ocean observatories, which covers all potential topologies. And therefore, it is quite complex (see: esonet.epsevg.upc.es:8080/1451/ref_model.html). This reference model can now serve as a touchstone in order to check the suitability of any proposed OOCL.
For a number of years, academia has discussed the IEEE1451 standard as a potential candidate for this OOCL. Originally, IEEE1451 has been designed as a standard for home automation and it is a NIST committee design. Therefore, it is extensive, complex and time-consuming to understand. Something, nobody wants to touch without being payed for. Furthermore, it became clear during the Brest workshop that IEEE1451 fails to address several properties, which are needed according to the reference model.
I venture to predict that eventually OOCL will resemble IEEE1451, because for too long and too often IEEE1451 has been hailed as the solution to an OOCL in discussions with funding agencies both in Europe and America. But only a subset of IEEE1451 will be suitable, and it will have to be extended in order to fulfill the needs of an OOCL.

Yellow Pages

In the framework of the ESONET project the „Yellow Pages“ have been created at Lisbon University (see: www.esonetyellowpages.com). This is a database on commercial products and services that are needed for ocean bottom systems. Short profiles for most companies in this field have already been entered. These are the main categories:

Sensors

ADCPs, Conductivity, CTDs, Current meters, Depth, DO sensors, Flow meters, Fluorometers, Hydrophones, Magnetometers, Multiparameters, PAR sensors, pH sensors, Pressure sensors, Redox, Sediment traps, Temperature, Tiltmeters, Transmisiometers, Turbidity, Water samplers.

Hardware components

Acoustic releases, Cameras (Figure 8), Connectors, Data loggers, Floats, Housings, Lasers, Lights, Underwater batteries, Underwater cables, Underwater switches.

Deep sea services

If your company is not yet listed in the Yellow Pages, please get in touch with support@esonetyellowpages.com. After registration you will receive a username and passwort, which allows you to login to the data base at the “MY EYP” tab. You can directly edit your existing entries; new entries will first be reviewed by the support team before being published. The Yellow Pages are a service of the ESONET project to the commercial community and therefore, entries in the Yellow Pages are free of charge.
As an added value to new customers, one of the data base fields is the “esonet reference”. If possible, this will hold links to users of the product in the ESONET community, who are willing to talk about their experience with the product.

Evaluation of Standards at Western Mediterranean Observatory, OBSEA

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Abstract- IEEE-1451[1] and OGC Sensor Web Enablement (OGC SWE)[2] define standard protocols to operate instruments, including methods to calibrate, configure, trigger data acquisition, and retrieve instrument data based on specified temporal and geospatial criteria. These standards also provide standard ways to describe instrument capabilities, properties, and data structures produced by the instrument. These standard operational protocols and descriptions enable observing systems to manage very diverse instruments as well as to acquire, process, and interpret their data in a uniform and automated manner. We refer to this property as "instrument interoperability". This paper describes integration and evaluation of MBARI PUCK protocol [3] at OBSEA [4,5] in Spain.

Keywords- MBARI PUCK Protocol, Instrument Interoperability, IEEE1451, OGC SWE

Introduction

To achieve instrument interoperability, the physical instrument must be reliably associated with software and information that conform to standard protocols and descriptions. In most cases today, the "firmware" that is physically embedded within the instrument does not conform to standards; instead standards-compliant external instrument "driver" software and metadata files residing on observatory host computers are logically associated with the physical instruments. Setting up the logical association is typically a manual process; technicians must install instrument driver software on the host, specify a host data port where the instrument is installed, and specify baud rates, configuration files, and so on. This manual configuration process can be tedious, time-consuming, and hence prone to human error. Moreover the configuration process must sometimes be performed aboard ships and buoys under severe environmental conditions that challenge human physiology and psychology, thus increasing the chances for error.
An alternative approach is to embed the standards protocols physically within the instrument. In this case the instrument will respond appropriately to standard operations, and will supply descriptive information in standard format. Thus the observing system can automatically identify the instrument and utilize the instrument and its data when it is physically installed, and there is no need for technicians to manually set up a logical association between physical instrument and host drivers and configuration files. There are several chal-

lenges to this approach that can be solved by using standards such as IEEE1451, OGC SWE and MBARI PUCK protocol described below.

