INTEGRATING USER-GENERATED INFORMATION FOR EMERGENCY MANAGEMENT

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KEY WORDS: Distributed geoprocessing, User generated information, Standard OGC Services, Spatial Data Infrastructures, emergency management.

ABSTRACT:

Geospatial technologies have evolved to offer users the functionality of data access and to model development to generate information. Nowadays Spatial Data Infrastructures represent the SOA paradigm in geospatial terms offering a set of interoperable distributed components to access, visualize and process data forming the Geospatial Web. Fostered by the European directive INSPIRE many public and private organizations keep on creating and publishing these geospatial data and tools through open services with standard interfaces to manage environmental information. Although the benefits of doing this are high, they are sometimes overcome by the efforts of implementing, configuring and maintaining these standard services. On other hand information technology and the Web are evolving to more collaborative environments through social networks forming what is being called Web 2.0 which purpose is actually to publish and share information, that is, in fact, the same goal as the Geospatial Web is pursuing. While the Web 2.0 is providing users with simple and easy interfaces with centralized infrastructures in which are exponentially adding content, Geospatial Web offers users a set of complex interfaces to maintain interoperable Geospatial Web Services. What we propose in this paper is Web 2.0-principles-based mechanisms for the current Geospatial technologies to facilitate and speed up the sharing of geospatial resources. We propose mechanisms to wrap user generated information and tools generating automatically standard services hiding the underlying technology. The availability of this information through standard services improve data and system interoperability providing rapid ways to access these data improving decision making during disaster and emergency management situations.

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1. INTRODUCTION

The number of environmental disasters that cause loss of life and property has increased in the last few years (EM-DAT, 2009, the forest fires in Spain has got a increase tendency in the surface affected by wildfire (Ministerio de Medio Ambiente, 2005), therefore emergency management and environmental protection have been recognized internationally as key challenges in the coming years (IPCC; INSPIRE; GMES; GEO, 2005).

Decision makers rely strongly on geospatial technologies to manage, organize and exploit efficiently geospatial resources scattered among numerous agencies and in multiple formats for managing disaster emergencies (Phillips et al., 1999). Geospatial technologies can be used to prevent disasters improving the monitoring of hazards through development of observation systems, integration of multi-source data and efficient dissemination of knowledge to concerned people (Nayak and Zlatanova, 2008).

The use of accurate and up-to-date geospatial information is a crucial aspect to understand the context of these environmental applications used in emergency situations (Mansourian et al., 2005; Zlatanova et al., 2006; Rocha et al., 2005). Therefore a key task in environmental research is to access the right data at the right time from remote repositories. Current research trends for discover and access geospatial resources are being addressed by deployment of interconnected Spatial Data Infrastructure (SDI) nodes at different scales to build a global spatial information infrastructure (Masser et al., 2008; Rajabifard et al., 2002). This net of SDI nodes acts as a backbone on which spatial resources are shared, accessed, and discovered to suit practically mostly user needs in multiple application domains (Bishop et al., 2000; Davis et al., 2009; Vandenbroucke et al., 2009).

Our viewpoint has been to consider environmental applications as distributed applications deployed on top on SDIs, because of the need for connection of systems at different scales, taking advantage of the inherent characteristics of the SDIs: standard interfaces, standard metadata, and well-known specialized services.

Operational SDI nodes require technological capabilities (skilled personnel, geospatial technologies and tools, etc.) for regular maintenance due to their dynamic nature (Mansourian et al., 2005). These capabilities are not available in many cases in most agencies and institutions. These missing details provoke a lack of rapid ways to share crucial information with other stakeholders and put many impediments to rapid availability and visibility of geospatial resources. This is affecting negatively to certain domains like emergency management where time is an important issue and speed must be prioritized over quality (Zlatanova et al., 2006).

In this work we address some of the issues related to the generation and publication of user information to make it more visible and available. Our contribution is three-fold: (i) defining an architecture base on INSPIRE principles in which to deploy distributed applications, used to generate new information by means of standard services, (ii) providing mechanisms to assist users to wrap resources (information and tools) generating and publishing automatically standard web services in SDIs and (iii), as pointed in the literature, metadata and catalogue services are key in SDI in order for resources to be properly and efficiently discovered (Craglia et al., 2007; Nogueras et al., 2005), we propose mechanisms to improve visibility by generating metadata and publishing them in open catalogues. We will illustrate this with a prototype which provides a proof of concept in a forest fire danger mapping use case.

2. MOTIVATION

The European Commission and the Member States look for suitable and efficient ways to prevent and avoid fire impacts. Forest fires analysis requires the development of information systems, datasets and services which could interact and communicate with each other. The use of applications and available computer tools combining different sources can increase the quality of the analysis and predict the spread of forest fires in an attempt to prevent or reduce major loss as well as damage to the environment.

