Applying OGC Sensor Web Enablement to Ocean Observing Systems

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***Abstract* – The complexity of marine installations for ocean observing systems has grown significantly in recent years. In a network consisting of tens, hundreds or thousands of marine instruments, manual configuration and integration becomes very challenging. Simplifying the integration process in existing or newly established observing systems would benefit system operators and is important for the broader application of different sensors. This article presents an approach for the automatic configuration and integration of sensors into an interoperable Sensor Web infrastructure. First, the sensor communication model, based on OGC's SensorML standard, is utilized. It serves as a generic driver mechanism since it enables the declarative and detailed description of a sensor's protocol. Finally, we present a data acquisition architecture based on the OGC PUCK protocol that enables storage and retrieval of the SensorML document from the sensor itself, and automatic integration of sensors into an interoperable Sensor Web infrastructure. Our approach adopts Efficient XML Interchange (EXI) as alternative serialization form of XML or JSON. It solves the bandwidth problem of XML and JSON.**

***Keywords* – Sensor Web; standards; metadata; interoperability; SensorML**

I. INTRODUCTION

In Ocean Observing Systems, the infrastructure for data management, communication and instruments has to be a flexible network, because unanticipated needs may emerge and unprecedented context-aware applications may need to be enabled. For example, a given kind of sensor may be deployed on various platforms such as floats, gliders or moorings, and thus must be integrated with different data acquisition systems. To achieve the interoperability in this infrastructure, the physical instruments must be reliably associated with software components that operate the instruments and manage their data and metadata.

One of the critical issues in an ocean observing system is the communication with the instrument or sensor. In the oceanographic instrumentation sector, there is no standardization of protocols used for the control and configuration of the instruments, and each manufacturer defines the syntax used and the set of commands for each of their instruments. Given the diverse nature of the instruments, it could be difficult to define a universal set of commands. It would, however, be feasible to use a common syntax and a set of common commands in addition to specific commands, depending on the nature of the instrument.

The main objective of standardizing basic installation processes for new instruments has the main purpose of reducing operating costs of the observatory. Since each instrument and manufacturer implements a different communication protocol and raw data format, it is necessary to invest much time in the programming of a software driver that allows the integration of the new instrument in the observatory network. On the other hand, there are marine observation platforms such as oceanographic buoys, where, in addition to the installation, a configuration tool is needed, and it is necessary to be able to perform this operation under extreme conditions. Standardizing these processes minimizes the risk of failures due to manual configuration. Another benefit of the standardization process is the facilitation of maintenance and replacement of instruments in the observatory and the maintenance of traceability of the data they generate [1].

Other benefits are the improved accessibility to data and interoperability between data sets. However, interoperability can only be achieved through extensive use of international standards. They specify regulations for data access, content, and exchange. The current situation is characterized by the fact that parallel approaches have been developed (IEEE 1451, the OGC set of standards, etc.) but they still lack community support. This paper introduces the Sensor Web architecture based on an OGC set of standards as an example of how interoperable standards help to facilitate the creation of an infrastructure for sharing oceanographic observation data and the integration of sensor data into applications [2].

II. INTEROPERABILITY APPROACH FOR OCEAN OBSERVING SYSTEMS

Oceanographic instruments are traditionally developed by small companies and lack standardization of the protocols for instrument control and configuration, or data retrieval. These instruments are often integrated into an observing system or sensor network, which provides a software infrastructure for functions such as data acquisition, data logging, and data transfer via hard-wired or wireless telemetry links.

In order to facilitate the integration of sensors into the ocean observing system, we propose a Sensor Web architecture based on the concepts of spatial data infrastructures and the Sensor Web Enablement (SWE) framework [3] of the Open Geospatial Consortium (OGC). The standards developed by OGC represent a conceptual model for Observations and Measurements (O&M) [4]. This standard describes how an *observation* is an action whose result is an estimate of the value of some *property* of a *feature of interest*, obtained using a specified *procedure*.

