OGC® Sensor Web Enablement: Overview And High Level Architecture

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ABSTRACT

A precursor paper (also available as an OGC White Paper) provides a high-level overview of and architecture for the Open Geospatial Consortium (OGC) standards activities that focus on sensors, sensor networks, and a concept called the "Sensor Web". This OGC focus area is known as Sensor Web Enablement (SWE). For readers interested in greater technical and architecture details, please download and read the OGC SWE Architecture Discussion Paper titled "The OGC Sensor Web Enablement Architecture" (OGC document 06-021r1).

Keywords

Sensor, OGC, "Sensor Web Enablement", "sensor web", transducer, geospatial, "web service", SOA, "service oriented architecture", imaging.

INTRODUCTION

A sensor network is a computer accessible network of many, spatially distributed devices using sensors to monitor conditions at different locations, such as temperature, sound, vibration, pressure, motion or pollutants[1]. A Sensor Web refers to web accessible sensor networks and archived sensor data that can be discovered and accessed using standard protocols and application program interfaces (APIs).

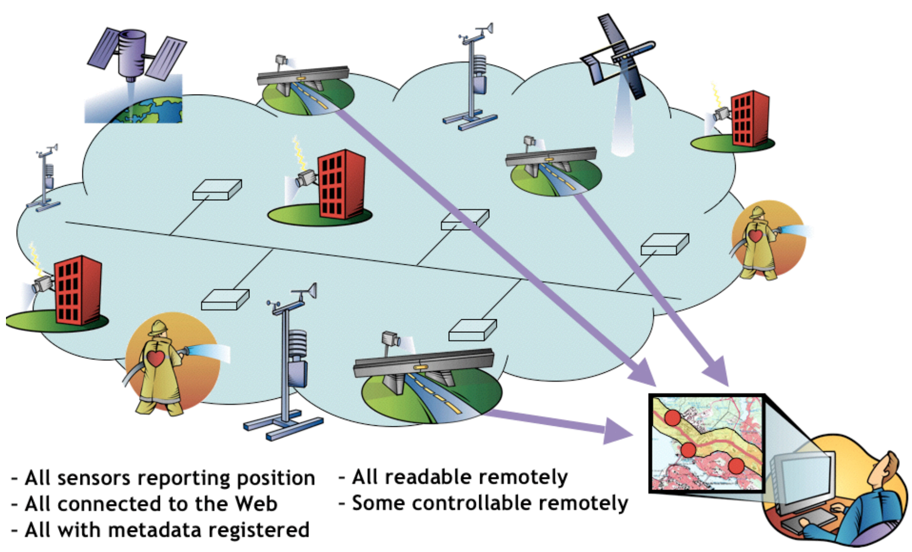

Figure 1: Sensor Web Concept

[1]Wikipedia - http://en.wikipedia.org/wiki/Wireless_sensor_network (Last viewed 18 March 2008)

In an Open Geospatial Consortium, Inc. (OGC)[2] initiative called Sensor Web Enablement (SWE), members of the OGC are building a unique and revolutionary 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, airborne and satellite-borne earth imaging devices and countless other sensors and sensor systems.

SWE presents many opportunities for adding a real-time sensor dimension to the Internet and the Web. This has extraordinary significance for disaster management, environmental monitoring, transportation management, public safety, facility security, utilities' Supervisory Control And Data Acquisition (SCADA) operations, industrial controls, science, facilities management and many other domains of activity. The OGC voluntary consensus standards setting process coupled with strong international industry and government support in domains that depend on sensors have produced SWE standards that are becoming established in all application areas where such standards are of use.

The sections below describe the high level SWE architecture, SWE standards, harmonization with other standards such as IEEE 1451, and several use cases.

HIGH LEVEL ARCHITECTURE

The models, encodings, and services of the SWE architecture enable implementation of interoperable and scalable service-oriented networks of heterogeneous sensor systems and client applications. In much the same way that Hyper Text Markup Language (HTML) and Hypertext Transfer Protocol (HTTP) standards enabled the exchange of any type of information on the Web, the OGC's SWE initiative is focused on developing standards to enable the discovery, exchange, and processing of sensor observations, as well as the tasking of sensor systems. The functionality that OGC has targeted within a sensor web includes:

- Discovery of sensor systems, observations, and observation processes that meet an application's or user's immediate needs;
- Determination of a sensor's capabilities and quality of measurements;
- Access to sensor parameters that automatically allow software to process and geo-locate observations;
- Retrieval of real-time or time-series observations and coverages in standard encodings
- Tasking of sensors to acquire observations of interest;
- Subscription to and publishing of alerts to be issued by sensors or sensor services based upon certain criteria.

