Field Sensor Network for Environmental Monitoring
- Sensor Asia Initiative and Applications -

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ABSTRACT

Sensor Asia is a new initiative to deploy high density real time sensor network using fieldservers in Asia in order to acquire various environmental information. The information from the sensor network will contribute to monitoring and modeling on various environmental issues in Asia, including agriculture, food, pollution, disaster, climate change and etc. The initiative is developing GIS and Sensor integration system as an infrastructure called Sensor Service Grid (SSG) to realize easy and low cost installation and operation of fieldserver networks. The fieldserver is an Internet based observation robot that can provide an outdoor solution for monitoring environmental parameters in real time.

1. INTRODUCTION

There have been greater advances in the field of Information and Communication Technology (ICT); numerous modes of connecting to the Internet are now available such as satellite services, ADSL, FTTH, GPRS etc. With the advent of these technologies, gathering sensor data from remote fields is now getting more convenient with the potential of making sensor networks truly ubiquitous. At the same time, advances in electronics and Integrated Circuits technology mean that sensors and sensing devices are getting inexpensive and more easily available. However, due to numerous technical aspects involved such as the requirement of extra data acquisition circuitry and the required knowledge of sampling, quantization and calibration equations, only highly skilled people generally use sensors in their applications. For wide-ranging reach and use of sensor networks, a system that supports sensor ‘plug&play’ is necessary so that even non-technical people can implement their own sensor systems easily and obtain data seamlessly.

The Sensor Asia Initiative aims to fill this need with its fieldservers and field-side agent boxes which can collect sensor data and connect to SSG infrastructure through the Internet. The data is collected from the fieldservers, to which the sensors are connected, and stored locally at the field in a database. At the same time the data is also sent to the archiving server at SSG after which the data can be published and seen on the Internet in real-time on GIS based web maps.

2. FIELDSERVER

The fieldserver (FS), developed by the Agricultural Research Center of Japan (NARC), is an Internet Field Observation Robot that consists of a set of multiple sensors, a web server, an Internet Protocol (IP) camera, an Ethernet Local Area Network (LAN) module and a wireless LAN module. It can provide an outdoor solution for environment monitoring and it can be used for a wide range of real time sensing applications. At the heart of the FS are a built-in webserver and an Analog-to-Digital converter. The analog voltage from sensors are converted and shown on webpage as table formatted data.

Figure 1. Typical fieldserver

In addition to the set of sensors, the FS is equipped with an IP network camera attached to it. The network camera can deliver video images and sound in real time using the Internet or an intranet. The camera is equipped with Ethernet network interface. The camera has built-in pan (left/right) and tilt (up/down) mechanism which can be controlled through a web browser to change the direction of the camera lens. The camera can also be preset to move to different rotation and zoom positions at fixed time intervals.

The fieldserver in itself is an excellent platform for data collection. However, the sensor connection, data archiving and transfer to outside world are not easy tasks for ordinary users. The use of SOS Stations with facilities of the SSG can simplify these tasks for any user.

3. SENSOR SERVICE GRID (SSG)

SSG is a sensor data middleware which provides users with a platform to receive data from remote field sensor networks. As it follows OpenGIS standards and specifications, other applications can be built based on the SSG. The SSG implementation has been designed to run in two parts – one at the sensor node in the field, i.e. the SOS Station, and the other at the SSG central servers. The SOS Station is a combination of fieldserver with a small Linux Box which gives a high capability for storing sensor data and provides data connectivity to outside servers using standardized data exchange protocols. The SOS Station is based on Sensor Observation Service (SOS) and the sensor data can be obtained in SensorML Observation and Measurement (O&M) encodings.

