NeXOS A1 Smart Hydrophone Integration into the Sensor Web Enablement Framework

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***Abstract*— The integration of marine sensor systems into marine observation platforms such as gliders, cabled observatories and smart buoys requires a great deal of effort due to the lack of standardization and diversity of architectures used in marine technologies. The NeXOS project addresses this issue through the adoption of a SEISI architecture (Smart Electronic Interface for Sensor Interoperability). This paper presents the application of this architecture, integrating the A1 Hydrophone developed by the NeXOS project into a Smart Buoy using the OGC Sensor Web Enablement framework.**

Keywords—Interoperability; standards; SensorML; platform integration; PUCK.

I. INTRODUCTION

Marine sensor systems and marine observation platforms are generally developed by relatively small and medium sized companies and research institutions, resulting in a vast variety of architectures and implementations, usually custom-made and, in many cases, using proprietary communication protocols. Moreover, a given kind of sensor may be deployed into different platforms such as gliders, cabled observatories and smart buoys, to name a few. The integration of sensors into marine observation systems requires an in-depth knowledge of the platform's hardware and software architecture, as well as knowledge of proprietary protocols implemented by the sensor. Usually a specific instrument driver has to be implemented for each application, resulting into a costly and time consuming procedure. Thus, reducing these efforts is vital necessity for the ocean observing community in order to efficiently expand marine observations.

The NeXOS project (*Next generation Low-Cost Multifunctional Web Enabled Ocean Sensor Systems Empowering Marine, Maritime and Fisheries Management*) addresses this issue for ocean optics and ocean passive acoustics, which are planned for deployment on mobile and fixed platforms [1]. The resulting data services will contribute to the Global Earth Observation System of Systems (GEOSS), the Marine Strategy Framework Directive (MSFD) and the Common Fisheries Policy of the European Union.

To meet these objectives, NeXOS addresses the whole data chain from the sensor to the end users adopting the Open Geospatial Consortium's (OGC) Sensor Web Enablement concept (SWE) to improve interoperability, data-sharing and multiplatform integration of the developed observation systems [2]. Regarding sensor systems, a Smart Electronic Interface for Sensor Interoperability (SEISI), is adopted, enhancing interoperability between sensors and platforms [3].

This paper presents a use case of the NeXOS Sensor Web Architecture, integrating the NeXOS A1 Hydrophone into the OGC SWE framework using the SEISI interface. A Smart Buoy is used as host platform, acting as intermediary between the hydrophone and an OGC Sensor Observation Service (SOS) [4]. Once the instrument data has been published on the SOS server it can be visualized using the Open Source 52°North JavaScript SOS client, enhanced within NeXOS. This client is open source and is available for adoption by other projects, sensor manufacturers and platform providers.

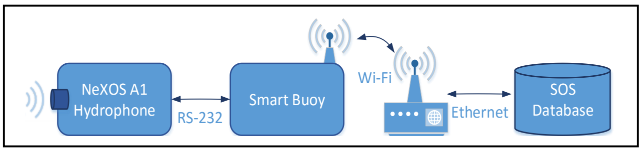

Fig 1. A1 Hydrophone integration scenario

Fig 2. SOS web client

II. NeXOS A1 Hydrophone

The NeXOS A1 Hydrophone is a two-channel, low-power, low-noise, compact-sized, digital hydrophone designed to be deployed in mobile platforms such as profilers and gliders. It has embedded functions for marine mammal detection, acoustic ship signature, seismic event detection and noise spectra monitoring. Regarding its internal design, the processing unit is a LPC4330 dual core (ARM Cortex M4/M0) with a RS-232 serial communication interface. The commands to configure, retrieve data and operate the instrument follow the SCPI standard. As a part of the NeXOS project, the A1 Hydrophone implements the SEISI interface.

