Building the O-Life Franco-Lebanese Environmental Observatory Using Sensor Web Enablement Framework : Challenges and First Approach

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***Abstract*— This paper introduces an approach how the Sensor Web Enablement (SWE) framework of the Open Geospatial Consortium (OGC) will be used in order to build a franco-lebanese observatory. We present the practical application of SWE services as a source of real-time observation data and the associated technical architecture for making the observations available on the Web to end users near real-time. We discuss the question of crossing sensor data with other data sources, e.g., data provided by human observations. We illustrate our approach with a first use case to monitor the snow weather stations in Lebanese Mountains.**

Keywords- O-Life; Environmental Observatory; Sensor Web Enablement; Lebanon; Snow monitoring

I. INTRODUCTION

Lebanon is bordering the eastern Mediterranean Sea (See Figure. 1). The Mediterranean basin is a priority area and a

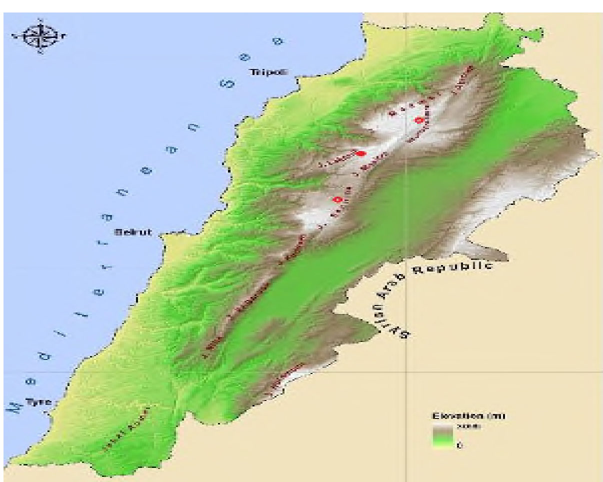

Figure 1. Study area in Lebanon's map of snow weather stations

leading area for the analysis of environmental data and for the extrapolation of trends that will allow a better management of the present and help envisage plausible scenarios for the future. For this reason, actors of the French and Lebanese scientific research community wished to establish a shared observatory between France and Lebanon called "Observatoire Libano-Français de l'Environnement", O-LiFE [1]. The main activity of the observatory is to study the critical zone around the Mediterranean, of water resources, biodiversity, natural hazards, and management of the environment and ultimately the study of land use. To carry out its mission, the O-LiFE observatory aims to construct environmental databases of the critical zone in consideration, create collaborative software tools and organize, share, sustain and enhance environmental data.

Building such an environmental observatory requires defining a technical architecture that must be able to store various types of data and to offer several services. The data and knowledge being handled are mostly spatial and collected from sensors and scientists. For this purpose, we propose an open, standards-based, modular architecture based on the OGC SWE framework. OGC SWE has indeed become currently a very useful monitoring technique at spatial and temporal scale especially after the considerable improvement in the ICT communication infrastructure.

In this paper, we discuss the challenges for building the technical architecture and present our first approach. The next section introduces the framework we propose to use. Section 3 details our context and the architecture we propose. Section 4 illustrates this approach with our first use case dedicated to snow while Section 5 concludes this paper.

II. OGC SENSOR WEB ENABLEMENT

In this section, we present the main ideas lying in the standard OGC that is used in most environmental observatories and that makes it possible to exchange and use data from such observatories. The OGC is an international, non-profit, voluntary consensus standards organization

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consisting of more than 500 companies, government agencies and universities [2]. The goal of the OGC is the creation and establishment of standards that enable global infrastructures for delivery and integration of geospatial content and services and to facilitate the adoption of open, spatially enabled reference architectures in enterprise environments worldwide.

Within the last years, the Sensor Web Enablement (SWE) architecture of the Open Geospatial Consortium (OGC) has matured into its second generation [3]. The main goal of this standards framework is the integration of sensors and sensor data into Spatial Data Infrastructures and thus makes it possible to use data measured by sensors in a broad range of applications. Thus, sensor data become an additional source for geospatial information besides conventional data types like maps. In addition, the availability of sensor data offers the possibility to integrate near real-time measurements with conventional geospatial data for visualization purposes.

The SWE framework consists of a set of standards defining data formats for sensor data and metadata, as well as service interfaces to access sensor data, task sensors or send and receive alerts based on sensor measurements [4].

III. PROPOSED IMPLEMENTATION

In this section we discuss the similarities and specificities of the O-Life Observatory and present how the OGC SWE standards are integrated in the O-Life infrastructure so that snow real-time data sources becomes available to end users.

