New Standards Enable Open S

Framework for Exploiting Web-connected Sensors and Sen

Imagine a large metropolitan area in which many cities have installed different highway video monitoring systems, all connected to the World Wide Web. Imagine a transportation manager using a map display interface to select highway segments or intersections the manager wants to view using video. The monitors have been installed independently at different times by different vendors using different equipment and software, but all the vendors have implemented a set of standards that enable the user's application to discover, control and access all of the monitors in the same way, as shown in Figure 1. Many of those standards - the OGC(r)'s Sensor Web Enablement (SWE) standards - have been approved by the OGC's membership and are beginning to be deployed in solutions.

By Sam Bacharach

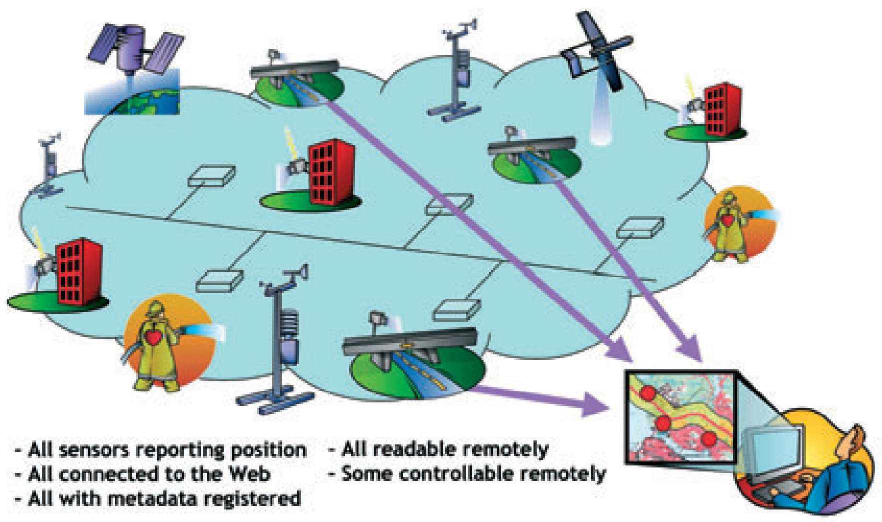

Figure 1: The OGC's Sensor Web Enablement (SWE) standards enable any kind of sensor system to be deployed on the Web in a way that makes the sensors discoverable and useable through open standard interfaces. (Figure courtesy of the OGC.)

Sensor Systems

Sensors are important in the geospatial world: Measurements made from sensor systems, whether from in-situ sensors (such as water monitoring) or dynamic sensors (like satellite imaging) make up most of the geospatial data used in geospatial systems. In the OGC's (http://www.opengeospatial.org) SWE initiative, members of the OGC are building a framework of open standards for exploiting Web-connected sensors and sensor systems of all types: flood gauges, air pollution monitors, stress gauges on bridges, mobile heart monitors, webcams, satellite-borne earth imaging devices and countless other sensors and sensor systems. Several of these standards were recently formally adopted by the OGC membership as OpenGIS(r) Specifications. Others are making their way through the OGC's consensus process.

Sensor Web Enablement enables developers to make their Web-accessible sensors discoverable, accessible, and controllable through standard protocols and application program interfaces (APIs).

Every sensor - whether it is attached to a satellite, a tower, an automobile engine, a human body, a pipeline, or a buoy - has a location, and a sensor's location is almost always important. Sensor metadata schemas standardized in the SWE effort provide a way for applications to discover the location of sensors whose metadata is published in online directories.

Consider the potentials of near-real time data layers in geospatial applications. Air quality sensors in a region can be automatically read at frequent intervals and those readings can be aggregated as map layers. Flood gages and rainfall gages can provide live map layers for flood monitoring during storms. Live and archived oceanographic data from multiple agencies' buoys, ships, satellites and autonomous underwater vehicles can be published in online directories for wide use, with applications automatically aggregating data from diverse sources into spatial data layers for diverse purposes.

This has significance for science, environmental monitoring, transportation management, public safety, border security, disaster management, utilities' Supervisory Control And Data Acquisition (SCADA) operations, industrial controls, facilities management and many other domains of activity. The OGC voluntary consensus standards process coupled with strong international industry and government support are beginning to help the new SWE specifications become established in application areas where such standards are of use.

SWE standards enable:

- Web-based discovery of sensor systems and observations, by means of catalogs in which sensor owners have published metadata describing their online sensors' parameters (including location);
- Retrieval of real-time or time-series observations and coverages in standard encodings;

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Bijschrift: Figure 2: Solar powered wireless weather station. (Photo San Diego State University Field Station Programs.)

