Sensor Web Enablement (SWE) for Citizen Science

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SENSOR WEB ENABLEMENT (SWE) FOR CITIZEN SCIENCE

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ABSTRACT

Using "the crowd" as a means to collect observations within a certain area is currently explored in various fields. The European Commission funds a set of research and development projects, all flagged as "citizen observatories" projects. The goal is to provide best practices on data modeling and processing for citizen observatories. The best practices help create and maintain crowdsourcing systems in an effective and secure way. The Open Geospatial Consortium (OGC) has developed a suite of standards to describe, access, and process crowdsourcing data in an interoperable way.

Concentrating on Biosphere Reserves in Wales, Germany and Greece, the main aim is to create a testbed environment, which will enable citizens living within Biosphere Reserves to collect environmental data using mobile devices. Information of use for policy formation and delivery is generated by quality controlling the crowdsourced data and aggregating with Spatial Data Infrastructure (SDI) reference data from authoritative sources. This paper describes how the Sensor Web Enablement suite of standards together with other OGC standards facilitates the setup efficient SDIs that integrate remote sensing data with in-situ crowd sourced data.

Index Terms— Sensor web, OGC standards, Crowdsourcing, Environment, Biosphere

1. INTRODUCTION

Crowd sourcing, meaning using a crowd of people to collect information about the environment, is an often-applied approach for low-cost and rapid data collection campaigns, covering a wide range of application domains and scenarios. These crowdsourcing campaigns and systems include a number of components, such as a mobile app usually loaded on a smartphone, some offline storage capacity if Internet connectivity is a challenge, synchronization mechanisms between the mobile app and the raw data server, quality assurance processes running on all incoming raw data, data processing, aggregation and improvement processes, data access and metadata enrichment services etc. This a complex system which requires standards in order to easily share results and to ensure the data is discoverable by the larger community.

A number of large-scale research projects are currently under way exploring the various components of citizen observatories, e.g. CITI-SENSE (http://www.citi-sense.eu), Citclops (http://citclops.eu), COBWEB (http://cobwebproject.eu), OMNISCIENTIS (http://www.omniscientis.eu), and WeSenseIt (http://www.wesenseit.eu) [1]. Common to all projects is the motivation to develop a platform enabling effective participation by citizens in environmental projects, while considering important aspects such as security, privacy, long-term storage and availability, or accessibility of raw and processed data. Data acquired through citizens can be enriched using other earth observation data form reliable sources, such as satellite imagery or data provided by administrative sources. Goal of this enrichment process is the provision of quality ensured data that can be re-used for other purposes once made accessible using discovery and access systems such as GEOSS or INSPIRE.

This paper describes the software architecture implemented for setting up crowdsourcing campaigns using standardized components as provided by ISO and the Open Geospatial Consortium, together with low level data serialization and transport standards. Particular focus is laid on the usage of Sensor Web Enablement (SWE) standard; a suite of service interface and data encoding standards to exchange observation data obtained by sensors [2]. The SWE standards are integrated into a completely standards-based architecture. The architecture allows for cost-effective citizen science crowdsourcing campaigns based on standard-compliant off the shelf products. This approach prevents vendor lock-in issues at a stage where citizen science frameworks are just being developed. The described approach allows defining crowdsourcing campaigns, inviting participants to crowdsourcing campaigns, and analyzing, processing, and visualizing raw and quality enhanced crowd sourcing data and derived products.

2. OGC & ISO STANDARDS

The OGC has published a set of Web service interface standards as well as data modeling and serialization standards that can be used to setup interoperable components. Together, these components form Spatial Data Infrastructures that allow for efficient and cost effective integration of crowd sourced data with other, externally gathered data. In this context, the aspects of ground-proofing remotely sensed data

as well as the derivation of high-value information by fusion of various data sources are of particular interest.

