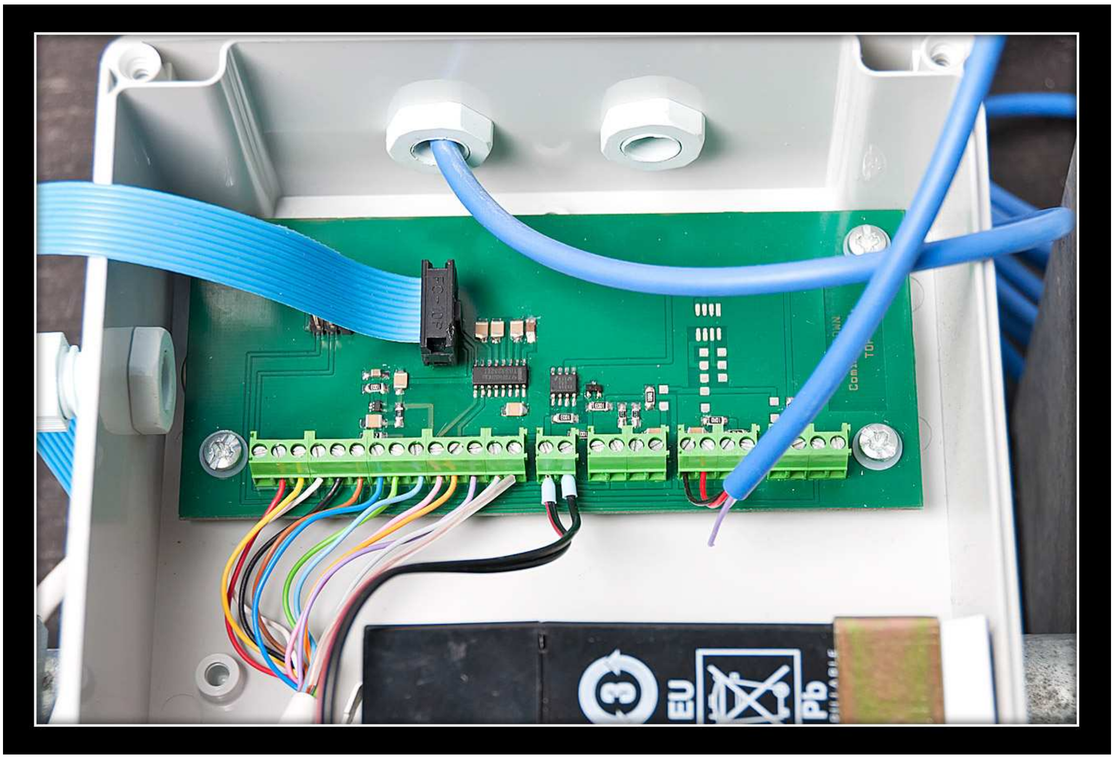

Figure 2. VLitNode prototype.

The hardware gateway is collecting data from sensors or sensor network and translates these data on Web server. Gateway is a small computer kit based on modules compatible with industrial standard PC104. Boards are stack together like building blocks. Each board has mounting holes in the corners which allow the boards to be fastened to each other with standoffs. The standard defines electrical connections, which is in Mort case supplemented by proprietary connectors providing specific buses and power connection. In the network the gateway creates the main data collector, buffer and transmitter to the outer world.

The gateway consists of power board (powering of other boards, battery handling), processor board (AVR Atmega with sram memory, flash), GPRS modem board (optionally with GPS module) and RS485 expansion board.

The gateway has a small four line alphanumerical display used to show the current status of the gateway and actually processed sensor measurements. The system uses modified open source real time operating system Ethernet (www.ethernut.de) with extensions respective to used peripherals and connected sensors. OS consists of several libraries and general API framework for user application with support of easy data acquisition via common API.

The VlitNode gateway uses one Vlit node connected through serial line as access point to the wireless Vlit node network, issues data acquisition and receives measured data. Then it adds time stamp and sensor unique number to sensor data packet and stores these in the internal memory. The system buffers acquired sensor data in its internal memory in ring buffer, in inbuilt flash memory or user SD micro card. Once the buffer is full, the oldest data are deleted.

After the data reach the server by UDP or TCP protocol, they have to be stored into the database. For that propose we have designed several web services that can be called using HTTP GET or POST. Server side applications perform insertions of data into the database (this is implemented as Java web application). Then a set request that is available as REST services has been implemented. These services enable client side application to query the database and retrieve output in JSON format. This format can be then easily used for AJAX based client application. The database design has been tested with special emphasis on performance and scalability.