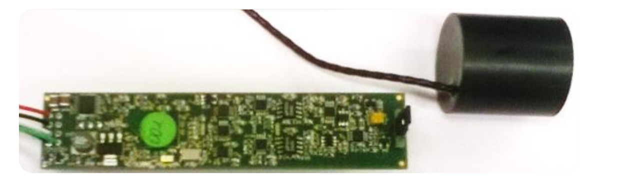

Fig 3. NeXOS A1 Hydrophone transducer and circuitry

III. Seisi Interface

A. SEISI Interface Overview

The Smart Electronic Interface for Sensor Interoperability (SEISI) has been proposed within the NeXOS framework, pursuing the enhancement of interoperability and the integration of sensors into the SWE architecture. It consists of a set of standards and protocols from various international organizations such as ISO, OGC and W3C that allow the direct data flow from the sensor to SOS servers, in compliance with the OGC Observation & Measurement standard [5].

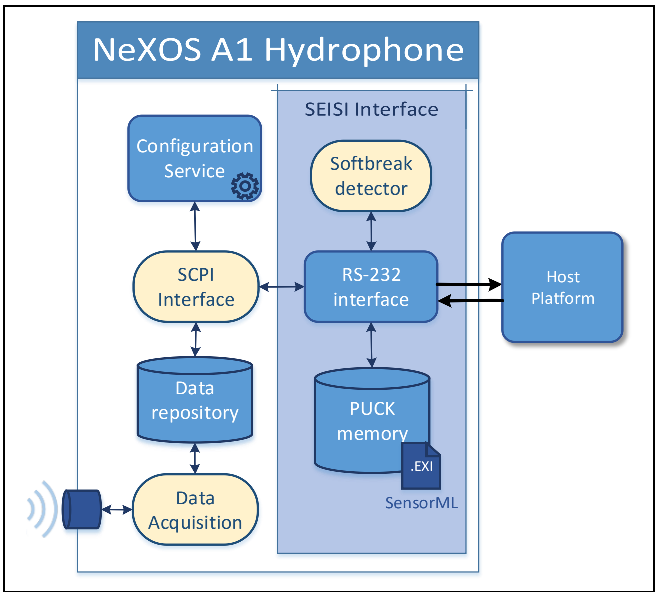

Fig 4. A1 Hydrophone communications interface

B. Sensor Model Language

The Sensor Model Language (SensorML) is an OGC standard for robust and semantically-tied description of processes and processing components of measurement and data acquisition systems [6]. Besides general metadata such as keywords, calibration parameters and identifiers, SensorML allows to effectively describe any communication interface of the system in a single standardized XML file, including commands and response formats, among others. A SensorML file describing the A1 Hydrophone SCPI communication interface and the set of tasks to be executed has been created. The tasks programmed within this file include instrument configuration, data acquisition and data processing.

C. PUCK Protocol

In order to enhance the hydrophone's interoperability the OGC Programmable Underwater Connector with Knowledge protocol (PUCK) has been implemented as a part of SEISI, permitting the instrument's automatic discovery through the softbreak detector service [7]. Moreover, this protocol also provides the possibility to define a non-volatile memory inside the instrument, accessible through the communication interface with standardized commands. This feature permits the automatic retrieval of stored files from the instrument's PUCK memory, used primarily for instrument description and characteristics. Within the SEISI interface the SensorML file describing the system is stored in the PUCK memory, so that the host platform can automatically retrieve the file. Thus the Hydrophone has a capability to auto-describe itself.

D. Efficient XML Interchange

Historically the use of XML files in embedded applications is difficult due to limited memory and file storage capabilities. However, the Efficient XML Interchange standard (EXI) enables the compression of large ASCII XML files into binary files [8]. In the case study an example SensorML file describing the instrument and implementing a simple mission was created and compressed. The EXI file generated was significantly lighter, resulting in a compression ratio of 9:1.

IV. Host Platform

A. Smart Buoy Description

For testing the capabilities of the SWE architecture and specifically the SEISI's interface interoperability, the NeXOS A1 Hydrophone was integrated into a Web-enabled platform, such as the Smart Buoy. This observation platform consists of a Raspberry Pi 2 Model B, a USB Wi-Fi dongle and battery encapsulated into a buoy-shaped case. The Smart Buoy is connected to the internet through an external wireless router. The Raspberry Pi operating system is the Raspbian OS Linux distribution running two applications: the SWE Bridge and the SOS Proxy.