IEEE-1451 and OGC SWE

The IEEE 1451 provides a specification to add a digital layer of memory, functionality, and communication to sensors. For example it enables sensors to be controllable and their measurements accessible through a network with sufficient information on the sensor characteristics and history.
OGC Sensor Web Enablement (SWE) provides a specification to Web-enabled sensors to be accessible and, where applicable, controllable via the Web. SOS provides a broad range of interoperable capability for discovering, binding to, and interrogating individual sensors, sensor platforms, or networked constellations of sensors in real-time, archived or simulated environments.
IEEE-1451 and OGC SWE are rather complex, which is to be expected as these standards are also quite comprehensive. This complexity presents challenges for instrument manufacturers who must thoroughly understand the standard and who must correctly implement it in firmware. Moreover embedded instrument processors are often designed for low cost and low-power environments, and hence may not be capable of fully implementing the standards. Another drawback is that manufacturers would likely have to abandon existing instrument firmware that does not implement the standard; this existing firmware often represents a very considerable investment by the manufacturer. A third drawback is that IEEE-1451 and OGC SWE are still evolving, again due to the comprehensive nature of these standards. Thus either the standard revision process must be very carefully managed to ensure “backwards compatibility”, or instrument firmware must be occasionally upgraded to remain compliant with the latest standard. Both of these alternatives present non-trivial challenges to instrument manufacturers and standards bodies.

MBARI PUCK Protocol

A third approach is provided by MBARI PUCK protocol. PUCK provides low level operations to communicate with instruments. PUCK does not itself implement all the levels of interoperability from OGC SWE and IEEE 1451. PUCK defines a simple standard embedded instrument protocol to store and retrieve information from the instrument. The information consists of a minimal instrument datasheet that includes a universally unique instrument serial number, a manufacturer ID, and a small amount of other metadata PUCK protocol also allows an optional “payload” consisting of any information needed by a particular observing system. The payload format and content are not constrained by PUCK protocol, and can include executable driver code that implements a standard operating protocol as well as metadata that describe the instrument in a standard way. Using PUCK protocol, technicians can store payload contents with the instrument before deployment. When the instrument is deployed, payload is retrieved by the host and utilized appropriately; e.g. the host can execute the driver code, and can use or distribute the standard metadata to other locations on the network. Thus standard IEEE-1451 and OGC SWE components can be automatically retrieved and installed by the host when a PUCK-enabled instrument is plugged in, overcoming the difficulties of manual installation. PUCK protocol is simple, and readily implemented in even simple instrument processors; several manufacturers now implement MBARI PUCK protocol in their instruments, and report just a few weeks of engineering effort to do so. PUCK protocol augments rather than replaces existing instrument protocols, and manufactures can usually implement PUCK by extending their existing protocol rather than starting from scratch. Since the protocol is simple, it is likely to be stable, so manufacturers to do not have to modify firmware to keep up with an evolving standard. As higher-level IEEE-1451 and OGC SWE standards evolve, the instrument PUCK payloads can simply be updated through PUCK protocol. The PUCK protocol specification is available at http://www.mbari.org/pw.

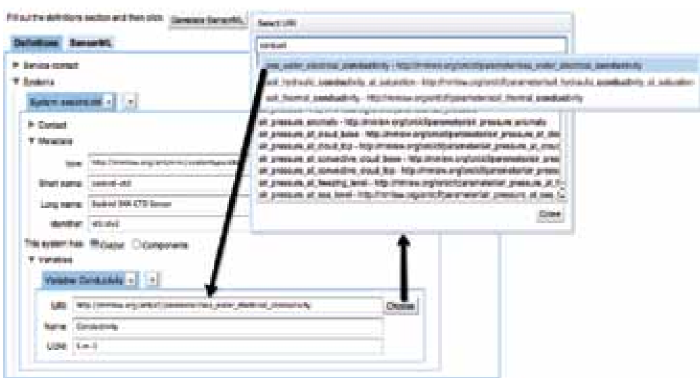

Fig.9 - Web interface to generate SensorML PUCK Payload

Puck Integration

Until recently, PUCK protocol was used exclusively on MBARI moored and cable-to-shore observatories. We describe tests to integrate and evaluate the protocol on non-MBARI systems as ESONET test-bed observatories such as OBSEA. We estimate the engineering effort required to integrate PUCK into these systems, and summarize the benefits gained for that effort. We discuss possible refinements to the protocol and describe plans to submit MBARI PUCK as a formal standard.