The SOS Station is capable of controlling more than one fieldserver and their cameras. It also has the capability to collect data from several types of weather stations and data loggers. Once deployed in the field, the SOS Station can be used to register sensors and fieldservers at the SSG central servers. The sensor set can be added or changed easily with a user-friendly interface; the calibration equation and other parameters will be selected appropriately to obtain the correct sensor output, with a feel of sensor 'plug&play'. Once registered, the SOS Station can be controlled and configured remotely from the SSG itself. The SOS Station has been made resilient to overcome firewalls and NATs, so that sensor data can be sent from any kind of Internet connection. The SOS Station has its own webserver, which is capable of displaying sensor data and images in the local network even if connection to the SSG is lost.

The primary work of the SSG implementation at the central servers is the collection of data from all such SOS Stations around the world, the management of all such stations, and the dissemination of information collected through the Internet. One of the main features of Sensor Asia is user-friendly data visualization. After the SOS Station is registered at the SSG, and it starts sending data, the SOS Station will automatically appear on the Web GIS map, together with its list of sensors as shown in Figure 2 below.

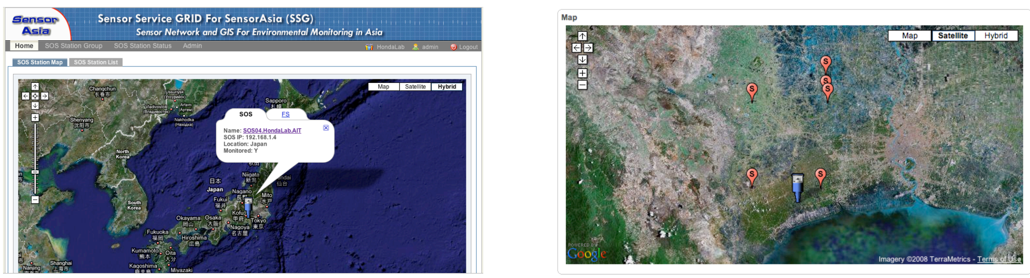

Figure 2. SSG showing the remote field location of SOS Station on Web GIS map.

The data being received from the SOS Station can easily be viewed in real-time in the form of simple dials and graphs as show in Figure 3. This web-based application provides functionalities to choose the duration of data to be viewed. The data can also be obtained in SOS based O&M format.

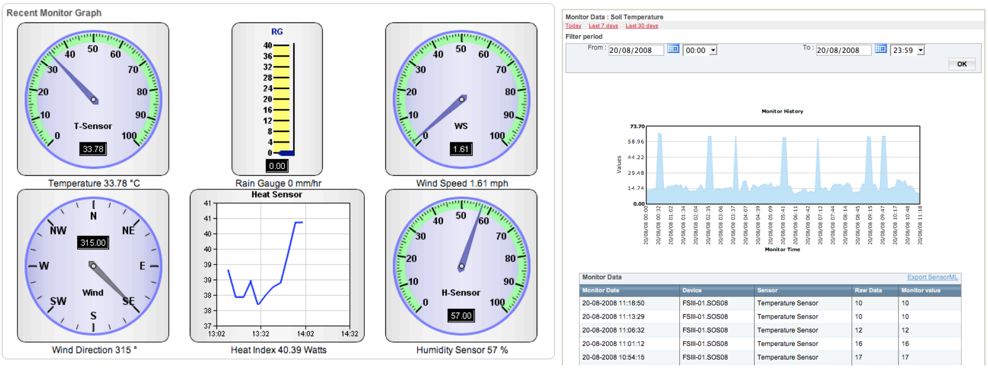

Figure 3. Data viewed in simple graphs and dials.

Along with the remote management of SOS Stations, the SSG application provides several levels of user management depending on authentication. Subscribers to the Sensor Asia services can designate their level of administrators, data editors and viewers. This provides access to management of the remote field servers from anywhere at any time with the reliability that all data is being stored at the SSG.

The Sensor Asia application also provides an interface to view images from the fieldserver camera as show in Figure 4. There is a provision to provide 10 pre-sets positions for the camera, according to which the camera will rotate periodically and transfer images in all these positions.

