Demonstration: A RESTful SOS Proxy for Linked Sensor Data*

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Abstract. Next generations of spatial information infrastructures call for more dynamic service composition, more sources of information, as well as stronger capabilities for their integration. Sensor networks have been identified as a major data provider for such infrastructures, while Semantic Web technologies have demonstrated their integration capabilities. Most sensor data is stored and accessed using the Observations & Measurements (O&M) standard of the Open Geospatial Consortium (OGC) as data model. However, with the advent of the Semantic Sensor Web, work on an ontological model gained importance within Sensor Web Enablement (SWE). The ongoing paradigm shift to Linked Sensor Data complements this attempt and also adds interlinking as a new challenge. In this demonstration paper, we briefly present a Linked Data model and a RESTful proxy for OGC's Sensor Observation Service (SOS) to improve integration and inter-linkage of observation data.

Keywords: Semantic Sensor Web, Linked Sensor Data, REST, Sensor Observation Service

1 Introduction

The Sensor Web requires well defined semantics to make observation data discoverable and reusable [2]. The Semantic Web provides the necessary framework by (i) formal and machine-readable ontologies for sensors, observations, and observed properties, and by (ii) using reasoning to discover implicit facts, relations, and contradictions. So far, the Sensor Web and Semantic Web are not well connected which limits data exchange as well as combining their services. To address this problem, we have proposed and partially implemented a Semantic Enablement Layer for Spatial Data Infrastructures (SDI) [3]. It encapsulates Semantic Web reasoners and ontology repositories within OGC Web services to enable a transparent and seamless integration of Semantic Web technologies with SDIs. This work focuses on enabling the reverse direction, i.e., making spatial information available on the Semantic Web without changing existing standards and implementations. To facilitate integration and inter-linkage of observation data, this

* This demonstration paper is a modified excerpt of the article by *Janowicz et al. 2011* [1]

demonstration paper presents a Linked Data model and a RESTful proxy for the Sensor Observation Service (SOS) interface of OGC's Sensor Web Enablement initiative [4]. For two related approaches on serving semantic-enabled sensor data see [7,8].

2 System Architecture

The RESTful SOS proxy is available as free and open source software[5]. It can be installed as a software facade in front of any OGC conform SOS and offers the core functionality to make sensor data available as Linked Data. Based on a well-defined URI scheme [1], the RESTful proxy extracts the user's query from the URI, encodes it into valid SOS queries, fetches the results from the underlying SOS, and converts them (after content negotiation) to RDF/XML aligned with the developed model for Linked Sensor Data (Figure 2). Consequently, each URI identifies a particular data set and at the same time encodes a query to the underlying SOS.

The RESTful SOS proxy is implemented using the *OX-Framework* [5], a software framework which facilitates the utilization of OGC Web Services, such as the SOS. The OX-Framework handles access of various service interfaces by providing a generic architecture that includes a plug-in mechanism for service adapters as extension points of the framework.

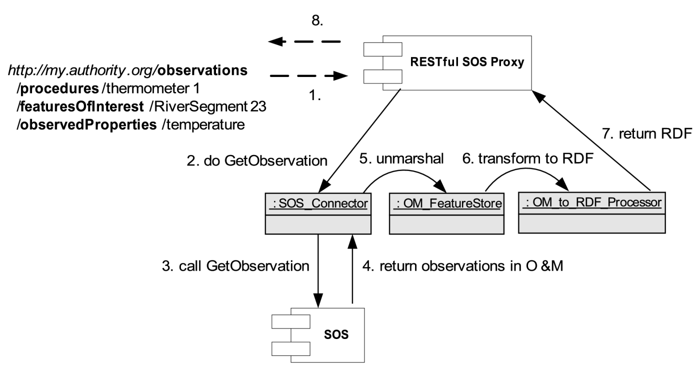

Fig. 1. Resolving a URI by the RESTful SOS proxy [1]

Three kinds of service adapters are needed for accessing a service (Figure 1): *Service connectors* trigger service operations and instantiate the common capabilities model. *Feature stores* provide the functionality to unmarshal received feature data into the internal feature model of the OX-Framework, while *data processors* run on the instantiated feature model and transform the feature data into other representations. We developed a data processor that converts observations into RDF-encoded Linked Data; however, we also support other representations such as KML or JPEG charts. The

[5] http://52north.org/RESTful_SOS

RESTful SOS proxy chooses the right data processor based on HTTP content negotiation.

3 Demonstration

The proxy exposes sensor data following a particular URI scheme. While OGC's Observations & Measurements standard supports unique identifiers, it currently does neither prescribe the use of HTTP URI's, the persistence of identifiers, nor clear and flexible linking strategies between resources. Ontologies abstract from data models and aim at describing the physical world. For example, they specify the notion of a stimulus which triggers a sensor and leads to the observation. The stimulus as such, however, is out of scope for O&M. Therefore, we introduce an intermediate Linked Data model by extending the W3C SSN ontology's Stimulus-Sensor-Observation (SSO) ontology design pattern [6]; see Figure 2. The relations between the presented classes act as links in our model and define the multiple navigation paths and external references.

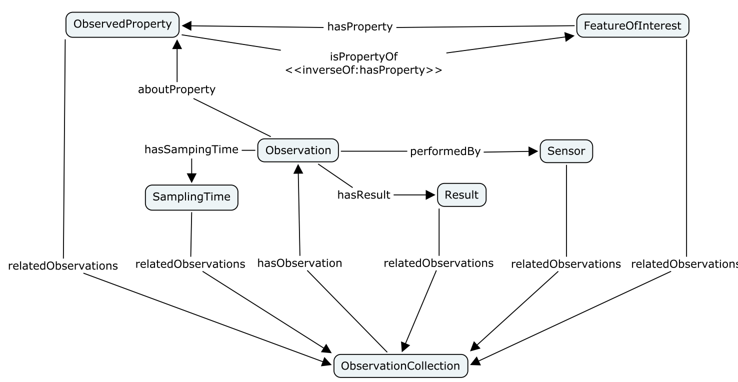

Fig. 2. Concept map with the classes and relations of the Linked Sensor Data model [1].

In the demonstration, we present how URIs act as identifiers for sensor data and as query filters which are mapped by the RESTful proxy to SOS GetObservation requests. For instance, the URI `http://v-swe.uni-muenster.de:8080/52nRESTfulSOS/RESTful/sos/AirBase_SOS/observations/sensors/HR:0002A/samplingtimes/2008-01-01,2008-12-31/observedproperties/concentration[NO2]` points to the observation collection with all NO_2 observations from a specific sensor during 2008.As the proposed solution offers the sensor data as a RESTful service, we will apply a common web browser to illustrate how queries are constructed and how users may interact with the service front-end.

4 Conclusion

In this demonstration paper, we report on the implementation of a transparent and RESTful SOS proxy that can serve Linked Sensor Data without any modifications to existing OGC services and existing SDI deployments. We decided to use a RESTful approach as it combines three key advantages. First, URIs are building blocks of Linked Data. REST allows us to identify data and at the same time encode the query using our URI scheme. Second, a major requirement of our vision of Semantic Enablement [3] is transparency, which is given by our REST proxy approach. Third, the REST paradigm focuses on simplicity with respect to application implementation.

Summing up, the proposed approach provides an important step towards the semantic enablement of existing information systems and infrastructures, and thereby eases the integration of dynamic information sources such as sensor networks. Delivering observations as Linked Data, connecting them with other data sources, and using ontologies and Semantic Web reasoners to improve retrieval, alignment, and matching are major building blocks for the implementation of novel information infrastructures.

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