Within the SWE initiative, the enablement of such sensor webs and networks is being pursued through the establishment of several encodings for describing sensors and sensor observations, and through several standard interface definitions for web services. Sensor Web Enablement standards that have been prototyped, built, and adopted by the OGC membership include the following OpenGIS® Standards:

1. **Observations & Measurements Schema (O&M)** – (OGC Adopted Standard) Standard models and XML Schema for encoding observations and measurements from a sensor, both archived and real-time.
2. **Sensor Model Language (SensorML)** – (OGC Adopted Standard) Standard models and XML Schema for describing sensors systems and processes; provides information needed for discovery of sensors, location of sensor observations, processing of low-level sensor observations, and listing of taskable properties.
3. **Transducer Markup Language (TransducerML or TML) –** (OGC Adopted Standard) The conceptual model and XML Schema for describing transducers and supporting real-time streaming of data to and from sensor systems.
4. **Sensor Observations Service (SOS)** - (OGC Adopted Standard) Standard web service interface for requesting, filtering, and retrieving observations and sensor system information. This is the intermediary between a client and an observation repository or near real-time sensor channel.

[2] The OGC is an international consortium of industry, academic and government organizations who collaboratively develop open standards for geospatial and location services. (See http://www.opengeospatial.org.)

5. **Sensor Planning Service (SPS) –** (OGC Adopted Standard) Standard web service interface for requesting user-driven acquisitions and observations. This is the intermediary between a client and a sensor collection management environment.
6. **Sensor Alert Service (SAS) –** (OGC Best Practices document) Standard web service interface for publishing and subscribing to alerts from sensors.
7. **Web Notification Services (WNS) –** (OGC Best Practices document) Standard web service interface for asynchronous delivery of messages or alerts from SAS and SPS web services and other elements of service workflows.

The goal of SWE is to enable all types of Web and/or Internet-accessible sensors, instruments, and imaging devices to be accessible and, where applicable, controllable via the Web. The vision is to define and approve the standards foundation for "plug-and-play" Web-based sensor networks. Sensor location is usually a critical parameter for sensors on the Web, and OGC is the world's leading geospatial industry standards organization. Therefore, SWE standards are being harmonized with other OGC standards for geospatial processing. The SWE standards foundation also references other relevant sensor and alerting standards such as the IEEE 1451 "smart transducer" family of standards (see page 8) and the OASIS Common Alerting Protocol (CAP), Web Services Notification (WS-N) and Asynchronous Service Access Protocol (ASAP) specifications. OGC works with the groups responsible for these standards to harmonize them with the SWE standards.

Advances in digital technology are making it practical to enable virtually any type of sensor or locally networked sensor system with wired or wireless connections. Such connections support remote access to the devices' control inputs and data outputs as well as their identification and location information. For both fixed and mobile sensors, sensor location is often a vital sensor parameter. A variety of location technologies such as GPS and Cell-ID with triangulation make mobile sensing devices capable of reporting their geographic location along with their sensor-collected data.

When the network connection is layered with Internet and Web protocols, eXtensible Markup Language (XML) schemas can be used to publish formal descriptions of the sensor's capabilities, location, and interfaces. Then Web brokers, clients and servers can parse and interpret the XML data, enabling automated Web-based discovery of the existence of sensors and evaluation of their characteristics based on their published descriptions. The information provided also enables applications to geolocate and process sensor data without requiring *a priori* knowledge of the sensor system.

