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Practical Experiences with Sensor Web Technology

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Abstract: This short paper introduces experiences made over the last years with the OGC Sensor Web technology and discusses challenges for the future. On the one hand, it shortly introduces typical application scenarios: the use of the Sensor Web for investigating relationships between environmental factors and health problems as well as a scenario for the large scale exchange of environmental data across Europe. On the other hand, it presents open challenges that need to be addressed in the future to further improve the Sensor Web and increase its practical applicability.

Keywords: OGC Sensor Web Enablement; Spatial Data Infrastructures; Sensor Data; Applications

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1. Introduction

Over the last years the OGC Sensor Web Enablement (SWE) standards have constantly evolved so that most of them are now available in their second generation [1]. In the past, several research projects (e.g. OSIRIS[1] and GENESIS[2]) as well as practical projects have contributed to advance the SWE standards to a state that allows building stable applications. This paper presents two project examples of practical SWE applications: the EO2HEAVEN[3] project aiming at exploring correlations between health problems and certain environmental factors as well as a project enabling the large scale exchange of environmental data across Europe conducted in cooperation with the European Environment Agency. Furthermore, an outlook is given, which challenges remain for future research in order to optimize SWE and bring it to further application scenarios that will benefit from an interoperable exchange of sensor data.

2. EO2HEAVEN

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[1] http://www.osiris-fp6.eu/

[2] http://www.genesis-fp7.eu/

[3] http://www.eo2heaven.org/

A typical application scenario for the OGC SWE technology are the questions addressed by the EO2HEAVEN project (Earth Observation and Environmental Modelling for the Mitigation of Health Risks) [2]. This project is funded within the Seventh Framework Programme (FP7) of the European Commission and aims at investigating the relationship between environmental factors (e.g. air pollution, certain weather conditions) and health problems (e.g. cardiovascular diseases, respiratory diseases). The start of the EO2HEAVEN was in February 2010 and its duration is three years.

For the research on a better understanding of the complex correlations between environmental influences and the human health, two thematic domains have been chosen: water as well as air pollution. To achieve this research objective, a multi-disciplinary and cross-domain approach is being followed so that stakeholders from different fields (health, environment, technology) are brought together.

A central concept of EO2HEAVEN is its Spatial Information Infrastructure (SII). This SII is intended to form the basis for exchanging data, knowledge and analysis functionality in order to answer relevant thematic questions. Through the EO2HEAVEN SII it becomes possible to exchange spatial information including conventional geospatial data such as maps or sensor data (local in-situ measurements as well as remote sensing data). Further, the EO2HEAVEN SII offers the necessary functionality for processing and analysing the different data sets. For this purpose the data sources of the EO2HEAVEN SII are linked to processing components (i.e. the OGC Web Processing Service). Thus, the EO2HEAVEN SII offers a framework and tools for supporting researchers in investigating the links between health and environment.

EO2HEAVEN is driven by three different case studies which are carried out in Europe as well as Africa. The work performed in the EO2HEAVEN case studies will rely on the technical solutions developed within the project in order to solve the thematic research questions. At the same time these case studies help to evaluate the developed technical results and to support a continuous improvement of SII concepts and their implementations. This approach ensures that the scientific objectives of EO2HEAVEN are successfully reached and that the developed software frameworks will be re-usable beyond the direct scope of the project. In detail, EO2HEAVEN addresses the following case studies:

- Dresden/Saxony (Germany): Investigation of the impact of environmental and climatic changes on allergies and cardiovascular diseases.
- Durban (South Africa): Research on impacts of environmental pollution (i.e. air pollution) on respiratory diseases.
- Uganda: Research on correlations between climatic conditions and the risk of cholera outbreaks.

The EO2HEAVEN SII lays out the foundation for answering those thematic questions. Especially the possibility for researchers to have an interoperable access to the data sets and well-defined interfaces for processing services is a key pillar within the EO2HEAVEN project. For working with climatic and environmental data, sensors are of special importance. This includes not only operational sensor networks but also historic sources of observation data which need to be integrated into the EO2HEAVEN SII as well. Thus, besides conventional elements of spatial data infrastructures, the OGC SWE framework plays an important role in EO2HEAVEN.

Besides addressing the thematic health questions, EO2HEAVEN makes a contribution to the advancement of OGC SWE. Gained practical experiences are used for improving the SWE standards.

For example, the new 2.0 version of the OGC Sensor Observation Service (SOS) [3] has benefitted from ideas and concepts developed within EO2HEAVEN. Another example is the development of profiles of SWE standards in order to increase their interoperability and usability (e.g. OGC Lightweight SOS Profile for Stationary In-Situ Sensors Discussion Paper [4]).

In summary, EO2HEAVEN is a good example of how SWE technology can be used for solving practical research questions. At the same time, due to its research character, EO2HEAVEN is able to contribute to advancing the OGC SWE architecture.

2. Sharing Environmental Data across Europe

The second practical project presented here deals with the sharing of near real-time environmental data across Europe, a project conducted for the European Environment Agency (EEA) (Figure 2) [5]. Within this project an operational SWE infrastructure that facilitates the exchange of environmental observations is envisioned.