Puck Integration at Western Mediterranean Observatory, OBSEA, Spain

At OBSEA Observatory (Figure 3), two CTD are been used to test the integration of PUCK protocol. Theses instruments were a RBR CTD with PUCK implemented in firmware and a Seabird CTD with an external PUCK hardware. Integration starts by developing the instrument metadata. Two different metadata files were implemented for each instrument: a SensorML file and a XML IEEE 1451 TEDS file. These files are stored in the PUCK payload memory. Each file is preceded by a tag that specifies the file type, as shown in Table 1 (the tag format and attributes will be proposed as an addendum to the PUCK version 1.3 specification)

Table I. Recommended Payload type name

Payload Type	Description
IEEE-1451- binary-TEDS	IEEE-1451 TEDS (binary format)
IEEE-1451-xml-TEDS	IEEE-1451 TEDS (XML format)
SWE-SensorML	SensorML format
MBARI-SIAM	MBARI SIAM JAR file

A web-based tool is being developed to simplify creation of SensorML and IEEE 1451 TEDS files for specific instruments, using consistent syntax and attribute names.
The user indicates the structure of the sensor system (system type, variables, and subsystems) while being able to choose URIs (Uniform Resource Identifiers) via drop-down lists containing standard entries for sensor types and variables, and then the tool generates the resulting document.
The drop-down lists are populated with definitions registered in the MMI Ontology Registry and Repository, ORR, http://mmisw.org/orr.
Figure 9 illustrates the basic interaction with the definition of an output variable. The user clicks a button to select an appropriate definition from the NetCDF Climate and Forecast (CF) Metadata Convention standard name vocabulary (http://cf-pcmdi.llnl.gov/). A similar selection mechanism is available for sensor types. The tool allows the description to include nested subsytems, each with the corresponding variables. Once the desired structure has been completed, the, Generate SensorML/TEDS“ button creates a file that can then be stored in an instrument's PUCK payload.
The communication between instruments (in this case 2 CTDs) and the NCAP host computer is implemented by a serial RS232 link. The host computer is running an IEEE1451.0 HTTP server and an automatic instrument recognition algorithm to automatically detect a new instrument plugged into a serial port. This detection protocol is shown in figure 10.
The host computer periodically interrogates the serial port for a PUCK-enabled instrument.
When the host receives a PUCK response from the serial port, the host retrieves the 96-byte PUCK datasheet and examines the UUID to determine if a new instrument has been installed. If so, the host retrieves the SensorML and IEEE 1451 TEDS description from the instrument's PUCK payload, and loads an appropriate driver.
Finally the driver retrieves a new data sample from the instrument. These operations are performed at the sampling frequency specified for the instrument.

