SensorWeb Hub as an interoperable research data infrastructure for low-cost sensor data sharing.

Tiziana De Filippis, Leandro Rocchi and Elena Rapisardi
National Research Council - Institute of Biometeorology, Florence, 50145, Italy

Correspondence to: Tiziana De Filippis (t.de.filippis@ibimet.cnr.it)

Abstract
Data accessibility, discovery, re-use, preservation and, particularly, data sharing are the key to promote the open innovation approach to research studies and enhance interdisciplinary analysis.
Emerging initiatives like the OpenAire and DMPonline portals are well known for support data sharing and Data Management Plan (DMP) in the framework of European funded projects. However, for national or sub-national research projects, there is a scarcity of open data infrastructures to collect, share and manage a huge amount of local research data. As a matter of fact, data collected for national research activities are often the missing piece of the puzzle as they are not easily findable, or accessible.
In this context the CNR-Institute of Biometeorology (CNR-Ibimet) developed an open source and interoperable platform, called SensorWebHub (SWH) to manage both mobile and fixed meteorological and environmental sensors data that integrate the existing monitoring networks in urban and agricultural research initiatives. The infrastructure has been developed to ensure access, management and preservation of data within and across research teams; it is a technical support service for coordinated management of data and encourages reuse and collaboration.
SWH is a bottom-up collaborative initiative to share real-time raw research data and pave the way for an open innovation approach in the scientific research, so contributing to the processes of the production and dissemination of research data.

Introduction
In the last years, RDIs' landscape offers networks and international programs aiming to build reliable and interoperable research data e-infrastructures to promote the open innovation approach to research studies and enhance interdisciplinary analysis.
RDIs are designed to follow different data policies and reference models. Many of European Environmental RDIs, with more than half of them prioritized in the roadmap of ESFRI (the European Strategy Forum On Research Infrastructures), are run by Institutions having as own duty data storage and management. Others are a legal entity or in the process of doing so or are linked to research programs funded by H2020 EU. The current state of RDIs development varying from operational to preparatory phase project (Zaho et al. 2015).
However, for national or sub-national research projects, there is a scarcity of open data infrastructures to store, share and manage a huge amount of local research data. So, small research institutions or projects are disadvantaged by the lack of common spatial data infrastructure and specific expertise that is crucial factors to reduce open data access fragmentation within and across research units. As a matter of fact, data collected by local research activities are often the missing piece of the puzzle as they are not easily findable, or accessible.
In this context the CNR- Institute of Biometeorology developed an open source and interoperable platform, called SensorWebHub (http://www.sensorwebhub.org/), to manage both mobile and fixed meteorological and environmental sensors data, that integrate the existing monitoring networks in urban and agricultural research initiatives. The data, collected through innovative low-cost and open source sensor devices, are processed and published using OGC (Open Geospatial Consortium) services and geospatial data standards. This infrastructure is currently focused on the following sensor data categories: Agrometeo, Meteo, Urban Climate, Renewable Energy, Indoor.

Objective

The aim of this work is to deploy an interoperable and open data infrastructure in order to help the scientific community to share relevant and timely data and services.

This initiative arises from the fact that researchers mainly store their data, as well as intermediate products processed for environmental and agro-meteorological investigations, in personal archives. However, if this data were shared they could be used for further applications in other research fields. Data, climate products, informatics procedures, code and pre-processed data on a geographical area of interest could thus be reused, reducing the time and human resources necessary for further investigations. The availability of an interoperable research data infrastructure to store and manage data could also facilitate and encourage the adoption of a data sharing approach.

On this premise, SWH has been developed with the aim i) to support the participating approach to monitoring urban environment; ii) to share research data acquired by low-cost sensors from no-conventional networks and fixed and mobile sensors; iii) to test new analysis procedures and integrated approaches using multi sources data; iv) to develop new web geoprocessing tools v) to encourage the development of user-friendly interfaces for different stakeholders.

The challenge is also to attract more internal researchers to share their data and quality checked climate products easily through an available data infrastructure, for further interdisciplinary investigations.

SensorWeb Hub infrastructure

SensorWeb Hub infrastructure and functions were designed to create a participatory environmental monitoring system where the data collected with innovative low-cost and open source sensor devices are processed and published using OGC (Open Geospatial Consortium) services and geospatial data standards.

SWH web application manages both mobile and fixed open source and low-cost sensor platforms, to integrate the existing monitoring networks (De Filippis et al., 2015).

This interoperable infrastructure is currently focused on the following sensor data categories: Agrometeo, Meteo, Urban Climate, Renewable Energy, Indoor.

The infrastructure is composed by: 1) the AirQino Sensor-Boxes (ASB) as main components of the sensor network; 2) a central GeoDataBase (GeoDB), the PostgreSQL/PostGIS, for data storage and management; 3) a GIS engine and a WebGIS application for viewing, querying and performing data analysis; 4) the specific web services for data flux management. The components (Fig.1) are organized in typical client-server architecture and interact from the sensing process to the representation of the results to the end-users adopting the OGC® SWE (Sensor Web Enablement) common standards.