A. *Similarities and Specificities of the O-Life Observatory*

O-LIFE will be built, as a first step, by combining and sharing data already collected and with direct access to in-situ sensors.

A survey has been conducted for O-LiFE supported research projects showed that there are existing databases and data but most of these data are dispersed, diverse, not updated, unpublished, insecure, not shared, and not accessible to public. Furthermore, in many cases data from many heterogeneous data sources might need to be compared and/or combined and different data sources have to be correlated. Moreover, there are different data sharing policy within the scientific community that prevents access to data. Sharing and leveraging data and research resources can avoid duplication of very expensive and time-consuming efforts, allowing scientists to spend more time in data analysis than in data collection and discovery, and enable more people to benefit from using environmental data. Advanced security concept is necessary so that only authorized users are able to insert/query data into the O-LiFE infrastructure.

Hence, it is necessary to develop a standardized system for collecting data at national level and develop a data sharing policy resulting in a sustainable database, interoperable, shared, and regularly updated. This first step aims subsequently to create an ambitious Circum-Mediterranean observatory network.

B. *Crossing Data*

O-LIFE aims to collect and exchange data from various sources, including sensor and human observations. As discussed in this paper, sensor data can easily be managed by the Sensor Web infrastructure. However, in some cases it may be difficult to manage human observations as such data do not always have a compatible structure. For instance, the way data are georeferenced, the type of data (e.g., textual data) can make it difficult to integrate the data directly as an input of Sensor Web. For this reason, we envision four possibilities for crossing data that will be explored in our work:

1) Transforming non sensor data so as to consider all data sources as inputs of Sensor Web;
2) Loading non sensor data directly in relational tables of the PostgreSQL database used to serialize Sensor Web data;
3) Crossing data thanks to an application within our infrastructure, thus relying on an application server to deliver the services;
4) Crossing data outside our platform, this option being taken by end-users after importing some data from O-LIFE.

C. *Proposed Architecture*

We choose to use the provided by 52° North German initiative for Geospatial Open Source software, 'Sensor Observation Service' (SOS) and 'Observations and Measurements' (O&M) [5]. The SOS is a web service to query real-time sensor data and sensor data time series and is part of the Sensor Web framework. A 52° North PostgreSQL database with a predefined schema by 52°North implementation of the SOS will be used to store the sensors data. The PostGIS spatial extension will be included in the PostgreSQL database. Apache Tomcat will be used as Servlet container. The proposed architecture is shown in Figure 2.

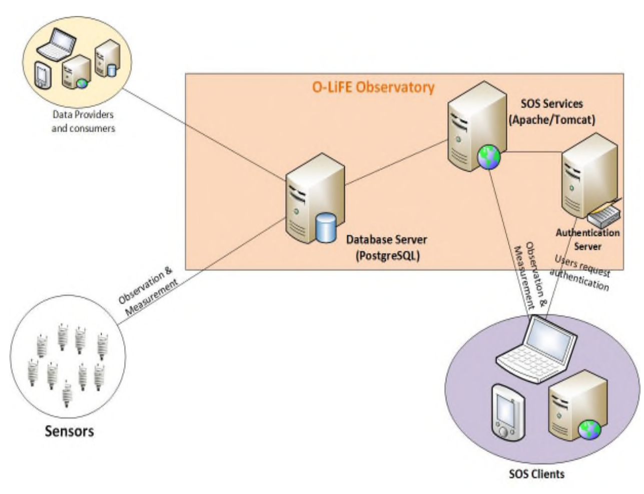

Figure 2. Proposed architecture for integrating the SOS platform into the O-LiFE architecture

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The SOS provides an interface for requesting sensor data sets based on temporal and spatial query parameters. The responses of the SOS containing the requested data are then returned using O&M. O&M is a model defining how to link observed values with all relevant properties (i.e., location, time, observed parameter, unit of measurement) that are necessary to interpret them. In the SOS interface, O&M is used in two operations:

1) GetObservation: O&M is the default output
2) InsertObervation: O&M is used for encoding all values that shall be inserted into a SOS server

The database server contains environmental data from different data providers for different thematic and structures. Sensors data will be hosted on the same server.

IV. CASE STUDY: SNOW WEATHER STATIONS

The observatory system is designed to support real-time monitoring which can collect sensors data. Snow weather stations will be used as our first use case.

A. *Presentation*

Lebanon is a real water palace, of which the study of snow and dynamics coats is instructive for several reasons: trends, hazards and climate predictability, redistribution of meltwater and impact on the availability of downstream water.