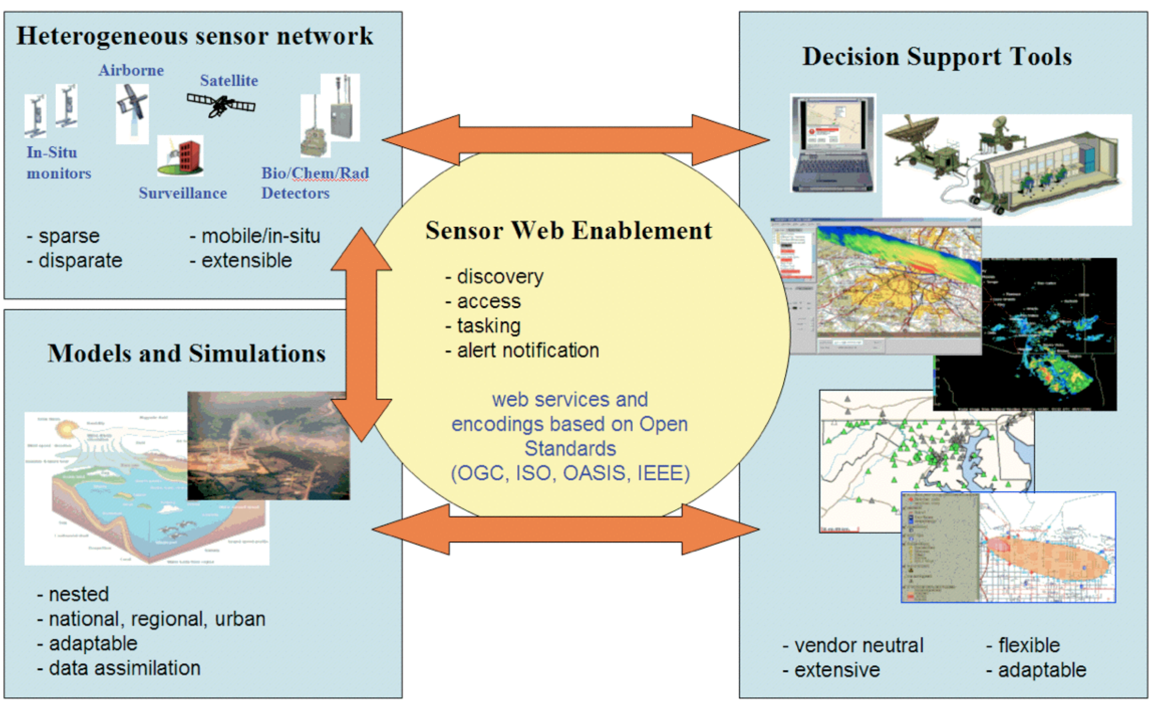

Figure 2: The role of the Sensor Web Enablement framework

Information in the XML schema about a sensor's control interface enables automated communication with the sensor system for various purposes: to determine, for example, its state and location; to issue commands to the sensor or its platform; and, to access its stored or real-time data. An object-oriented approach to sensor and data description also provides a very efficient way to generate comprehensive standard-schema metadata for data produced by sensors, facilitating the discovery and interpretation of data in distributed archives.

THE SWE STANDARDS FRAMEWORK

Below we describe each of the seven SWE specifications. Five of these documents are available as adopted OpenGIS Standards and two are available as OGC Best Practice papers on the OGC public Web site.[3] The Best Practice paper is the final step below approval as an OpenGIS Standard. These are available to the public at no charge.

In this paper we also describe other standards that are important in Sensor Webs.

Sensor Web Enablement was a main topic in the OGC Web Services 3 (OWS-3) and OGC Web Services 4 (OWS-4) Interoperability Initiatives and is a main topic in the ongoing OGC Web Services 5 (OWS-5) and EC08 Interoperability Initiatives. In these major testbed activities, which began in May 2005, a number of current and pending OpenGIS® Standards were developed or extended. Professional videos developed by WNET, the OGC, and OGC members demonstrate the OGC member work on interoperability and sensors accomplished during OWS-3 and OWS-4 (http://video.google.com/videoplay?docid=-7153530463394016693&q=OGC&pl=true).

Observations & Measurements (O&M)

The OpenGIS Observations and Measurements (O&M) Standard provides a standard model for representing and exchanging observation results. O&M provides standard constructs for accessing and exchanging observations, alleviating the need to support a wide range of sensor-specific and community-specific data formats. O&M combines the flexibility and extensibility provided by XML with an efficient means to package large amounts of data as ASCII or binary blocks.

The Observations and Measurements (O&M) Standard describes a conceptual model and XML encoding for measurements and observations. O&M establishes a high-level framework for representing observations, measurements, procedures and metadata of sensor systems and is required by the Sensor Observation Service Standard, for implementation of SWE-enabled architectures, and for general support for OGC standards compliant systems dealing in technical measurements in science and engineering.

As defined within the O&M Standard, an *Observation* is an event with a *result* that has a value describing some phenomenon. The observation is modeled as a Feature within the context of the ISO/OGC General Feature Model. An observation feature binds the result to the *feature of interest*, upon which it was made. An observation uses a *procedure* to determine the value, which may involve a sensor or observer, analytical procedure, simulation or other numerical processes. O&M has an accompanying OGC Best Practices titled "*Units of Measure Use and Definition*" (OpenGIS® Document OGC 02-007r4). The basic information needed to understand a measured value is the value and the unit of measure. The document identifies eight different ways, and various options of these ways, to tie the value and the unit of measure. The goal is to develop a preferred way to structure this information in XML.