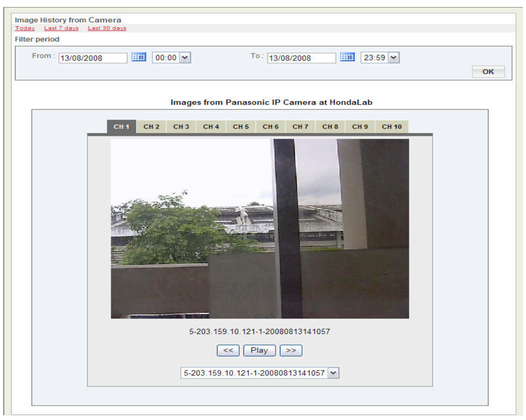

Figure 3. Camera interface of Sensor Asia application

The SSG provides a platform for ubiquitous and open sensor networks. The queries and response to and from the Agent Boxes are base on standardized XML. At the core of the implementation is the OpenGIS Sensor Observation Service; sensor data are formatted in standard Observation and Measurement (O&M) encodings. Third party applications can obtain sensor data through standard XML interface. Sensor manufacturers can easily make their sensors to ‘plug&play’ using the data feeder template programs of the Sensor Asia application.

4. SENSOR ASIA FIELD APPLICATIONS

Authors have been setting up fieldservers for various applications such as crop monitoring, landslide monitoring and glacier monitoring, as test-beds of SSG development in various parts of the Asia Pacific.

An agricultural crop monitoring system has been setup near Chiang Mai, Thailand which collects various sensor data and sends them to SSG server at AIT. The setup consists of fieldserver with camera, soil moisture sensors, CO_2 sensor, heat flux sensors, and a DAVIS weather station. This kind of crop monitoring system can be helpful to improve consumer confidence about the quality of agricultural practices in the field by using real-time data.

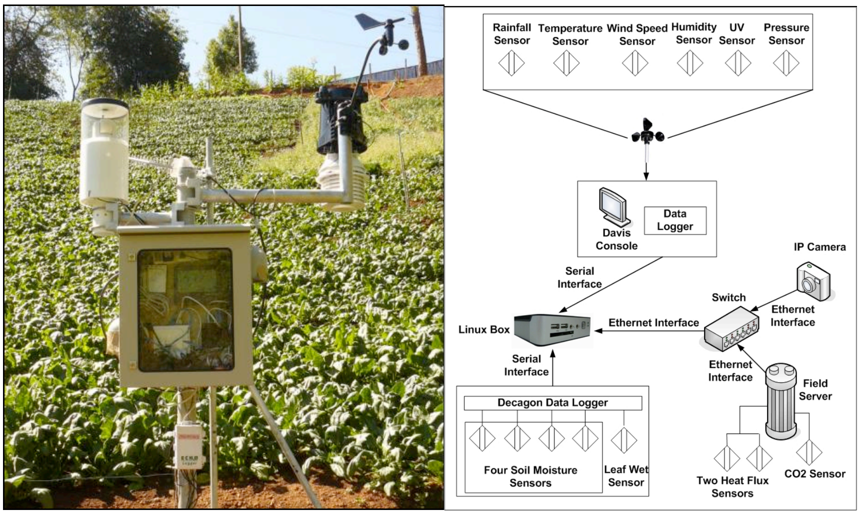

Figure 4. Crop monitoring field sensor network setup near Chiang Mai, Thailand.

A landslide monitoring system has been setup in the Banjarnegara Region of Java, Indonesia. The monitoring system consists of a fieldserver with camera, two extensiometers placed above and below the data collection point in order to check ground displacement, and a rain gauge to constantly check the antecedent as well as current rainfall which affect land movement.

