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Agile access to sensor network

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Abstract

The work in this paper aims at increasing the interoperability and improving accessibility of data provided by sensor networks. This way, this data can be employed by different devices and with diverse context requirements, such as specific location and time. To address this problem Geographic Information System (GIS) services, such as the Sensor Observation Service (SOS), in conjunction with Representational State Transfer (RESTFul) architecture are used. A standard-based solution that increases interoperability is presented. It also allows for a better integration of data already published in different semi-structured formats in order to be used by various platforms (web or mobile). Furthermore, this system adds value to original sensor data in order to assist in the decision making process.

Keywords: air quality sensors; meteorological sensors; heterogeneous sensor sources; RESTFul services; sensor observation services

1 Introduction

This paper describes a system for the processing of sensor data, the publication of these data as interoperable services and their interoperable access from multiple platforms. The goal of this work is to provide interoperable access to heterogeneous data formats coming from environmental sensor networks by using standards or agile interfaces for enabling its easy access. To achieve this, Open Geospatial Consortium (OGC) standards following the INSPIRE architecture [1] are used. INSPIRE should provide environmental data related to 34 themes, including transport networks, land cover and hydrography, INSPIRE provides important parts of the European contribution to a Global Earth Observation System of Systems (GEOSS).

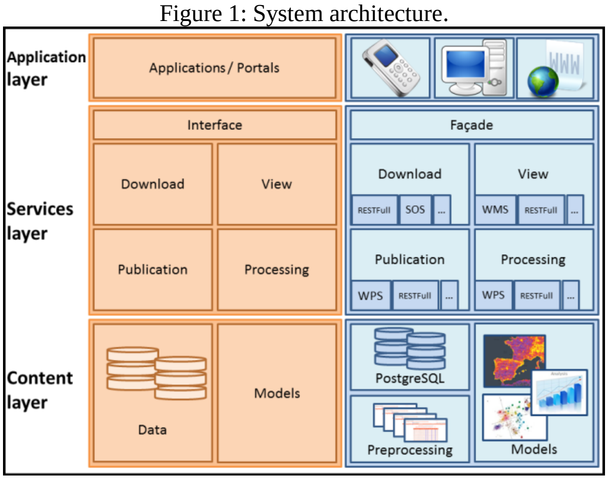
Standard format such as the Sensor Observation Service (SOS) are used. SOS provides a standardized web service interface that allows clients to access descriptions of associated sensors and their collected observations [2]. Other types of interfaces are provided which are capable of lightening the use of these data sources to be consumed by more restrictive devices such as mobile phones, although without compromising the interoperability standards. In this project an interface Representational State Transfer (RESTFul) has been used, following the principles of Internet of Things (IoT) [3].

Finally, this work is completed with an analysis models. A hotspot model is designed following Air Quality Index (AQI). For this model the OGC standard is used to process spatial data, Web Processing Service (WPS) [4]. WPS specification is generally defined to provide standard-based access to a wide variety of calculations of spatial data using web services. The use of WPS ensures service interoperability.

2 System design

The present system follows the INSPIRE technical architecture, which contains three layers [2]: content layer, service layer and application layer. At the top layer reside the users and applications (clients). At the middle layer reside all services that provide the required functionality such as accessibility and processing of data. The INSPIRE initiative guarantees interoperability in such systems.

Figure 1: System architecture.



This system operates in the three layers of the Spatial Data Infrastructure (SDI) architecture. In the content layer, it must perform a preprocessing to integrate different and distributed sources into this single system. In the services layers, the different sources are interrelated, (geo) visualizing and processing data to derive useful information by generating indexes or predictions such as pollutant concentrations in an area. In addition, our system should allow access to these services from any device that has Internet access, from a desktop, web or mobile application. In the application layer, client applications consume services provided by the previous layer.

Figure 1 shows the conceptual architecture of this system. On the left side, the conceptual view the system's architecture is shown. In the content layer, the data is found, obtained from different heterogeneous sensor sources. In addition scientific models are also found that they use to model and process the data. In the services layer, four different services are found as well as an extension of the functionality as recommended by INSPIRE; download service, view service, publish service and processing service. Finally, in the application layer, applications and portals for displaying information can be found.

On the right side of the figure, there is a more technological view of the proposed system. At the bottom, is the pre-processing module, where the system implements the preparation and integration of the information in different structures, such as databases.

Once the data has been processed, it is inserted into the database. The PostgreSQL databases are used. In this way, multiple data sources are integrated with different structures and characters, and are offered in a structured and interoperable way.

Different scientific models are defined, which are applied to process the data and derive required information: for example, view (heat maps), analysis (clustering), prediction or propagation.

The different services are deployed: data and processing Services, where published data and processes based on standard interfaces, such as, SOS, WPS [4], Web Map Service (WMS) [5] and other light-weighted interfaces, such as, RESTFul to implement data and map services. In order to develop a scalable and extensible system a pattern design is followed [6], to develop and expose components. The Façade pattern is used. It will be able to offer a single entry point for all services. The multiple interfaces are available through a façade component able to encapsulate the complexity of various interfaces to obtain entry to the same data to increase interoperability. The aim is to provide a variety of interfaces, without losing interoperability of GIS standards, to publish and consume sensorial data. This allows us to increase the variety of information received.

A RESTFul service is offered, to download sensorial data. This allows for a better management of the SOS interface [7]. In this way, a RESTFul interface is developed that encapsulates the downloading service.

Furthermore, the processing services are also deployed offering different interfaces for the same functionality in order to increase interoperability and better adaptation to the client applications.