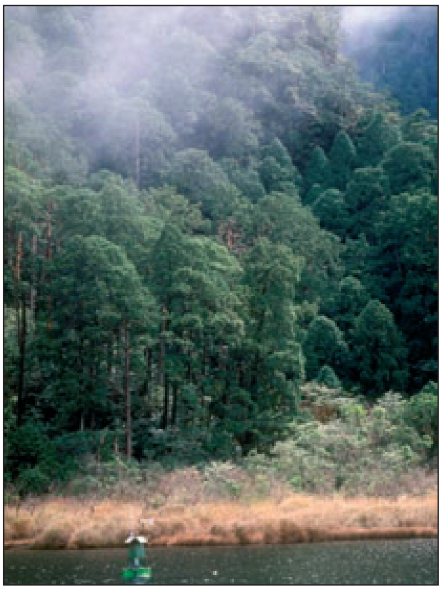

Figure 3: A wirelessly-connected buoy provides real-time data. (Photo by Dong-kuan Liao, Virginia Coast Long-Term Ecological Research (VCR/LTER) project)

- Tasking of sensors to automatically acquire observations of interest;
- Subscription to and publishing of alerts to be issued by sensors or sensor services;
- Automated metadata creation: The OGC approach to sensor and data description uses XML (eXtensible Markup Language) schemas. This makes it efficient to generate comprehensive standard-schema metadata for data produced by sensors, facilitating the discovery and interpretation of live data streams. Also, simple batch programs can be written to create standard metadata for data in distributed archives.

SWE specifications are consistent with other OGC geospatial standards as well as other relevant sensor and alerting standards such as the IEEE 1451 'smart transducer' family of standards and the OASIS Common Alerting Protocol (CAP), Web Services Notification (WS-N) and Asynchronous Service Access Protocol (ASAP) specifications. Beneath the "Web public" interfaces and encodings based on the OGC standards, a Web service might communicate with its sensor system through a proprietary or custom interface or through an interface that implements the IEEE 1451 standard.

The SWE Standards Framework

There are currently five proposed and adopted SWE specifications:

- OpenGIS Observations and Measurements (O&M) Best Practices Document [www.opengeospatial.org/standards/dp] provides a standard model for representing and exchanging observation results, alleviating the need for organizations to support a wide range of sensor-specific and community-specific data formats. O&M has an accompanying OGC Best Practices Paper titled "Units of Measure Use and Definition" (OpenGIS(r) Project Document OGC 02-007r4) which recommends ways to structure values and units of measure in XML;
- OpenGIS Sensor Model Language (SensorML) Implementation Specification v0.0 (05-086r2) (http://portal.opengeospatial.org/files/index.php?artifact_id=12606) provides an information model and encodings that enable discovery and tasking of Web-resident sensors and exploitation of sensor observations. SensorML provides a functional model of the sensor system rather than a detailed description of its hardware. Within SensorML, everything including detectors, actuators, filters, and operators is defined as a process model, which defines the inputs, outputs, parameters, and method for a process;
- OpenGIS(r) Transducer Markup Language (TML) Implementation Specification v0.0 http://portal.opengeospatial.org/files/index.php?artifact_id=14282: a method and message format for describing information about transducers and transducer systems and for capturing, exchanging, and archiving live, historical and future data received and produced by them. TML, which had its origins outside of OGC, provides models for a transducer's latency and integration times, noise figure, spatial and temporal geometries, frequency response, steady-state response and impulse response.

Figure 4: All necessary surveillance camera parameters, including direction of view, are accommodated in the SWE specifications. (Photo by Luke Hennig.)

Some of these are important for real-time streaming of data. TML was introduced into the OGC standards process in 2004 and is now part of the SWE family of candidate standards. It complements and has been harmonized with SensorML and O&M;

- OpenGIS(r) Sensor Observation Service (SOS) Implementation Specification v0.0 (www.opengeospatial.org/standards/requests/32) defines an API for managing deployed sensors and retrieving observation data. It provides access to observations from sensors and sensor systems in a standard way that is consistent for all sensor systems. The SOS is the intermediary between a client and an observation repository or a set of sensors or sensor systems. Clients implementing SOS can also obtain information that describes the associated sensors and platforms. Clients typically depend on registries that provide metadata for the different types of sensors and the kinds of data that they are capable of providing. Searches on the registries might reveal, for example, all the active air pollution sensors in London.
- Sensor Planning Service (SPS) Implementation Specification v0.0; (www.opengeospatial.org/standards/requests/34) defines interfaces for a service to assist in collection feasibility plans. It specifies interfaces for requesting information about services for the purpose of determining the feasibility of an intended sensor planning request, for submitting such a request, for inquiring about the status of such a request, and for updating or canceling such a request. The developers and likely users of the SPS specification are enterprises that need to automate complex information flows in large enterprises that depend on live and stored sensor and imaging data.

Areas of Sensor Web Standards Harmonization

IEEE 1451 Transducer interfaces Developing an open standards framework for interoperable sensor networks requires finding a standard way of connecting two basic interface types - transducer interfaces and application interfaces. Specifications for transducer interfaces typically mirror hardware specifications, while specifications for service interfaces mirror application requirements. Most of the OGC's specifications are service interface specifications (and none are transducer interface specifications).