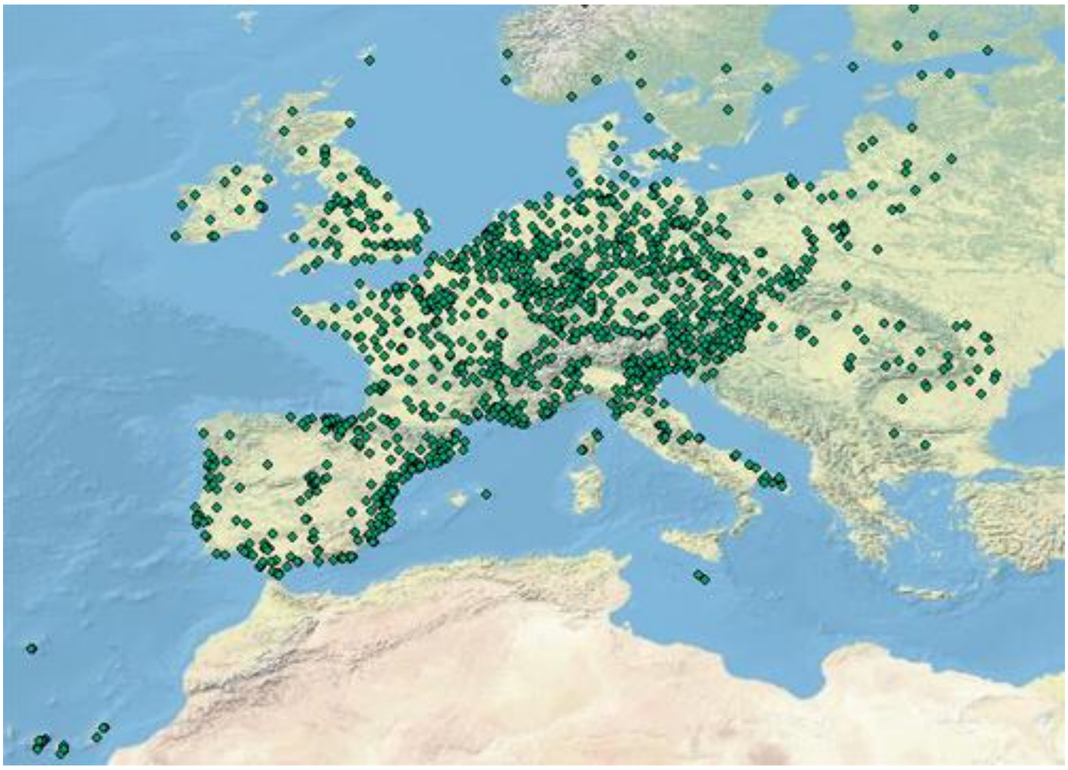
The main motivation of this project lies in the role of the EEA. A core task of the EEA is the provision of data about the environment in order to support policy makers in their decision process and to inform stakeholders as well as the general public. To achieve this goal the EEA is collecting environmental data from its 32 member states. However, the integration of these different data sources is cumbersome and requires high adaptation efforts, since the data sets provided by the member states are delivered in proprietary data formats through various interfaces. Thus, there is currently no common way for enabling the flow of environmental data between the member states and the EEA. Instead, the EEA has to manually adapt its systems and infrastructure to the different interfaces and formats used by the member states.

In order to overcome the significant overheads caused by this heterogeneous landscape of data formats and interfaces, the EEA plans to establish an OGC SWE infrastructure as a common integration layer. This approach offers several advantages to the EEA:

- Interoperability: the SWE framework abstracts from different underlying data models, formats and interfaces so that an interoperability layer for facilitating the data integration is available.
- Vendor independency: the EEA does not need to prescribe a certain product of a specific vendor.
- Domain independency: the SWE framework can cover different types of environmental data (e.g. hydrological data as well as air pollution measurements).

To establish SWE as an interoperability layer enabling the exchange of near-real time environmental data between the EEA and its member states, several challenges are addressed. First, it is necessary to develop an architecture that enhances the existing EEA infrastructure (i.e. the existing databases and data flows) so that SWE based data exchange is supported. Here, an important aspect is to enable the output of environmental data available in the databases of the EEA through the OGC Sensor Observation Service (SOS) interface. This makes sure, that the EEA is able to serve the available environmental data in an interoperable way. Second, the data flows from the member states to the EEA are addressed. Finally, there is a strong need to support relevant stakeholders (i.e. the EEA member states) in implementing SWE. By ensuring the availability of SWE compliant (mainstream) software components that can be easily deployed and documentation of best practice approaches how to enable the support of the SWE standards, the implementation of SWE by the member states is facilitated.

Figure 1. Air quality monitoring stations across Europe (integrated into the EEA infrastructure)



In summary the EEA is a good example for the practical benefits of the SWE framework. By providing an abstraction layer that hides the heterogeneity of different software systems and domains, the integration of environmental data flows on a large scale is significantly facilitated.

4. Future Research Challenges and Conclusions

The two examples described in this paper show, how SWE can be used for building different applications. The matured state of the SWE standards makes it possible to create productive and operational systems. However, for the future some research challenges remain.

An important aspect is the definition of domain specific SWE profiles. Such profiles adapt the different relevant SWE standards to the needs of a thematic community and describe a common agreement how to apply SWE within a specific domain. The benefits of such domain profiles are on the one hand improvements in interoperability as these profiles ensure a common way of implementing the SWE standards among multiple stakeholders. On the other hand, members of a specific domain receive better guidance (e.g. best practices how to model data in a SWE compliant way). An example for such a domain specific SWE profile is OGC WaterML 2.0, a profile of the OGC Observations and Measurements standard [6].

Also, new concepts such as Representational State Transfer (REST) and Linked Data may have an impact on future versions of the SWE architecture. They have the potential to lead to new protocol bindings for the SWE interfaces and to alternative data modeling approaches.

Finally, the topic of event based Sensor Webs will need further work as according standards are not yet finalized. Here the OGC Publish/Subscribe (PubSub) Standards Working Group is working on a stable standard.

In summary, the introduced project examples have shown practical usage scenarios for the OGC SWE technology. Today the SWE framework has reached a degree of maturity that allows realizing operational systems. Although there are still research challenges for the future, it can be stated that OGC SWE is ready for its practical application.

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