The right side of the figure shows the interaction with the user via the client applications. In the first approach, and due to the increasing demand in mobile devices, a client application is developed and these services are provided with lighter interfaces for efficient communications.

3 Services

This section details the different services created for developing this system. As already explained, a RESTFul interface is created, this interface is adapted to the SWE services. Also, a SOS service and another service that returns the KML's are built. Finally, hotspot model is shown.

3.1 RESTFul services

As a first approximation to the accessing and downloading service, a service that implements a RESTFul interface is designed. A RESTFul interface is an architectural model that can be efficiently implemented as a combination of the Hypertext Transfer Protocol (HTTP) and TCP/IP. In addition, the RESTFul interface offers better access from any device, even from mobile phones [8], which have inferior technical features.

The RESTFul web service has been developed following the paradigm of IoT and more specifically Web of Things (WoT) .WoT is the evolution of IoT [9], which uses web standards such as RESTFul for implementation. In the concept of the WoT, web servers are embedded into everyday objects, where they were turned into "smart things" [10].

The RESTful enables access to sensor resources by Uniform Resource Identifier (URI). The service supports the listing of all sensors and the retrieval of their sensor data. Connected sensors are listed at the entry point of the sensor platform. The output format is JavaScript Object Notation (JSON). JavaScript Object Notation (JSON) has the advantage of being more compact than eXtensible Markup Language (XML). JSON is a lightweight text-based data exchange format; read- and writable by humans as well as parse and generate by machines [11].

Sensor data is returned when accessing the corresponding resource. The pattern of the URI-Scheme is defined as:

http ://<server>/<sensorId>/<method>

<server> the entry point of the sensor platform. It provides a collection of sensors which are attached to the platform.
<sensorId> refers to an identifier for a specific sensor. When accessed this resource should list a collection of all available methods applicable for this sensor.
<method> stands for the method of interaction with the sensor.

3.2 Sensor Observation Service

This system also provides an SOS interface which guarantees a standard interface capable of using sensor data in an interoperable way. The implementation of 52North (SOS version 2.0) is used. SOS has three core operations which provide its basic functionality: GetCapabilities, DescribeSensor and GetObservation.

3.3 Vector Sensor data format

Another RESTFul operation is designed that is capable of exporting the data in a Keyhole Markup Language (KML) file. This operation has 3 parameters, "date1" with the initial date, "date2" with the deadline and "comp" component to show.

The generated KML shows columns graphics for each sensor, and it shows a different color for the three defined levels: good, moderate, unhealthy for sensitive groups, unhealthy, very unhealthy and Hazardous (Table 1). These levels are defined following AQI, only for the components: O, NO2, SO2, CO and PMx.

3.4 Hotspot model

A model is created that classifies observation through AQI. This processing service is designed that is to be implemented as a standard-based processing service. This service offers one operation, which through air quality observation, classifies this value on one level (Table 1).

Table 1: Different levels of thresholds.

	AQ Index
Good	0-50
Moderate	51-100
Unhealthy for Sensitive Groups	101-150
Unhealthy	151-200
Very unhealthy	201-300

4 Use case: heterogeneous air quality and meteorological data sources

Two different data source are worked with in this process. One of them is the Valencia network of surveillance and control of air pollution[1], which is able to perform analysis of the air in real-time. Although in this article we focus on air quality in the Valencia network; we have also worked on data from the Meteoclimatic network.

Figure 2: **(a)** List of air quality stations. (**b**) last observation in map.

For a first prototype, an application for the Windows Phone OS has been created. Figure 2(a) shows a screen shoots of the mobile application where the list of all sensors and users can view information about station and historical observation. Figure 2(b) shows how the sensors are placed using a pushpin and user can see last observation about active pushpin.

The client offers the possibility to help to make decisions. The map view mode allows visualization of hotspots. A hotspot is considered when any measure exceeds a permissible level. So the thresholds that AQ Index establishes are taken. In the following table (Figure 3(a)) different colours for each contaminant level have been set.

In this way, when a component of a station has a superior level that its threshold, the pushpin is shown in the colour that it has defined in the table (Figure 3(b)). When you click on the pushpin, the colour of the component value appears in the colour that corresponds to the measured level.

These points can help to make a decision, for example: route planner. This way, it is possible to obtain a route that is far from any hotspot.

Figure 3: **(a)** different levels of thresholds and. (**b**) map with hotspot

	Color	Push pin
Good	Green	
Moderate	Yellow	
Unhealthy for Sensitive Groups	Red	
Unhealthy	Red	
Very unhealthy	Red	

a)

b)

5 Conclusions

At present, there are many data sources about sensors, but they have a problem, they contain heterogeneous data. An important challenge is to increase the interoperability of this data sources. In this paper a service-oriented architecture is proposed to implement an application, which orchestrates a workflow for the management of heterogeneous data formats provided by sensor network. A system that aims at the integration of unstructured data sources with different character is proposed, and which offers them in a structured and interoperable way. In addition, the service layer in our application is enhanced with a module that implements the design pattern façade, and acts as a "middleware" between the client and the services to increase interoperability by implementing several interfaces and helping users to get information easier.

This is a recent and ongoing research project and there are still questions to be answered and tasks to be implemented in the future, such as, the addition of new sources of information, the development of the middleware (façade), whether to increase the interoperability of the services, the addition of the processing models to communicate more sophisticated information to users, such as display of not only measured

[1] http://www.cma.gva.es/web/indice.aspx?nodo=4581&idioma=C

sensor values but also simulated values to run news propagation and prediction models...

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