Sensor Model Language (SensorML)

The OpenGIS Sensor Model Language (SensorML) Standard provides an information model and encodings that enable discovery and tasking of Web-resident sensors and exploitation of sensor observations.[4]

The measurement of phenomena that results in an observation consists of a series of *processes* (also called *procedures*), beginning with the processes of sampling and detecting and followed perhaps by processes of data manipulation. The division between measurement and “post-processing” has become blurred with the introduction of more complex and intelligent sensors, as well as the application of more on-board processing of observations. The

[3] OGC specification documents can be found at http://www.opengeospatial.org/specs/?page=baseline

[4] SensorML got its start in earlier NASA and CEOS (Committee for Earth Observation Satellites) projects. It was brought into OGC because OGC provides a process in which this and other elements of Sensor Web Enablement could be developed in an open consensus process.

typical Global Positioning System (GPS) sensor is a prime example of a device that consists of basic detectors complemented by a series of complex processes that result in the observations of position, heading, and velocity.

SensorML defines models and XML Schema for describing any process, including measurement by a sensor system, as well as post-measurement processing.

Within SensorML, everything including detectors, actuators, filters, and operators are defined as process models. A *Process Model* defines the *inputs*, *outputs*, *parameters*, and *method* for that process, as well as a collection of metadata useful for discovery and human assistance. The inputs, outputs, and parameters are all defined using SWE Common data types. Process metadata includes identifiers, classifiers, constraints (time, legal, and security), capabilities, characteristics, contacts, and references, in addition to inputs, outputs, parameters, and system location.

SensorML provides a functional model of the sensor system, rather than a detailed description of its hardware. SensorML treats sensor systems and a system's components (e.g. sensors, actuators, platforms, etc.) as processes. Thus, each component can be included as part of one or more process chains that can either describe the lineage of the observations or provide a process for geolocating and processing the observations to higher level information. In SensorML, all processes, including sensors and sensor systems, have input, output, parameters, and methods that can be utilized by applications for exploiting observations from any sensor system. In addition, SensorML provides additional metadata that are useful for enabling discovery, for identifying system constraints (e.g. security or legal use constraints), for providing contacts and references, and for describing taskable properties, interfaces, and physical properties.

TransducerML (TML)

The OpenGIS Transducer Markup Language (TML) Standard is a method and message format for describing information about transducers and transducer systems and capturing, exchanging, and archiving live, historical and future data received and produced by them. A transducer is a superset of sensors and actuators. TML provides a mechanism to efficiently and effectively capture, transport and archive transducer data, in a common form, regardless of the original source. Having a common data language for transducers enables a TML process and control system to exchange command (control data) and status (sensor data) information with a transducer system incorporating TML technology. TML utilizes XML for the capture and exchange of data.

Transducer Markup Language defines:

- A set of models describing the hardware response characteristics of a transducer
- An efficient method for transporting sensor data and preparing it for fusion through spatial and temporal associations

Sensor data is often an artifact of the sensor's internal processing rather than a true record of phenomena state. The effects of this processing on sensed phenomena are hardware-based and can be characterized as functions.

TML response models are formalized XML descriptions of these known hardware behaviors. The models can be used to reverse distorting effects and return artifact values to the phenomena realm. TML provides models for a transducer's latency and integration times, noise figure, spatial and temporal geometries, frequency response, steady-state response and impulse response.

Traditional XML wraps each data element in a semantically meaningful tag. The rich semantic capability of XML is in general better suited to data exchange rather than live delivery where variable bandwidth is a factor. TML addresses the live scenario by using a terse XML envelope designed for efficient transport of live sensor data in groupings known as TML clusters. It also provides a mechanism for temporal correlation to other transducer data

TML was introduced into the OGC standards process in 2004 and is now part of the SWE family of standards. It complements and has been harmonized with SensorML and O&M. TML provides an encoding and a conceptual model for streaming real-time "clusters" of time-tagged and sensor-referenced observations from a sensor system. SensorML describes the system models that allow a client to interpret, geolocate, and process the streaming observations.

Sensor Observation Service (SOS)

The OpenGIS Sensor Observation Service Standard defines an API for managing deployed sensors and retrieving sensor data and specifically "observation" data. The goal of SOS is to provide access to observations from sensors and sensor systems in a standard way that is consistent for all sensor systems including remote, in-situ, fixed and mobile sensors. Whether from in-situ sensors (e.g., water monitoring) or dynamic sensors (e.g., airborne / satellite imaging), measurements made from sensor systems contribute most of the geospatial data by volume used in geospatial systems today. Therefore, the SOS is a critical element of the SWE architecture, defining the network-centric data representations and operations for accessing and integrating observation data from sensor systems.