For main data storage Postgres with PostGIS relation database management system are used. Couple of functions and trigger functions have been implemented in Plpgsql to process and sort the data during the insertion for improving the performance.

5. Developments

The SOS interface named Senslog was the main part of the development within the EnviroGrids@BlackSee project. The idea of Sensor Webs was established for these cases. The OGC's Sensor Web Enablement (SWE) activities have established the interfaces and protocols that will enable Sensor Webs.

The following standards are the most relevant for SWE:

- Observations & Measurements (O&M) – The general models and XML encodings for sensor observations and measurements.
- Sensor Model Language (SensorML) – The general models and XML schema for describing sensors and processes associated with measurement.
- Transducer Markup Language (TML) – General characterizations of transducers, their data, the phenomenon, transporting the data, and any and all support data (metadata) necessary for later processing and understanding of the transducer data.
- Sensor Observation Service (SOS) – The service provides an API for managing deployed sensors and retrieving sensor data (observations).

SOS provides access to observations from sensors and sensor systems in a standard. The same way is used for any type of sensor systems. It can be remote sensing, in-situ, fixed and mobile sensors. SOS leverages the O&M specification for modelling observations and the TML and SensorML specifications for modelling sensors and sensor systems. SOS is primarily designed to provide access to observations. In Senslog we are mainly focused on publication of observation in standard form for consumers of observation. It could be analytical modules, view client etc.

For every SOS implementation three operations are mandatory:

- GetCapabilities – provides the means to access SOS service metadata.
- GetObservation – provides access to sensor observations and measurement data, a spatio-temporal query filtered by phenomena can be used.
- DescribeSensor – retrieves detailed information about the sensors and processes generating those measurements.

All SOS requests and responses are in the form of XML encoded documents sent by HTTP POST method. The forms of requests and responses are provided in W3C XML Schema (XSD) language. These schemes are part of the SOS Implementation standard. SOS is one of the SWE technologies building the Sensor Webs. It uses partially components from other SWE standards. The last part of the development was focused on the client side. The SOS client in HSLayers is a component which can be used for browsing data from any OpenGIS Sensor Observation Service (OGC SOS) compliant services. The component can be used together with map application based on HSLayers, or independently with any non map application.

The actual version of the component supports only operations from the OGC SOS Core Profile which must be implemented in every OGC SOS compliant service.
Operations supported in the actual version are:

- 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;
- GetObservation - provides pull-based access to sensor observations and measurement-data via a spatio-temporal query that can be filtered by phenomena and value constraints.

The future versions of the components will contain also operations from the OGC SOS Enhanced Profile and will offer more functionality for working with data from the OGC SOS services.

- User invokes HSLayers SOS Client UI dialog;
- User inputs URL of required OGC SOS;
- HSLayers SOS Client sends GetCapabilities request to OGC SOS, parses its response and displays available information about OGC Service (name, abstract) in UI;
- User selects offering and all parameters for required observations (procedure, observed property, date-time interval);
- User invokes getting observations;
- HSLayers SOS Client sends GetObservation request with all passed parameters to OGC SOS, parses its response and display all obtained data in table and chart;
- If HSLayers SOS Client is used within map application based on HSLayers, user can displays location of obtained observations.