One common requirement of all stages of the emergency response cycle is to inform decision makers with tailored output. (Brunner et al, 2009). In the case of wildfire emergency; getting the information faster than the spread of the fire is a key issue, good availability of the information in the first stages of event is very important. The information should be quickly and easily accessible and presented in an appropriate way to ensure the understanding of the situation (Almer et al, 2008).

The fact of working with distributed applications increases the interoperability by means of standard services but the distribution of the information and the processes in different sources and applications, has made the task of discover and process the data an arduous work. Having all the processes predefine in advance and the data publish in a SDI, will enhance the information delivery regarding to the forest fires behavior in the next hours. (Scholten et.al., 2008)

The spatial information regarding the forest fires is not only generated by the state or regional governments, also the municipalities are generating spatial information. The processes used in this analysis and their results (user generated information) are not published in the SDI, and during a wildfire the information is not accessible for the forest fires managers. To publish the information is necessary to have some knowledge of traditional SDI services, and normally local authorities do not have this knowledge on the house, remaining the generated information unpublished in an open SDI. Providing these technicians with tools to automatically generate the services to publish the information will increase the availability of this kind of information through standard services improving the interoperability can help decision makers to access it and plan better the immediate actions.

3. RELATED WORK

The wrapping of data as web services to achieve interoperability and reusability is described in many works (Fileto, 2001; Díaz et al.,2009), where they describe several approaches for data integration over the Web like the common wrapper techniques (Roth and Schwarz, 1997) and standards for exchanging geographical data among systems (Albrecht, 1999).

Many works describe SOA-based architectures to support the sharing of geospatial resources (data and tools). The use of client-server model in web mapping applications or the distributed GIS approach to SOA-based applications represented by the SDI paradigm, in which standardized interfaces are the key to allowing geospatial services to communicate with each other in an interoperable manner responding to the true needs of users is an alternative to desktop or locally networked GIS applications because it functions across the boundaries between diverse organizations, stimulates the use of standard formats and exchange protocols, and permits the distribution of geospatial functionalities to relevant user (Foster, 2005; Friis-Christensen et al., 2007; Kiehle et al., 2006; Alameh, 2003; Yang et al, 2008; Brunner et al, 2009;Fook et al, 2009, Friis-Christensen et al., 2009; Granell et al, 2010).

Fook et al (2009) describe a geoweb architecture to share models and modelling results. Although some of them talk about the sharing of the geoprocessing results, none talk about the automatic generation of standard services to deploy these results.

Within the category of geospatial data processing works relevant to emergency response, Brunner et al (2009) describe a system to provide distributed geospatial processing to support collaborative and rapid emergency response, storing results in public data bases, they also propose as future work the implementation of relevant standards as OGC Web Processing Services (WPS) (Schut, 2007).

Regarding the availability and reuse of user generated information in environmental applications, (Rocha et al., 2005) report how MEDSI uses OGC (Open Geospatial Consortium) Web Services to provide and manage geospatial information, creating crisis centres with geospatial services that are accessible in an out of the crisis centres. In (Abdalla et al, 2007) the authors present a case study to demonstrate the utility of interoperable web services for disaster management discussing the strengths and weaknesses of leveraging GIS interoperability.

Our work describes an architecture to deploy distributed application on top of SDI by wrapping geospatial resources using the OGC standards. In contrast to previous works, our approach improves these scenarios by increasing availability of user generated information not in the form of documents but through standard services that can be consumed in other scenarios.

In emergency management context, the Andalusia regional government (("La Junta de Andalucia") has developed a system, named SIGDIF (de Sarriá et al, 2007), to manage forest fires emergencies. The SIGDIF system contains a couple of subsystems. The first subsystem performs simulation tasks for forests fires based to compute different data layers coming from the data base of the "Junta de Andalucia". On the other hand a second subsystem handles the availability of the forest fires units, and human resources involved in forest fire. Another example of forest fires management system is the SIGIF from the "Generalitat Valenciana" (López and Poyatos, 2007). This system focuses on the prevention and surveillance of forest fires. The system allows a decentralized access to the spatial data, including fire simulation and location of the forest fires
These systems at local level, both SIGDIF and SIGIF describe the use of OGC standards to publish spatial data, moreover they do not allow collaborative participation of user, in terms that they are close, internal systems, not openly available to external users nor to add or share new user generated information.

4. ARCHITECTURE

In previous works (Díaz et al, 2008; Granell et al, 2010) we described how to execute distributed applications on top of SDI, in this work we describe the basic modules of an architecture in which, on one hand, distributed geospatial applications can be deployed and, on the other hand, we can include mechanisms to wrap user generated information, generating automatically standard services, to increase its availability.

We have built a conceptual architecture that aims at deploying distributed environmental applications and improving the availability of user-generated information based on the INSPIRE technical guidelines. This SOA-based architecture, is composed of three layers like defined by INSPIRE. Figure 1 outlines the three-layer architecture that contains the minimum number of modules that we consider are necessary to run distributed application on top of SDI.