The SOS is the intermediary between a client and an observation repository or near real-time sensor channel. Clients can also access SOS to obtain metadata information that describes the associated sensors, platforms, procedures and other metadata associated with observations.

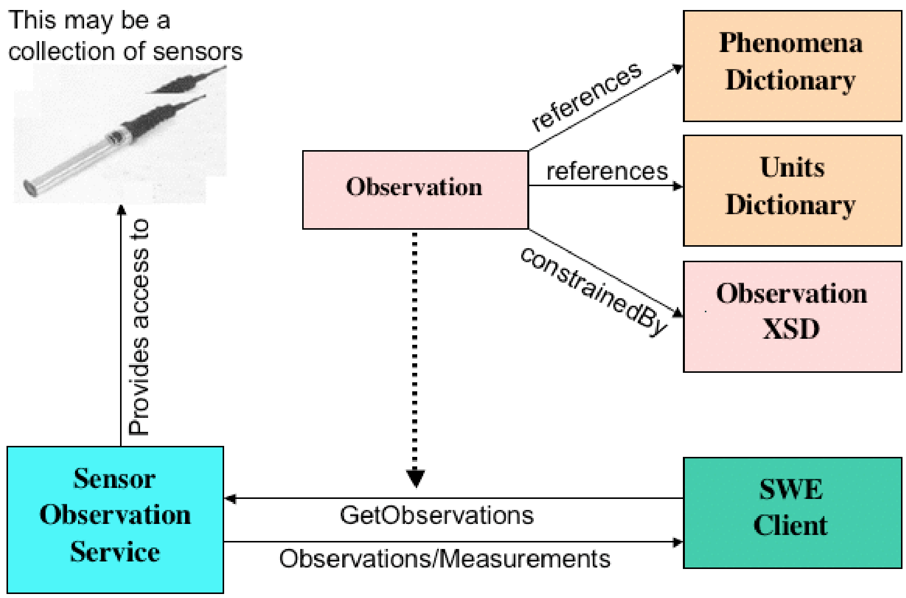

Figure 3: Sensor Observation Service Concept

Figure 3 above shows a SWE client making use of the SOS to automatically obtain observations and measurements from a collection of sensors. The SOS might also control the sensors for the client. The client depends on registries that provide metadata for the different types of sensors and the kinds of data that they are capable of providing.

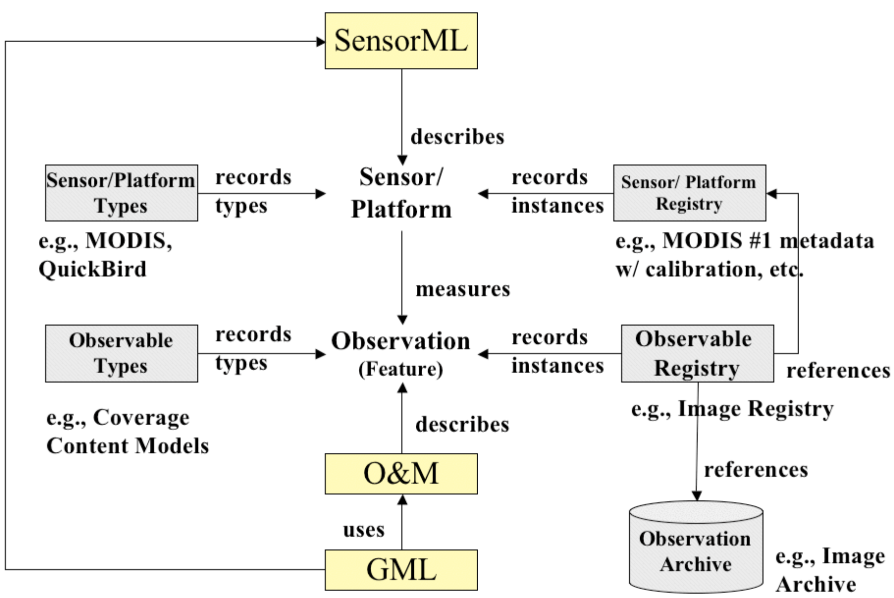

Figure 4: Role of registries in the Sensor Web

Figure 4 above shows the role that registries (also called catalogs) play in a fully operational Web Services based Sensor Web. The schema for each sensor platform type is available in a registry, and sensors of that type are also in registries, with all their particular information. The schema for each observable type is available in a registry, and stored collections (data sets) of such observables and live data streams of that type are also in registries. Searches on the registries might reveal, for example, all the active air pollution sensors in Los Angeles. Similarly, automated methods implementing the SOS standard might be employed in an application that displays a near real-time air pollution map of the city.