The snow weather stations are installed in Lebanon as part of an agreement for scientific and technical cooperation for research on snow hydrology project and an observatory of joint project of the snow in the Mediterranean between CESBIO, the National Council for Scientific Research in Lebanon and the Saint Joseph University in Beirut [6].

The three snow weather stations are located in three different regions (Mzaar, Cedars, Laqlouq) comprising sensors measuring temperature, snow height, relative humidity, precipitation, air pressure, wind speed and wind direction. The outdoor sensors are powered by solar cells as appears in Figure 3. Sensor observations are sent remotely via a TCP/IP connection through the Internet to the SOS server hosted in the O-LiFE observatory datacenter using GPRS modem. Users will be able to query snow sensors data and access animated visualization of spatial-temporal data, including time series presentation. Table I shows a snapshot of data generated by the snow weather stations.

Figure 3. Snow weather stations in Laqlouq region, Lebanon

B. *Expected Results*

The proposed approach for in-situ sensor near real-time data acquisition is supposed to be a first step towards establishing the SWE framework within O-LiFE Observatory. The observatory aims to establish a national Spatial Data Infrastructure (SDI) for Lebanon ensuring acquisition, archiving and management of multi-scale satellite imagery and in-situ datasets for the Lebanese territory and making it accessible by the scientific community and by various public actors involved in environment and management.

Data from in-situ or remote sensing devices form the basis for analyzing gradual processes, such as snow melting, water shortages, or increasing drought. In-situ and satellite measurements are not directly comparable due to their basic configurations. In-situ sensors provide point based measurements at ground level whereas satellites observe the entire atmosphere. The near real time in-situ data could be used to calibrate and validate remote sensing data and models. Later, approaches to consolidate remote sensing data, and in-situ data will be considered to get more accurate results. This is highly prioritized by the O-LiFE observatory to make use and share all available source of data. Nevertheless, a special effort should be made to add additional in-situ sensors in different research areas and to include existing in-situ sensors in the country to the Observatory SDI. Besides, solutions to include mobile human sensors through mobile applications should be considered and developed to have vast amount of incoming georeferenced data and to allocate these data using the SWE standards.

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V. Conclusion

In this paper, we investigate the possible ways for data management within O-Life observatory. We discuss the specificities of this context and we propose an architecture based on the standards of the Open Geospatial Consortium. This work is being currently implemented in the framework of a collaboration between French and Lebanese organizations. Many perspectives are associated to this first approach. First, we aim at benchmarking our proposal with real data collected in the various data sources. Second, we aim at studying how our architecture can provide valuable services to scientists both for raw data crossing and exchanges and for analytical processing. Finally, we aim at studying how the O-Life data can be shared through Open Data for better enabling interoperability and linked to other open resources [7].

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Table I. Example of part A of the data generated by the snow weather stations

TimeStamp	AirTemp (C)	vit_vent (m/s)	Direction vent (degree)	Std direction vent (degree)	Pression (mbar)	Geonor (Hz)	Geonor (mm)	Wind max (m/s)
2015-04-09 08:00:00	8.06	13.49	190.8	12.5	764.1	2090	27.73	24.5
2015-04-09 07:30:00	8.34	13.34	187.1	10.66	764.3	2090	27.74	23.81
2015-04-09 07:00:00	8.97	14.77	189.8	10.99	764.2	2090	27.72	23.86
2015-04-09 06:30:00	9.19	14.24	186.1	11.49	764.2	2090	27.72	24.7
2015-04-09 06:00:00	8.67	11.11	187.2	13.52	765	2090	27.74	20.24
2015-04-09 05:30:00	9.49	11.18	185.6	10.64	764.9	2090	27.74	22.25
2015-04-09 05:00:00	10.21	13.12	183.3	11.19	764.5	2090	27.74	20.78
2015-04-09 04:30:00	10.63	13.9	183	11.6	764.5	2090	27.73	26.17
2015-04-09 04:00:00	11.36	16.05	188.9	12.64	764.4	2089	27.7	32.19

TimeStamp:date and time of the measured values
AirTemp (C): Air temperature in Celsius
vit_vent (m/s): Wind speed in m/s
Direction vent (degree): Wind direction
Std direction vent (degree): The standard deviation of wind direction
Pression (mbar): Atmospheric pressure in mbar
Geonor (Hz): frequency of vibrating wires in Geonor precipitation gauge
Geonor (mm): accumulation of precipitation in the bucket
Wind max (m/s): Maximum Wind speed

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