SIOOS: Semantically-driven Integration of Ocean Observing Systems

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ABSTRACT

The diversity and heterogeneity of ocean observing systems obstructs the information flow needed to fully realise the benefits. SIOOS is a prototype for semantically-driven integration of ocean observation systems. SIOOS is built upon our Semantic Service Architecture platform, making rich use of complex ontologies and ontology-to-resource mappings to offer a flexible, semantically-driven integration environment. The SIOOS prototype draws on a federation of autonomous web and sensor observation services from the Integrated Ocean Observing System (IOOS). In this demonstration, we will use typical information management scenarios drawn from the ocean observation community to highlight major features of the SIOOS and show how these features address some of the challenges faced by the IOOS community.

1. INTRODUCTION

Ocean observing is critical to the design and development of ecosystem-based management of public health risks, water quality and living marine resources. The diversity and heterogeneity of ocean observing systems obstructs the information flow needed to support decision making and promotion of economic, environmental and social benefits.

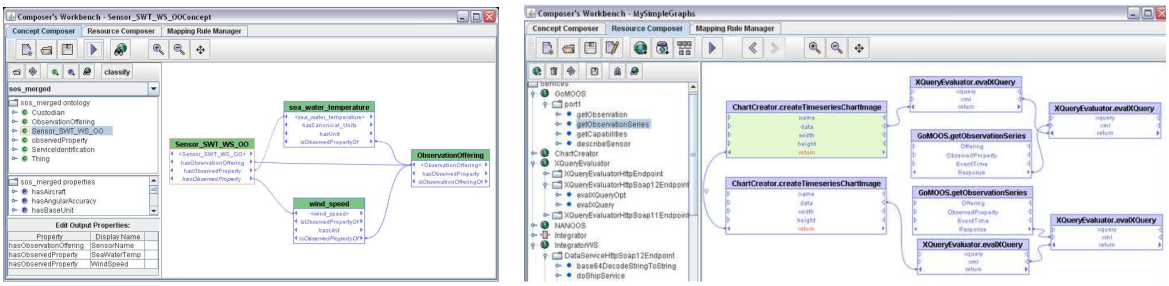
The U.S. National Oceanic and Atmospheric Administration has proposed a vision for an Integrated Ocean Observing System (IOOS), to seamlessly integrate distributed heterogeneous ocean observing systems. IOOS represents a partnership of 17 Federal agencies and 11 Regional Associations sharing responsibility for the design, operation, and improvement of the national network of observations. One way to manage the diversity of the ocean observing systems is to develop and implement standards for the representation of data, such as the OGC's Sensor Observation Service (SOS), and its associated metadata. Such standards provide only an interaction protocol and a syntactic format for data representation and do not address integration and interoperability in a federated context. For example, an observation of *Sea Water Temperature* might be labeled `Temperature`, `R TEMP`, or even `watertemperature`, within the IOOS federation and the user is left to deal with this. For another example, users are not able to query multiple observations from multiple services with a correlated result: such as the names of sensor platforms and their respective measurements for sea water temperature and wind speed.

In this demonstration, we present a Semantically-driven Integrated Ocean Observation System (SIOOS) in the context of IOOS. The SIOOS adopts a web service composition approach using a Semantic Service Architecture (SSA) platform [1]. The SSA platform is semantic-intensive: relying on rich service descriptions expressed as an ontology that is related to underlying service implementations through expressive mappings [3]. The SIOOS enables a user's expressions phrased over a domain ontology to be resolved to service compositions that may include both data-oriented services and other modelling and analysis tools into a single executable workflow. Compositions developed using SIOOS may be deployed as fresh virtual web services for the community. These services are re-useable by applications or, complemented with suitable client interfaces, by human users.

2. SEMANTIC SERVICE ARCHITECTURE

Our Semantic Service Architecture (SSA) is an information integration architecture which has been successfully applied to multiple domains including water resources [1] and health research [4]. The SSA comprises physical resources, resource descriptions, domain ontologies, mappings between domain ontologies and resource descriptions, a problem model, and a sophisticated Web service run-time environment.

The SSA has a Concept Composer, a Mapping Rule Manager, a Resource Composer, a Composition Compiler and a Workflow Executor, all accessed through the client tool called the Composer's Workbench. The Concept Composer allows users to specify *semantic compositions* using an OWL-DL domain ontology. We define a *semantic composition* as a conjunctive query expression over ontology classes, object properties and datatype properties, that can be realized, after a translation step, as a composition over resources. The Mapping Rule Manager manages mappings from resource descriptions to the domain ontology. A first-order predicate calculus mapping language has been developed for this [3]. The Resource Composer manages the compositions over resources such as database tables and web service operations. These kind of compositions are called *resource compositions*. The Composition Compiler plays two roles. It translates a



(a) A concept composition to query sensors and observations.

(b) A resource composition to query sensors and observations.

Figure 1: An example: Query sensors and observations using the SIOOS

semantic composition to a resource composition by using the relevant mappings. It also translates a resource composition to a workflow which is executed by the Workflow Executor.

3. THE SIOOS

The SIOOS was configured from the SSA by processing the necessary information in the IOOS resources and embedding it into the SSA. We obtained the IOOS resources, including the SOS installations and the related metadata, from the OpenIOOS[1] Portal. In order to enable access to sensor observation data through the Composer's Workbench, we map the physical operations that retrieve and manipulate the data to semantic descriptions that have been transformed from the SOS metadata to OWL ontologies. In other words, our configuration process uses the available SOS metadata from various SOS installations to generate OWL descriptions of the data together with mappings to physical operations that are described by the ontology. The main features of the SIOOS can be summarized as follows.

Facilitates data access. The SIOOS approach to data access exploits the standard, where it exists, but also accommodates variability from both the federation and the standard through the customised mappings.

Facilitates data discovery and understanding through contextual placement. The SIOOS naturally leverages contextual knowledge through capture (and reuse) of resource-specific knowledge as it relates to resource or domain ontologies, mappings within ontologies and mappings onto the user's problem model. This supports multidisciplinary application.

Facilitates sound application of data through integration and interpretation. The SIOOS enables the scientist to apply tools (such as visualization or statistical checks) to the observation data, and then use the (possibly processed) data and tools to address his problem.

Supports autonomy of service provision by providers and regional solutions. The SIOOS is able to make the best of common representation wherever it exists and it is also capable of admitting different architectures for data delivery through its configuration capability, and different data representation formats and data models through its semantic mapping capability.

Figure 1 shows a simple example using the SIOOS to easily and quickly query real-time ocean observations delivered by different Sensor Observation Service installations with multiple observed properties. The user first uses the Concept Composer to form a semantic query to seek the names of sensor platforms and their respective measurements for both sea water temperature and wind speed. After defining the semantic composition in terms of the ontology in Figure 1(a), the user clicks the "Run" toolbar button and the Concept Composer communicates with the composition compiler to generate a grounded resource composition which is shown in Figure 1(b). The user executes this resource composition and a workflow is generated. Finally the user executes the workflow and the result of sensor platforms and the observation measurements for sea water temperature and wind speed are returned in an HTML format.

4. CONCLUSION

We have presented the SIOOS, a rich-semantics approach to a federated Integrated Ocean Observing System. Benefits of SIOOS include: it provides enhanced discovery of ocean observation data through higher fidelity data descriptions; it uses semantics to enable data integration and service composition over federated services; and it admits different presentations for data delivery. More detail is given in [2].

5. REFERENCES

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