5.1. OGC Sensor Web Enablement

The OGC Sensor Web Enablement (SWE) defines a suite of standards that allow the setup of Spatial Data Infrastructures for sensor data. SWE contains service interface standards to discover and access observation data obtained by sensors and to control and to task sensors and actuators. These service interface standards are complemented by a set of sensor and observation model and serialization standards to encode the actual data. The Sensor Observation Service (SOS) defines a transactional interface to obtain and store sensor observation data [3]. The Sensor Planning Service (SPS) supports the definition of tasks to be executed by sensors or actuators [4]. Observation & Measurement (O&M), released as part of the OGC SWE suite and as ISO 19156, defines a model and serialization of observation data [5,6]. Sensors can be described using the Sensor Model Language (SensorML) [7]. Both services and data models are complemented with SWE Common components that implement common aspects of service interfaces (SWE Services Common), and data models (SWE Data Common) [8,9]. All standards are not restricted to physical sensors, but can be applied to humans as sensors just as well. The particular strength of these standards is their capability to provide as much information as necessary, means that the same standards can be used to provide highly abstracted as well as highly detailed data.

5.2. Other OGC Standards

One requirements often specified by crowd sourcing campaigns is the capability to support offline storage of sensor information. For this purpose, the OGC has produced the GeoPackage standard. GeoPackage is an OGC standard for storing geospatial data and information in an SQLite database. The standard describes a set of conventions for storing a number of content types, such as vector features, tile matrix sets (pyramids) of imagery and raster maps at various scales, schema, metadata, and a number of extension data. Thus, it can be considered the ideal container format for both crowd-sourced data as well as background data loaded on mobile phones to support the data collection process in the field.

The OGC Web Processing (WPS) standard defines an interface to any type of data processing and analysis. It defines the required input data and products along with the execution parameters. The WPS can be used to generate GeoPackages with any content. By defining calls to source services using OWS Context, another OGC standard, a user can use a WPS to build GeoPackages containing well defined geospatial data.

The Geosynchronization Services (GSS) is currently under development at OGC. The service allows users to submit new data in the form of a transaction. The GSS then informs a data reviewer of the pending transaction. The reviewer, either a human or a process façaded by WPS interface, approves or rejects the proposed transaction. By this, the GSS can introduce any sort of raw data quality assurance. Once approved, the GSS notifies subscribers of the new transaction. Again, subscribers might be humans or other processes. Optionally, the GSS forwards the transaction (both raw and reviewed) to any number of Sensor Observation Services to make it persistent. Making use of SWE data models and encodings, all transactions can be processed the same way, independently of the nature and observed properties.

3. STANDARDIZED ARCHITECTURE

A standardized approach uses data services such as INSPIRE download services or other Spatial Data Infrastructure services such as Web Mapping, Web Coverage, or Web Mapping services to provide background data. A client can identify the necessary data and make it known to WPS in the form of OGC Web Context documents. The WPS retrieves the data accordingly, stores all data in a GeoPackage, and provides this GeoPackage together with the crowd sourcing sampling campaign application to the crowd member. The crowd member collects all data, stores it locally in a GeoPackage while being offline, and syncs all data with a GSS once a sampling trip has been completed and connectivity is established again. The GSS stores all raw data in SOS, executes arbitrary data quality assurance and data fusion processes and stores the data in SOS again. Applying dedicated security, access control and privacy settings, all data can be made available from these SOS.

4. CONCLUSION & OUTLOOK

The strict setup using internationally adopted standards such as OGC standards from Sensor Web Enablement, GeoPackage, and Web Processing Services, as well as security and metadata/cataloguing standards in combination with well defined profiles of those standards where necessary (e.g. SWE O&M profile, SensorML profile), cater for maximal flexibility and interoperability between various campaigns. All profiles are currently under development in a joint effort between the citizen observatories projects mentioned above. This interactive cooperation ensures that a wide variety of use cases, such as biological monitoring, ocean water color analysis, odor analysis, or air pollution research are supported with minimum complexity of the used standards.

The described architecture makes use of components compliant to standards developed by the Open Geospatial Consortium. The strict application of a set of these standards allows for the setup and operation of highly efficient crowd sourcing systems. Though further best practices developments and examples are required to simplify the setup

and system design process, the described standards already cater today for flexible and interoperable components and systems.

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