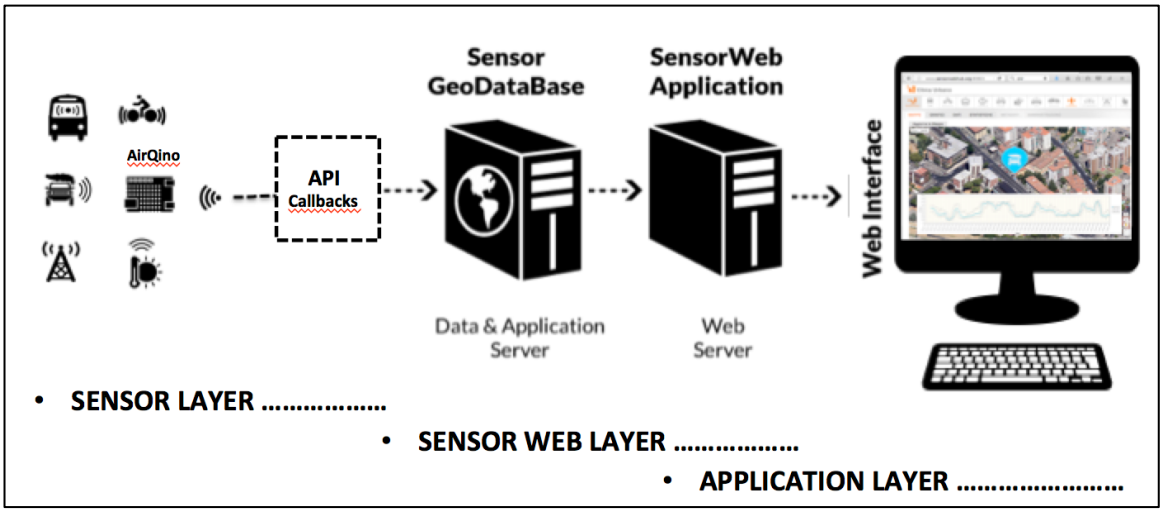

Figure 1 – SensorWeb Hub infrastructure components.

Specific web services were developed using JavaEE technology. They work as web service callback and reads all sensing data, performs a data quality check on Arduino devices and stores them in the GeoDB. Using PostGIS functions, the geographic information is transformed from NMEA RMC standard into point elements for PostgreSQL. UML (Unified Modeling Language) as formal language adopted in the ISO TC/211 (https://committee.iso.org/tc211) context for geomatic data description has been used for formal data model definition. The web interface and functions have been developed using J2EE technology with Java Server Faces and PrimeFaces library for GUI (Graphic User Interface) customization. Using any desktop or mobile browser, all collected data can be visualized in near-real time in table or chart format, or tracks, and spot values on a Google mashup.

Results and discussions

SWH's data and web services are now available at http://www.sensorwebhub.org/. The whole framework source code of underlying SWH application is deployed on GitHub platform at https://github.com/n3tmaster/SensorWebHub. At present, the platform manages data from field campaigns on urban climate monitoring, agro-meteorological survey and renewables energy related to the funded project at local scale. It is a work in progress initiative open to manage and sharing further raw data coming from different research projects. The infrastructure supports multiple research communities and individuals. The data, accessible through the web interface and also by standard web services (API and RestFul services), in the first instance are sharing within CNR-Ibimet research units (e.g. Geomatic and ICT, agricultural sustainability, air quality monitoring.) but could be downloaded also from other users (practitioners, students and external researchers) taking into account the recommendations in their proper use. SWH has multiple scopes and responds to different researchers' needs. From ICT & Geomatic point of view, it is conceived for implementing and testing interoperable OGC standards and RDIs reference models. The educational goal is to disseminate the best practices on data management and sharing and support the researchers in adopting RDIs guidelines in the life cycle of their research activities. It also facilitates the exchange within the research's team and offers easy solutions for a remote control of non-conventional environmental monitoring networks. Furthermore, SWH offers a real data set to develop customized web applications for a general public (citizens, farmers, decision makers students, developers). In addition, the adoption of interoperable web services facilitates data sharing and their reuse in order to enable real interdisciplinary innovation.

SWH infrastructure is designed to manage further Ibimet-CNR environmental data and services derived from advances in research in applied meteorology and climatology. The use of open source tools and standardized interoperable web services ensure sustainability in the development and deployment of web applications with geo-referenced data and customized territorial analysis that could be connected to other interoperable RDIs.

Lastly, the availability of an interoperable and open source infrastructure enhances both the timeliness and quality of information provided and offers a technical bridge that enables open sharing of data following the guidelines and principles of the research data infrastructure actions, under the umbrella of RDA (Research Data Alliance https://www.rd-alliance.org).

Bibliography

De Filippis, T., Rocchi, L., Rapisardi, E., 2015. SensorWeb Hub infrastructure for open access to scientific research data. Geophysical Research Abstracts, Vol. 17, EGU2015-7847-2, EGU General Assembly.

ESFRI 2016 Public roadmap 2018 guide dated 9th December 2016.
https://ec.europa.eu/research/infrastructures/index_en.cfm?pg=esfri. Last accessed 18/09/2017

Zhao, Z., Martin, P., Grosso, P., Los, W., de Laat, C., Jeffrey, K., Hardisty, A., Vermeulen, A., Castelli, D., Legre, Y., Kutsch, W., 2015. Reference Model Guided System Design and Implementation for Interoperable Environmental RIs, DOI:10.1109/eScience. 2015.41.