Spatial data infrastructures empowered by interoperable volunteered geographic information

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Abstract

This contribution discusses the role of SDI for creating and sharing VGI on the Internet. Some guidelines are drawn to adopt an open and integrated SDI framework to manage and share VGI and heterogeneous multisource geospatial information, thus achieving interoperability among different information sources and thus making it possible a wider fruition of the information available on the Web.

Keywords

Spatial data infrastructure (SDI), Smart application, Volunteered geographic information, Geospatial data and metadata, Interoperability.

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Introduction

Interoperability is a cornerstone in a modern Spatial Data Infrastructures (SDI) that is particularly attractive when data sources are distributed and heterogeneous.
Heterogeneous multisource information may comprise authoritative information, certified by local or national organizations in charge of providing a specific theme to the public, and nowadays also Volunteered Geographic Information (VGI) freely created by citizens (Goodchild, 2007). VGI can be in the form of free texts, pictures and classification categories and is associated with the geographic coordinates of the place where it is created, named geo-reference.
Until recently the exploitation of VGI by web applications has been prevented for the difficulty of integrating the VGI with authoritative geospatial-data. This is due to the lack of VGI applications compliant with standards to publish on the Web and to access the created information. Applications platforms for the creation of VGI are generally closed worlds. To see and analyse VGI often there is no other alternative than accessing the application geoportal, thus preventing the possibility to correlate the created information with both VGI by other applications, and authoritative geospatial-data relative to the same territory.
In this contribution, we propose an interoperable VGI management framework based on an Open Geospatial Consortium (OGC) standard SDI that allows integrating VGI, created by heterogeneous applications, possibly installed on smart devices, with other geospatial-data.
Our pilot solution consists in defining a layered framework which allows publishing VGI on the Web by means of OGC standard geospatial-services. With respect to current practices, this approach offers the advantage of viewing and analysing the created VGI by any geoportal compliant with

OGC standard Web services. One could then access to distributed heterogeneous geospatial-data, comprising several sources of VGI, through a single access point.

The interoperability problem of VGI

The Global Earth Observation System of Systems (GEOSS) and the European Infrastructure (INSPIRE) (EU, 2007) describe the architecture and components for designing and implementing interoperable SDIs based on a top down approach (Nativi *et al.*, 2011).
On the other side, VGI is characterized by the absence of standards for data management, deployment and retrieval. This deficiency has caused the creation of ad hoc approaches and consequently of great heterogeneity of VGI – both in semantics, formats and contents.
VGI integration with scientific and authoritative geospatial data provides a collaborative complementary view of the reality that deserves the definition of best practices and standard approaches (Craglia, 2007). Several proposals have been defined to access from an OGC standard SDI several sources of Web 2.0 data from social networks (Nuñez *et al.*, 2011; Diaz *et al.*, 2012). These approaches face the problem of integrating existing VGI in a standard SDI framework while do not consider the problem of defining best practices for creating a crowdsourcing framework and platform with related services that deploy interoperable VGI directly, as we propose in the following section.

Interoperable VGI creation and management

The problem of interoperability of Web services providing access to GI is very up to date as testified by the OGC Cross-

Community Interoperability initiative (CCI) (CCI, 2015) that investigates the role of domain ontologies and tools to create, assemble, and disseminate VGI. Specifically, the initiative suggests the creation of ontologies to define the shared vocabulary used to model a domain; the extension of the use of OGC services and standards for VGI deploy and access; the expansion of gazetteer functionality to include gazetteer conflation; and the management of the uncertainty of VGI.

In line with these ideas, we pursue both the adoption of ontologies to normalize VGI contents, OGC standard Web services to publish and access VGI, and conflation of the geo-references of VGI in order to cope with ambiguities and imprecision of the VGI geo-reference. Figure 1 depicts the architecture of the proposed framework for Interoperable VGI management.

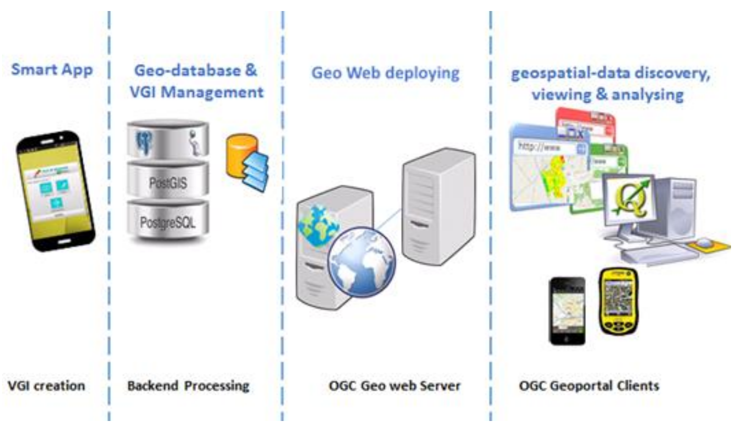

Figure 1 - SDI framework for interoperable VGI creation and management

One can observe that the architecture comprises four main layers defining process environments that communicate only with the adjacent layers by exchanging standard protocols

(Kliment *et al.*, 2014). Each process environment may reside on a distinct hardware or virtual machines, and may consist of several specific software components. From left to right we have the VGI creation environment layer, consisting of a smart application installed on a Smart device. It allows creating VGI items comprising both text, images and categories selected from a domain ontology and a punctual geo-reference that can be automatically detected by the GPS and possibly manually modified by moving the pin on the map to a different desired location. The VGI storing and management layer on the one side sends/receives data from the Smart App, process it to cope with ambiguities of VGI geo-references and stores it into the geo database, and on the other side it answers standard SQL/Spatial queries received by the geo web server environment layer. To resolve ambiguities of the VGI geo-references, external knowledge on the entities of interest is used provided in the form of a conflation layer that represents the spatial objects to which the VGI items must be associated on the basis of their punctual georeference. The geo web server environment layer, comprises a GIS Web server (e.g. Geoserver), that periodically deploys on the web the VGI items stored in the geo data base in distinct layers (a layer for free text and image VGI, one for categorical VGI, and one layer for each Volunteer role) and answers OCG standard requests submitted by the external rightmost layer for both maps (WMS) and features (WFS) and a Catalogue server (e.g. Geonetwork) that deploys metadata extracted from each VGI item to enable discovery (CSW). Indeed, the rightmost layer may be considered outside the proposed framework, since any OGC standard geoportal can access and display the VGI geospatial-data by submitting WMS –(T) and WFS requests to the geo web server, such as QGIS.

Conclusion

The proposed framework allows creating, describing and managing VGI in a consistent and interoperable way for target application contexts by employing ontologies to normalise the information and conflation techniques to deal with ambiguities and imprecision of the geometric dimension of VGI. The normalized descriptions constitute the basis of a semantic approach for dealing with VGI that will facilitate the querying and the correct interpretation of VGI provided. In such an approach authoritative GI and VGI are managed and shared in a consistent way, thus realizing full interoperability.

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