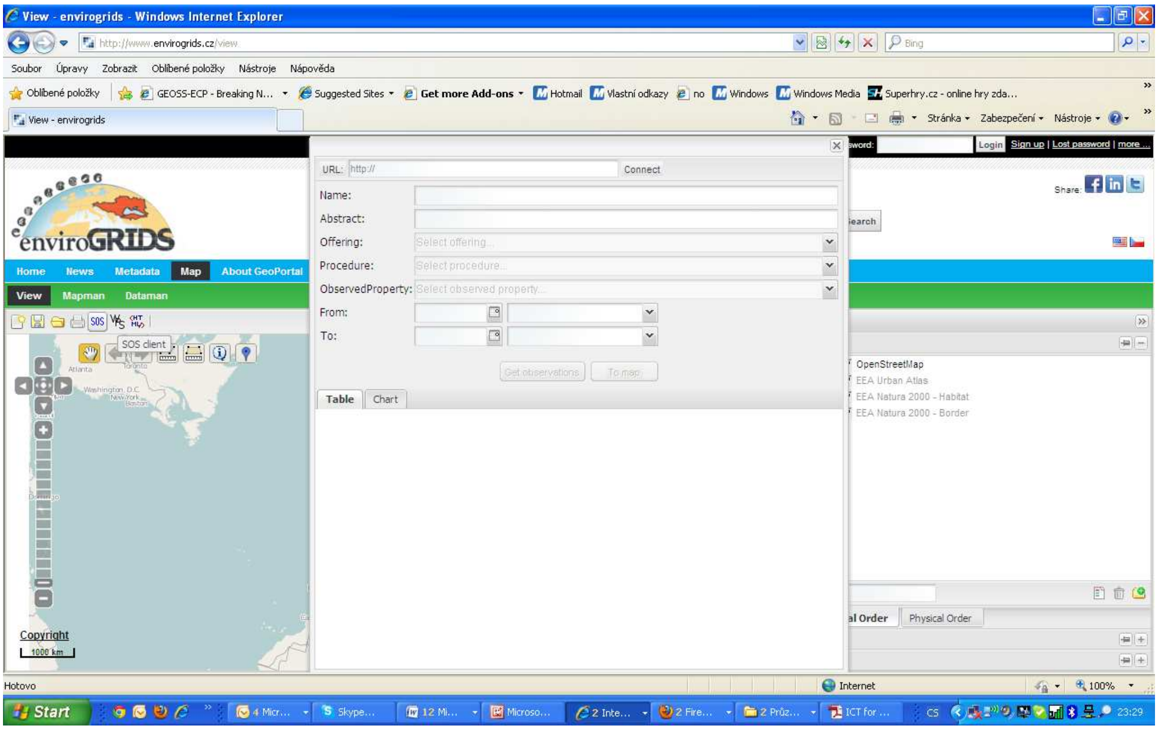

Figure 3. HSlayers SOS client.

6. Results

The total of 22 monitoring/pump wells, the mutual distance of from 100 up to 300 meters, an electrified railway line and road leads across the measurement line are placed in the given locality. The work on pilot is described by next steps:

- Pressure sensors for the height of the water level were placed into the well.Output electric quantities of the sensor are transferred to a data communication protocol.The data protocol brought into a radio module is transferred to a radio communication protocol.
- Data are transferred from individual measuring points (wells) using VLIT technology to the gateway, which ensures the necessary data pre-processing (i.e. conversion of the water level to absolute altitude) and sending the data to the Internet. The receiving module of the server part arranges receipt of measured data, the check thereof and saving the data in the database.
- The measured data are saved based on Sensor Observation Services standards in the central relation database, measured values will be made available to authorised persons using an Internet browser and the system will be able to send alert (Sensor Alert Services) in case of approaching limit values.

Figure 4. Locality.

Figure 5. Sensor deployment.

7. Business Benefits

The implementation of sensors environment in EnviroGRIDS could be viewed from two perspectives:

- Poor implementation of Sensor Observation Server and client for Sensor Observation, which are now two independent components. The first is published as Open Source under name Senslog, the second is part of HSlayers (also Open Source product). This allows integration of both components with other modules. Senslog is able to transform heterogeneous observation into interoperable form of SOS. It allows to access heterogeneous measurements by analytical modules including GRIS application trough SOS. The condition is including the SOS client as part of this solution. The SOS client is the first example of client allowing visualisation of sensor measurements including dynamic graphs.
- The implementation of complex solution as part of URM, which could demonstrate with heterogeneous sensors the possibility of accessing sensor measurements based on given requirements, their analysis and visualisation. They are implemented on concrete pilot case as examples. The pilot case could be extended to any regions of the project, but could be also easily modified for different types of monitoring. This technology could be easily modified also for African purposes.

8. Conclusions

The paper describes the following work:

    - There were defined testing scenarios for testing Sensor Observation Services - Measurement of level underground water;
- There were implemented:
    - SOS server for publishing heterogeneous sensor observation in interoperable form;

- o SOS invoking client for HSlayers;
- There were tested descriptions and discovery of Sensors Observation by Catalogue System Micka;
- The SOS services were integrated with full sensors chain (some operation are coming from other projects) including:
  - o Single sensors for Measuring Level of Underground Water;
  - o Sensors Network for Measuring Level of Underground Water;
  - o MORT hardware gate for interconnecting Sensors or sensors network with Web environment;
  - o Android based Smartphone's or tablets as tools for human observation;
  - o Software gateway (daemon) for integration of sensor measurement with Web;
  - o PyWPS server for analysis of sensor data;
  - o Integration of SOS with LearnSens system;

The implementation demonstrates functionality of all solution and possibility to use it in practice. The solution could be easily transferred also in the context of African countries.

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