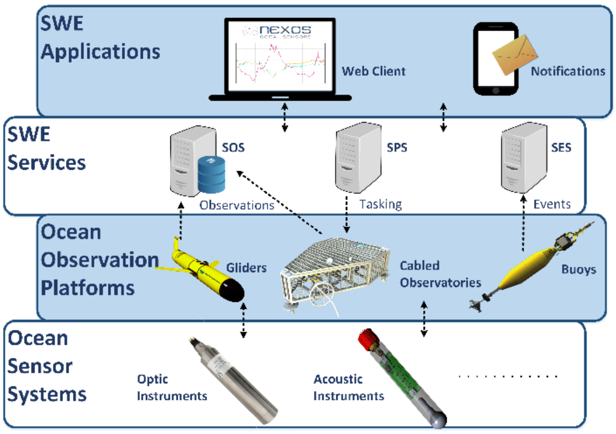

Figure 1 Overview of the standardized OGC SWE interfaces

The implementation of the different SWE services, envisioned in the OGC SWE architecture, could depend on the type of observatory platform on which the oceanographic instruments are installed, as shown in Table 1. Therefore, the oceanographic instruments that will be connected to observatories with a continuous and high bandwidth communication channel could implement the full capabilities of the OGC Sensor Observation Service for data access and data push. On the other hand, oceanographic instruments deployed in platforms with a low communication bandwidth or discontinuous link could only implement some of the data push capabilities of the OGC Sensor Observation Service. Moreover, all these instruments will need to implement a configuration service using the OGC Sensor Planning Service, which will allow the observatory operators to configure the oceanographic instruments based on the mission requirements.

Table 1 Services requirements for different types of platforms

Type	***LINK***	***Instrument Services***		
		Data Access Service	Configuration Service	Data Push Service
Cable observatory	GPRS/ Fibber optics	✓	✓	✓
Gliders/ Profilers	Satellite		✓	✓
Scientific vessels & FerryBoxes	GPRS/ WiFi/ Satellite	✓	✓	✓

To realize the integration of oceanographic instruments into the SWE architecture, the communication between them has to be based on the O&M 2.0 standard that describes a model and an XML Schema to encode data gathered by sensors (archived as well as real-time data). In order to maintain the traceability of the data generated by a specific oceanographic instrument into the SWE architecture, we used the OGC Sensor Model Language (SensorML) to describe the sensor or process that generated that data. Similarly to O&M, the SensorML 2.0 standard describes a model and an XML Schema to encode the metadata of an instrument or a process. Based on SensorML 2.0, we are able to describe the oceanographic instruments, the communication protocol, the observatory platform used for acquisition, and the processes needed by the acquisition system of the observation platform to perform measurements. Such description can be done including an "*AggregatedProcess*" component into the SensorML document of the instrument as shown in the figure below. A data acquisition system can use such a SensorML instance to translate the communication from the sensor protocol into a standardized OGC SWE communication.

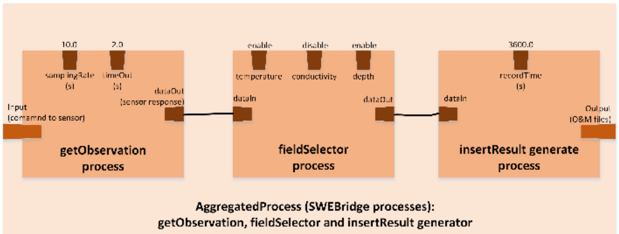

Figure 2 Overview of the standardized OGC SWE interfaces

As illustrated in Figure 2, the acquisition system will first use the description given by the "getObservation" process to retrieve data from the instrument. It will then filter the sensor response based on the description found in the "fieldSelector" process. Finally, it will generate the appropriate O&M transaction for the SWE services based on the description of the "insertResult" process.

III. IMPLEMENTATION OF THE DATA MANAGEMENT AND INSTRUMENT CONTROL ARCHITECTURE

Oceanographic instruments that are deployed on cable observatories, ships or buoys with Ethernet connection, most of them with limited bandwidth, are implementing a lightweight SOS [6] and SPS [7] interface. The oceanographic instruments that are deployed on glider and profiler technologies are used in global observation with communication via costly and energy-demanding satellite links of very low, discontinuous bandwidth. They have implemented these standard services through software components located on observatory platforms.