Sensor Planning Service (SPS)

The OpenGIS Sensor Planning Service (SPS) Standard enables an interoperable service by which a client can determine collection feasibility for a desired set of collection requests for one or more sensors/platforms, or a client may submit collection requests directly to these sensors/platforms. Specifically, the standard specifies interfaces for requesting information describing the capabilities of a SPS for determining the feasibility of an intended sensor planning request, for submitting such a request, for inquiring about the status of such a request, for updating or canceling such a request, and for requesting information about further OGC Web services that provide access to the data collected by the requested task.

SPS defines interfaces for a service to assist in collection feasibility plans and to process collection requests for a sensor or sensor constellation.

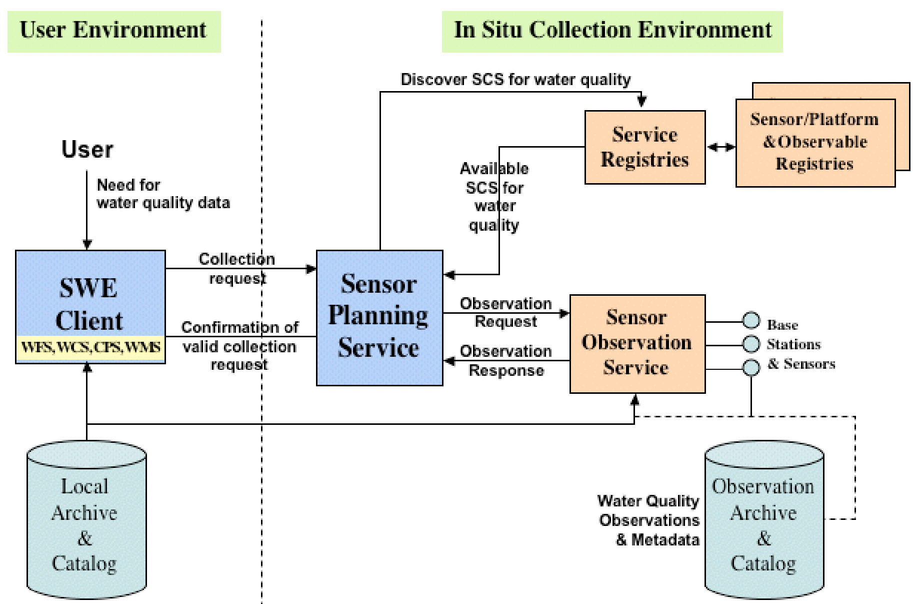

Figure 5: Typical in situ Sensor Planning Service

The developers and likely users of the SPS standard will be enterprises that need to automate complex information flows in large enterprises that depend on live and stored data from sensors and imaging devices. In such environments, specific information requirements give rise to frequent and varied collection requests. Quickly getting an observation from a sensor at the right time and place may be critical, and getting data that was collected at a specific place at a specific time in the past may be critical. The SPS standard specifies open interfaces for requesting information describing the capabilities of a SPS, for 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.

An example of an environmental support system is diagrammed above in Figure 5. This system uses SPS to assist scientists and regulators in formulating collection requests targeted at water quality monitoring devices and data archives. Among other things, it allows an investigator to delineate geographic regions and time frames, and to choose quality parameters to be excluded or included.

Sensor Alert Service (SAS)

The OpenGIS® Sensor Alert Service Best Practices Paper (OGC Document 06-028r3) specifies interfaces for requesting information describing the capabilities of a Sensor Alert Service, for determining the nature of offered alerts, the protocols used, and the options to subscribe to specific alert types. The document defines an alert as a special kind of notification indicating that an event has occurred at an object of interest, which results in a condition of heightened watchfulness or preparation for action. Alerts messages always contain a time and location value. The SAS Best Practices Paper describes an interface that allows nodes to advertise and publish observational data or its describing metadata respectively. It is important to emphasize that the SAS itself acts like a registry rather than an event notification system! Sensors or other data producers do advertise their offers to a messaging server. The messaging server itself forwards this advertisement to the SAS. If a consumer wants to subscribe to an alert, it sends a subscription-request to the SAS. This operation is a lookup rather than a real subscription. That is, the SAS will not send any alerts. All actual messaging is performed by a messaging server. The response sent by the SAS will contain the communication endpoint. It is up to the consumer to open a connection to this communication endpoint. The SAS response contains all information necessary to set up a subscription.