Fig 5. Smart Buoy case and electronics

B. Sensor Web Enablement Bridge

In some SWE applications the sensor may communicate directly to the SOS server and inject the obtained data in the

O&M format. However, many instruments do not have Ethernet interface nor the required processing power to manipulate and encode the data in the required format. To overcome this limitation the Sensor Web Enablement Bridge (SWE Bridge) has been developed.

The Sensor Web Enablement Bridge is a cross-platform software component meant to be executed on the host platform, providing Web-capabilities to non-Ethernet instruments, such as the NeXOS A1 Hydrophone. The Bridge automatically detects any plugged instrument, retrieves its SensorML description, decodes it and configures itself to execute the mission scheduler. Afterwards, it collects and processes the instrument's data, storing it locally in compliance with the O&M 2.0 model. Due to the variety of platforms and architectures where the SWE Bridge has to be hosted it has been designed as a cross platform component, with very low memory needs and minimal dependence on hardware resources.

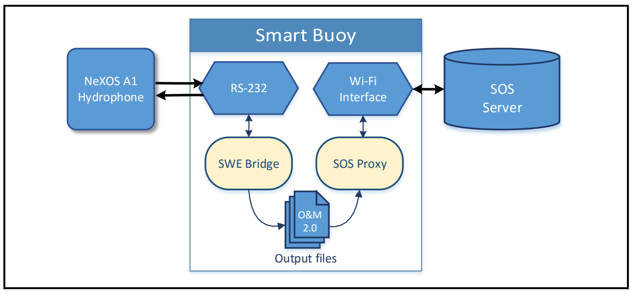

Fig 6. Smart Buoy software architecture

C. SOS Proxy

To send the O&M data files to the SOS server, in this case the Open Source SOS server of 52°North, which was enhanced within NeXOS to meet the project requirements, platform-dependent resources need to be used, such as Ethernet communications or satellite links. In the presented scenario a SOS proxy is implemented, sending the O&M files through a Wi-Fi interface.

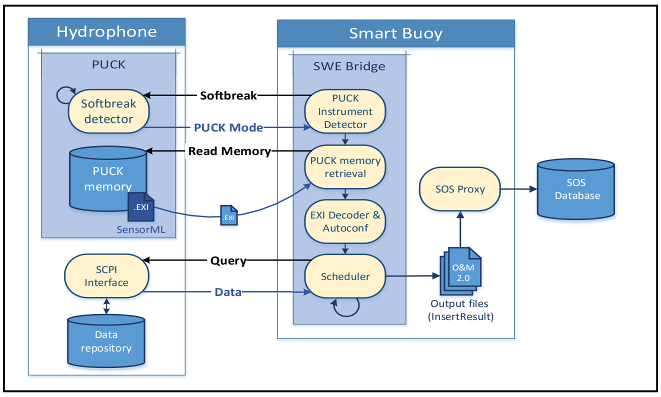

Fig 7. NeXOS A1 Hydrophone - Smart Buoy interoperability.

V. Interoperability

Once the instrument is connected to the platform, the SWE Bridge identifies an instrument using the PUCK auto-detection. Immediately after the detection, the SWE Bridge starts the retrieval of the EXI-encoded SensorML file. Once the file transmission is completed, it is decoded and the bridge auto-configures the scheduler. Afterwards, the scheduler runs the set of tasks described in the SensorML file, starting the programmed instrument mission, directly inserting the O&M resulting files into an SOS Server.

VI. Conclusions

The adoption of the Sensor Web Enablement Architecture and the SEISI interface provides a powerful way to minimize the efforts for integrating an instrument into different platforms due to the capability of auto-detection and auto-description.

Regarding interoperability between the sensor and the platform only a minimal effort is needed to modify the SensorML description file to adapt it to the new environments. Once the instrument is plugged to any Sensor Web Enabled platform, such as the Smart Buoy, data flows from the sensor to the SOS database automatically start. Thus, the presented architecture demonstrates a new approach for achieving end-to-end plug and play observing systems.

Acknowledgment

NeXOS is a collaborative project funded by the European Commission 7th Framework Programme, under the call OCEAN-2013.2 - The Ocean of Tomorrow 2013 - Innovative multifunctional sensors for in-situ monitoring of marine environment and related maritime activities. It is composed of 21 partners including SMEs, companies and scientific organizations from 6 European countries. Visit: www.nexosproject.eu.

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