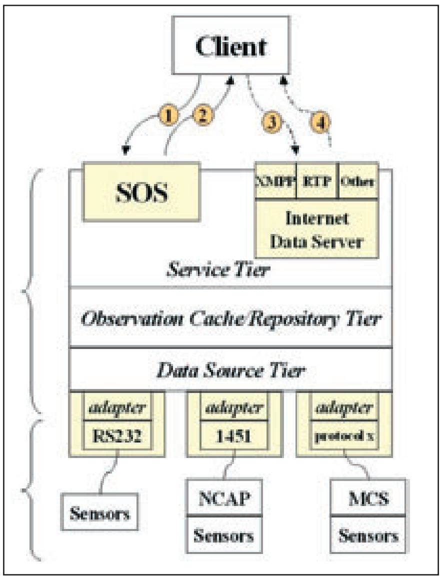

Figure 5: IEEE 1451 interfaces connect to sensor hardware. IEEE 1451 sensor applications connect to the Web through SWE interfaces.

Figure 6: One ORNL application involves chemical and radiation sensors at truck weigh stations. (Photo Metler Toledo.)

IEEE 1451 Transducer interfaces
(http://ieee1451.nist.gov/intro.htm) are standard interfaces for 'smart' transducers. At the transducer interface level, a 'smart' transducer includes enough descriptive information so that control software can automatically determine the transducer's operating parameters and issue commands to read or actuate the transducer.
The object-based scheme used in 1451.1 makes sensors accessible to clients over a network through a Network Capable Application Processor (NCAP), and this is the point where smart sensors interface to services defined in the OGC Sensor Web Enablement specifications, as shown in the figure.

Imaging Sensors
SWE's sensor model is sophisticated enough to support encoding of all the parameters necessary for characterizing complex imaging devices such as those on orbiting earth imaging platforms. ISO and OGC have cooperated to develop two ISO standards that are relevant to the SWE effort: ISO 19130 Geographic Information - Sensor and Data Model for Imagery and Gridded Data and ISO 19101-2 Geographic Information - Reference Model - Imagery (http://www.isotc211.org/).

Two SWE Projects

52° North's Sensor Web Enablement Suite
52° North (www.52n.org/) is an open partnership organization composed of several organizations founded in two cities on the 52nd parallel – Muenster, Germany and Enschede, The Netherlands. The group develops open source software, with a focus on interoperable web services and data encoding models for Spatial Data Infrastructures (SDIs). This includes novel web services that provide functionality for SDI management, mobile geocomputing, and the integration of real time geosensor data and spatio-temporal simulation models into SDIs.

52° North developers are currently developing a multi modal client framework called 'OWS Access Framework' (OXF) that simplifies the implementation of OGC Web Services (OWS). As part of this work, they are developing Sensor Web building blocks that are generic open source implementations of the SWE specifications.

The Sensor Web components of OXF are being used in Germany's contribution to the Tsunami warning system being deployed in the Pacific and Indian oceans. They have also been used in fire monitoring systems in South Africa as well as in the watershed management system in The Netherlands.

Members of the OGC are currently involved in a major testbed activity called OWS-4. In the OWS-4 fictional scenario, different sensors and other support data are required to extract reliable information to avoid a potential disaster at an airport. The University of Muenster, a member of 52º North, is participating in the SWE "thread" of the testbed, refining their OXF integrated framework through feedback from multiple participants who are building on the OXF open source implementations.

SensorNet
In a project called SensorNet, the Oak Ridge National Laboratory (ORNL), a U.S. Department of Energy facility, has been working with other organizations, including the OGC, to develop an open interoperability framework for wide-area sensor networks. SensorNet is being deployed for a variety of purposes, including the enhancement of security at U.S. ports and highway facilities and a major military installation. Systems conforming to the SensorNet framework subscribe to open standard interfaces, schemas and encodings. Measurements and alerts from legacy and new measurement systems are combined and integrated into information for federal, state, local and private stakeholders across the United States.

The ORNL approach takes advantage of the consistency built into the OGC's suite of specifications. The developers have embedded SWE encodings into application schemas that implement the OGC's OpenGIS Geography Markup Language (GML) Encoding Specification and OpenGIS Web Feature Service (WFS) Implementation Specification. Implemented in this way, each observation is a feature.

Conclusion

OGC's SWE specifications are certain to be key parts of an integrated framework for discovering and interacting with Web-accessible sensors and for assembling and utilizing sensor networks on the Web. OGC members will continue to address new areas of Sensor Web Enablement in the OGC Specification Program's committees and working groups and the OGC Interoperability Program's testbeds and pilot projects. OGC invites additional participation in the consensus process and also invites technical queries related to new implementations of the emerging standards. See web links below.

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