When the instrument is attached to a 'host' computer aboard a vehicle, buoy or other observatory platform, the host uses the protocol description provided inside the SensorML document to operate the instrument. We use the OGC PUCK protocol to enable interoperability and access to the SensorML document of the oceanographic instruments. OGC PUCK is a simple protocol that makes it possible for instruments to carry information that enables sensor networks to use the instrument and its data. OGC PUCK defines a simple protocol to store and retrieve information from an instrument over RS-232 and Ethernet [5]. As shown in Figure 3, this information consists of a SensorML file. OGC PUCK has been implemented in instrument firmware augmenting the "native" instrument command set.

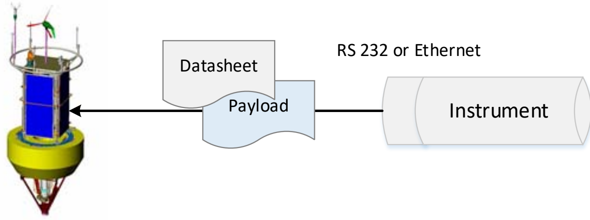

Figure 3 Host issues OGC PUCK commands to retrieve datasheet and payload

One key advantage of implementing OGC PUCK is that the standard enables the automatic instrument integration into sensor networks ('Plug and Work') in a very easy manner. Based on the OGC standards, we implement the interface of oceanographic instruments with basic standard protocols for sensor detection, identification, configuration and execution of measuring operations. We demonstrate the use of this set of standards on two oceanographic instruments, an optical and an acoustic instrument shown in Figure 3 [8], which have been deployed on an oceanographic buoy.

Figure 4 Optical and Acoustic instruments developed based on proposed architecture

At connection, the oceanographic instrument is identified by the platform acquisition system using the OGC PUCK protocol. Immediately after the detection, the acquisition system (SWE Bridge) retrieves the SensorML file. Next, the SensorML document is decoded and the SWE Bridge starts to run the set of tasks described in the SensorML, performs measurements, generates the resulting O&M files and inserts them into the standard SOS Server using the observatory specific communication channels as depicted in Figure 5.

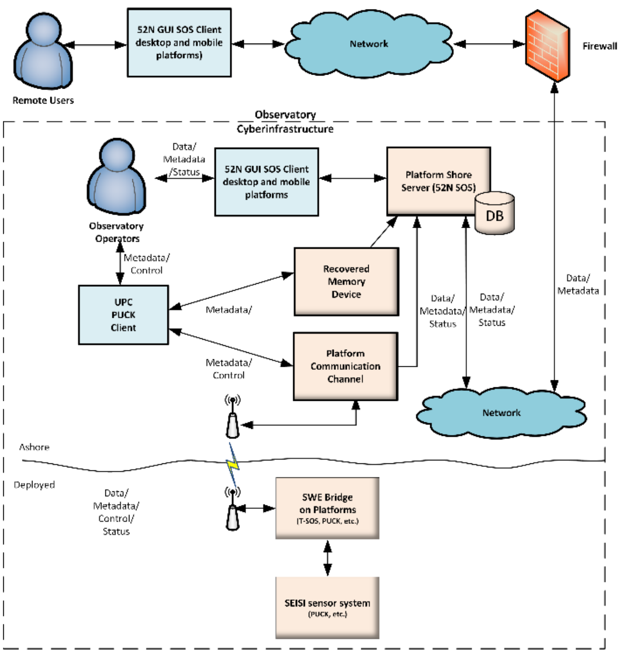

Figure 5 SWE architecture developed for observatory platforms with satellite link

We use the Efficient XML Interchange (EXI) encoding [9] for an efficient transmission of the O&M transactions through the limited bandwidth provided by the satellite link,. Using EXI encoding of the O&M transactions, we achieve at least 50% smaller messages in comparison with other encoding types such as XML or JSON.

IV. CONCLUSIONS

This architecture is able to fulfil the central requirements for establishing an interoperable exchange of oceanographic sensor data. While first components are already available, it will be continuously developed and enhanced during this year. Based on currently ongoing evaluation activities of the first available implementations and further emerging requirements, the Sensor Web components will be advanced to a comprehensive suite of tools for sharing oceanographic observation data in an interoperable manner.

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