Therefore, a SAS implementation relies on other alerting protocols and standards. For instance, users could register with a SAS enabled alert registry to receive OASIS Common Alert Protocol (CAP) alerts for specific types of observations, such as weather events or earthquakes[5].

Web Notification Service (WNS)

The OpenGIS® Web Notification Service (WNS) Best Practices Paper (OGC Document 06-095) specifies an open interface for a service by which a client may conduct asynchronous dialogues (message interchanges) with one or more other services. As services become more complex, basic request-response mechanisms need to contend with delays/failures. For example, mid-term or long-term transactions demand functions to support asynchronous communications between a user and the corresponding service, or between two services, respectively. A WNS is required to fulfill these needs within the SWE framework.

The WNS includes two different kinds of notifications. First, the “one-way-communication” provides the user with information without expecting a response. Second, the “two-way-communication” provides the user with information and expects some kind of asynchronous response. This differentiation implies the differences between simple and sophisticated WNS. A simple WNS provides the capability to notify a user and/or service that a specific event occurred. In addition, the latter is able to receive a response from the user.

OTHER AREAS OF SENSOR WEB STANDARDS HARMONIZATION

The OGC has an active coordination program with many other standards groups and has been active in the Sensor Standards Harmonization WG (SSHWG) led by the National Institute of Standards and Technology (NIST). The broad challenge of SSHWG is to "integrate sensor and non-sensor data in a decision support network."

IEEE 1451 Transducer interfaces

Developing an open standards framework for interoperable sensor networks requires finding a universal 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. The sensor interfaces and application services may need to interoperate and may need to be bridged at any of many locations in the deployment hierarchy.

At the transducer interface level, a "smart" transducer includes enough descriptive information so that control software can automatically determine the transducer's operating parameters, decode the (electronic) data sheet, and issue commands to read or actuate the transducer.

To avoid the requirement to make unique smart transducers for each network on the market, transducer manufacturers have supported the development of a universally accepted transducer interface standard, the IEEE 1451 standard.

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[5] "OASIS Advances Common Alerting Protocol and Emergency Data Exchange Language." http://xml.coverpages.org/ni2005-09-08-a.html (Last viewed 18 March 2008)

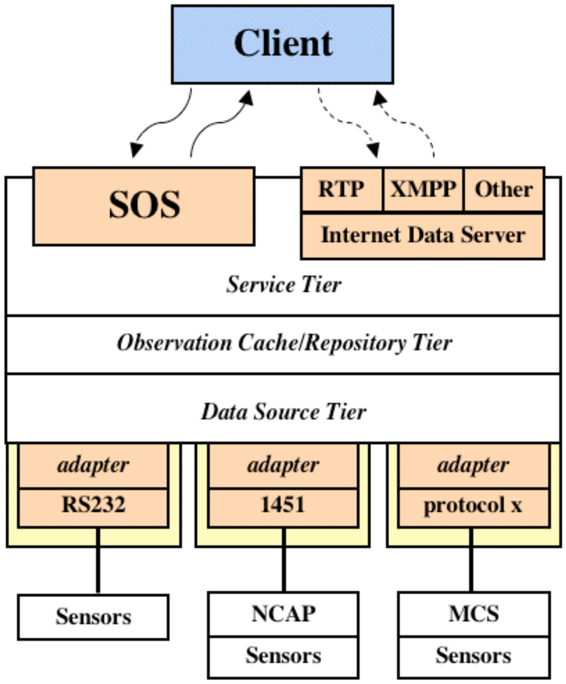

Figure 6. IEEE 1451 in the SWE Interoperability Stack

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 of interface to services defined in the OGC SWE standards. In Figure 6, SWE services such as SOS act as clients (consumers) of IEEE-1451 NCAP services and TEDS documents, thereby enabling interactions with heterogeneous sensor systems via scalable networks of applications and services.

Imaging Sensors

The SWE 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 (OGC Abstract Specification, Topic 7). Other related work for support of imaging sensors within the SWE context include: OpenGIS® Geography Markup Language (GML) Encoding Standard ,, GML Application Schema for EO Products Best Practices Paper (OGC Document 06-080r2), OpenGIS® GML in JPEG 2000 for Geographic Imagery Encoding Standard and OpenGIS GML Encoding of Discrete Coverages Best Practices Paper (OGC Document 06-188r1).