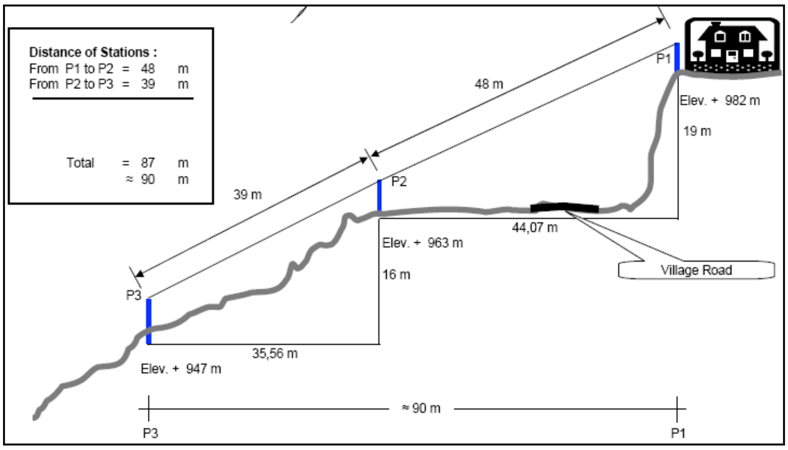

Figure 5. Extensiometer Settings above and below the fieldserver position for landslide monitoring

At the same time a water pressure gauge was also placed at a depth of 2.5 meters to measure the underground water level. The system applies algorithm based on local observations by landslide experts to provide warning messages at several levels. A graphical interface is also provided at the local site for community people to see the data. The data and images collected at the site are also sent to a server at AIT.

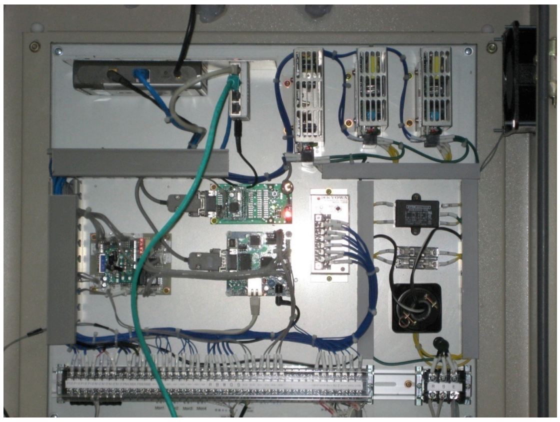

Figure 6. The fixed pole with rain gauge and network camera, and the outdoor box with fieldserver and other associated circuits

Another test-bed has been setup in the Nepal Himalayas for glacier lake monitoring. Due to global temperatures rising, glacier ice is melting at an alarming rate and lakes are being formed in high altitude areas from the melt-waters. There is a danger of these large bodies of water bursting out suddenly due to earthquakes or other reasons and the water flooding out the lower inhabited valleys like a tsunami. Such a phenomenon is known at Glacier Lake Outburst Flood (GLOF).

Figure 7. fieldservers and wireless relay station for monitoring Imja Lake (5000m)

One of the glacier lakes in a highly critical condition of turning into a GLOF is the Imja Lake (5000m) in the Everest Region. Two fieldservers with cameras and water level sensor have been setup in the area, one near the lake and one at the ridge of nearby Island Peak at around 5200m. The data from the fieldservers are being sent over a long distance WiFi network over 24 kilometers, with two relay stations in between. The final connection to Internet is made through a satellite connection at Namche Bazar (3440m), the main trading center in the area.

5. CONCLUSIONS

One of the problems in setting up of a fieldservers and sensors in the field and their operation is that the work requires highly skilled engineers for networking and web programming. It results in high installation cost and eventually will hinder the purpose of Sensor Asia to deploy high density sensor network. SSG has been developed to solve this issue. SSG supports sensor plug&play, registering sensor nodes, archiving, publishing, and visualization. These functions are important to lower the cost of installation and the make the fieldserver as off-the-shelf products for everyone. SSG supports SOS (Sensor Observation Service), one of the OGC standards, as a base technology to standardize sensor information exchange within and outside of the system. The plethora of different sensors available for climatic, meteorological and agro-hydrological phenomena that can be connected to the fieldservers, as well its support to connect other data loggers and weather stations, Sensor Asia applications based on the SSG are ideal for ubiquitous field sensor networks for any kind of environmental monitoring.

6. REFERENCES

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OpenGIS Sensor Observation Service http://www.opengeospatial.org/standards/sos