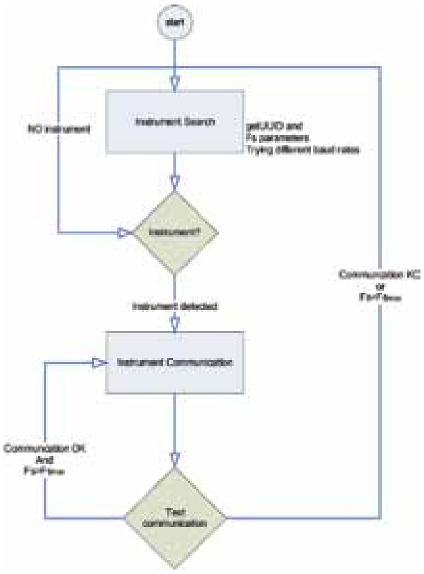

Fig.10 - Automatic Instrument Recognition protocol

The IEEE1451.0 HTTP server running on the NCAP host computer keeps track of instruments or TIMs connected to the NCAP serial ports. A web application based in Google Maps retrieves the information from the NCAP using IEEE1451.0 commands such as "http://esonet.epsevg.upc.es:1451/1451/Discovery/TIMDiscovery?ncapId=4&responseFormat=xml"and ReadTIMGeoLocationTEDS command in order to mark the position of the instrument in the Map as is shown in Figure 10.
In addition a Sensor Observation Service (SOS) runs on the NCAP host computer, in parallel with the IEEE1451.0 server. This SOS updates its properties about the number of instruments connected to the host. An SOS client such as Compusult's SenseEarth (http://sensearth.ca/) retrieves the SensorML instrument description originally stored in the instrument PUCK, thereby visualizing information geographically in a Google Maps application and reading data from the instruments. Figure 11 shows the schema of the instruments and services running the SOS and Figure 12 shows a Compusult SOS client used to visualize real-time data.

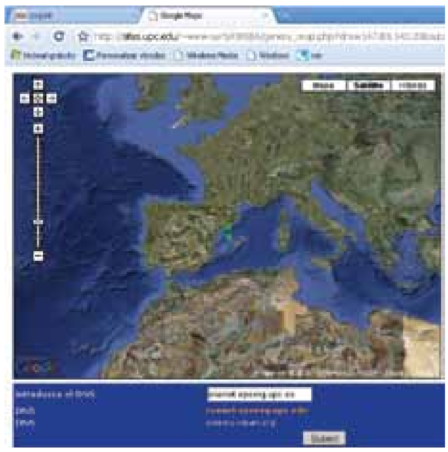

Fig.12 - Google Maps application to show instrument availability

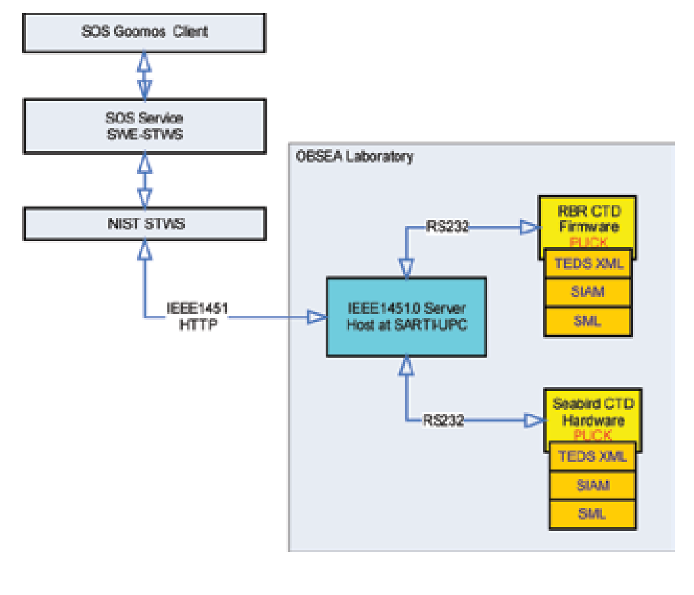

Fig.11 - Block Diagram of the Test Bench

Conclusions

PUCK Protocol can co-exist and it is compatible with other existing standards as IEEE1451 or SWE – SOS. The use of PUCK protocol with in an instrument facilitate the integration of the instrument within an observatory allowing storage of the description of the instrument metadata in different payloads types as IEEE1451 XML TEDS or SensorML. The engineering effort required integrating a PUCK enable instrument into and observatory is very small. Within a working day a computer science engineer is able to understand and communicate with a PUCK enable instrument, storing and configuring its payload. Approximately one week is enough time to define the payload and generate the code to be ready to integrate the instrument into the observatory. An automatic instrument recognition protocol has been proposed in order to enable the host to automatically configure a new instrument using PUCK Protocol and different Payload types.

Fig.13 - SOS Client from Compusult

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Excerpts from "Instrument Interface Standards for Interoperable Ocean Sensor Networks"

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Transducer Electronic Data Sheet (TEDS)

The transducer electronic data sheet ("TEDS") is a key concept of IEEE 1451. A TEDS describes characteristics and