SWE IMPLEMENTATIONS AND DEMONSTRATIONS

The OGC's fourth OGC Web Services testbed activity, OWS-4, culminated in a December, 2006 demonstration based on a hypothetical scenario in which a bomb containing highly toxic radioactive material was discovered as a container was being unloaded from a ship at a wharf near New York City. Before the bomb could be disarmed, it exploded, injuring people and releasing a wind-borne plume of radioactivity. Disaster managers from state, federal and local agencies attending the demonstration saw live Web-based information systems being used to find, access and integrate diverse geospatial resources, many of which were live sensors, just as these managers' systems might be used in a real disaster. The information flowed from many different data sources through Web services. Most of the software involved was commercially available off-the-shelf software implementing OGC standards.

In the demonstration, a radiation sensor whose Web interface conformed to SWE standards triggered an alert that automatically set several processes in motion. Other sensors in the vicinity were polled. A server managed by the Emergency Operations Center (EOC) alerts the EOC operator and automatically prepared a report, including a map display of sensors reporting high radioctivity. This automated process involved "service chaining" of multiple online services that publish or process sensor locations and other geospatial data. An EOC manager notified local fire and police departments immediately, as well as the appropriate state and federal agencies.

Online catalogs conforming to the OpenGIS® Catalog Services Standard provided the means for the EOC operator to determine the location and other features of a wide variety of online sensors. The sensor data and metadata were immediately displayed on a map. Video cameras near the explosion were immediately accessible, and the operator could control those that provided remote control, because the SensorML standard addresses sensor control parameters.

Anticipating the need for real-time weather information, the operator accessed NASA's Earth Observation-1 (EO-1) satellite ground system, instructing the satellite through an open interface to provided images of the New York/New Jersey area over the next several days. The acquisition request was accepted by the EO-1 planning systems and the image was acquired on December 8th during the OWS-4 demonstration. NASA satellites are in fact being fitted with implementations of SWE standards to make such use possible.

The fundamental concept of Geospatial Decision Support (GeoDSS) is that a decision maker at a single workstation should be able to identify geospatial resources anywhere, access the resources, bring them into an operational context, and integrate them with other resources to support the decision process. The EOC operator's operational context is different from the first responder's operational context. Data displayed in police and firefighters' handheld devices and on-board computers needs to be rendered using cartographic styles these first responders are familiar with, styles that may be different in different jurisdictions. OGC standards such as the OpenGIS Styled Layer Descriptor Encoding Standard enable software and services running on different devices to tailor data "portrayal" for the user of the device.

Active 2008 OGC Interoperability Initiatives that involve SWE standards include: Empire Challenge Pilot (EC Pilot), Federated Earth Observation Pilot (FedEO), GALEON IE (Geo-interface for Atmosphere, Land, Earth, and Ocean netCDF IE), GEOSS (Global Earth Observation System of Systems) Architecture Implementation Pilot, Ocean Science Interoperability Experiment (OceansIE) and OGC Web Services, Phase 5 (OWS-5).

Some current SWE implementation efforts:

- Oak Ridge National Laboratory's (ORNL) SensorNet program at Fort Bragg, North Carolina, developing a collection of systems for the detection, identification and assessment of chemical, biological, radiological and nuclear threats
- SensorWeb, being developed by SAIC for the Defense Intelligence Agency (DIA)
- The Heterogeneous Mission Accessibility (HMA) project of the European Space Agency and various partner organizations in Europe
- Persistent Universal Layered Sensor Exploitation Network (PULSENet), a Northrop Grumman Corporation internal research and development project
- SANY (Sensors Anywhere), co-funded by the Information Society and Media Directorate General of the European Commission, contributing to the Global Monitoring for Environment and Security (GMES) program
- The German organization 52North provides a complete set of SWE services under GPL license. One project using 52North's software is the German Indonesian Tsunami Early Warning System (GITEWS), a 35-million euro project of the German aerospace agency, DLR, and the GeoForschungsZentrum Potsdam (GFZ), Germany's National Research Centre for Geosciences.
- The Consortium of Universities for the Advancement of Hydrologic Science Inc. (CUAHSI) representing more than 100 U.S. universities, uses SWE standards in its Hydrologic Information System (HIS).

CONCLUSION

OGC's SWE standards are positioned to become key parts of an integrated framework for discovering and interacting with Web-accessible sensors and for assembling and utilizing sensor networks on the Web. This will have significant benefits for crisis response and management, because crisis response and all phases of disaster management can benefit from humans and software clients being able to discover and access online sensors and imaging devices 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.