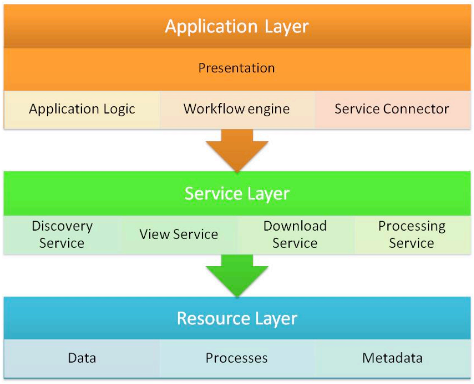

Figure 1 Conceptual architecture for distributed environmental applications

4.1 Application Layer

The application layer contains the user interface (shown as *Presentation* in the Figure 1). Distributed applications can differ in their presentation nature from a desktop application to Web Geoportal. The second sub-layer is composed of the *Application Logic*, the *Workflow Engine* and the *Service Connector* modules. The *Application Logic* module implements the functionality of the application itself. In distributed applications the *Workflow Engine* implements a service-chaining mechanism and therefore there is a need to have the *Service Connector* module to be able to connect to these remote services. The *Service Connector* implements the interfaces to access to the services placed in the service layer. In our case, if the INSPIRE implementing rules recommend to implement geospatial services according to standard OGC interfaces, the service connector has to implement the client side of this OGC interfaces.

4.2 Service Layer

The core of this architecture is the service layer, where the services reside according SOA principles. These services, based in INSPIRE Service types provide the capacity to discover, access and process data to generate and extract the desired user information. Here we emphasize the need of following INSPIRE implementing rules for the INSPIRE service types, so that the Service connector will be able to connect to available services, increasing the interoperability of our system. The services connect to the data layer below to provide to the applications the required resources, thus acting as resource wrappers and mediators offering standard interfaces (Wiederhold 1992), providing the system with syntactic interoperability (Sheth, 1999; Bishr, 1998; Díaz et al, 2009).

4.3 Resource Layer

The resource layer contains the geospatial resources stored in their original formats. Resources, in this case, are data, processes, metadata, etc.

5. SYSTEM OVERVIEW: SHARING USER GENERATED INFORMATION FOR EMERGENCY MANAGEMENT

Geospatial information systems should fulfil basic requirements like data exchange using OGC standards, efficient data management, different communication channels, support textual and geo-data visualization, friendly user interfaces, to support the needs of a crisis management (Almer et al, 2008). In this context the success factor of web services technology has permitted to promote service integration and interoperability among distributed information sources. SDI, as the GIS approach to (SOA) offers the possibility to access distributed spatial data through a set of policies, common rules and standards that facilitate interconnecting spatial information users in an interoperable way.

We present an extended architecture (Figure 2) in which to deploy these kinds of distributed applications and share resources. To ensure that these resources are interoperable through open, community consensus standards (Yang et al, 2008) we provide mechanism to wrap this resources as OGC services. The issue at this point is how we share new generated information. Our approach is to serve this new information through the services available in the service layer. Another issue is who is doing this.

Many of the stakeholders involve in emergency management make use of the geospatial processing to generate information, the fact is that not all them have the knowledge to deploy new this information as a geospatial services. Traditional SDIs don't offer mechanism for public participation or even easy mechanisms to deploy new information. Figure 2 shows our proposed architecture with mechanism to assist users to share their information. Close to Web 2.0 principles where technology is hidden and any user is potentially able to add information to be shared by other stakeholders. Another peculiarity of our approach is that this user generated information will be shared by being published in standard OGC services. Thus, these resources are available to different users in an interoperable way.

As we can appreciate in **Error! Reference source not found.** 2 we have extended the architecture with a new module called *Service Framework*. This new module implements the functionality of wrapping resources as standard services compliant with the INSPIRE directive

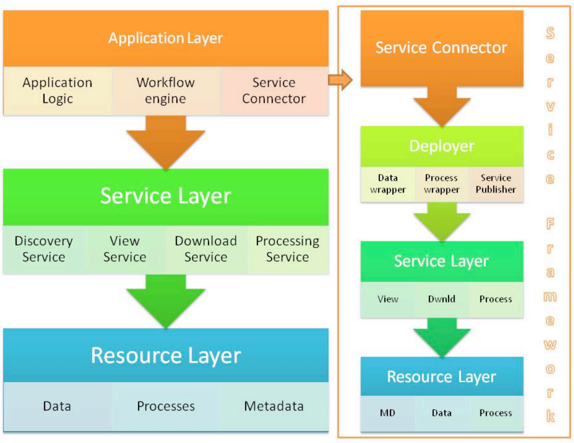

Figure 2. Extended architecture for sharing user generated information

This new module contains the mechanisms for improving availability and visibility of geospatial resources. The *Service Framework* is split in several layers. First and at the same level of the application layer of our proposed architecture we find the *Service Connector* which is the module that will integrate this functionality in any distributed application.

Second we can see the *Deployer* which could be placed at the application level as well. The *Deployer* is composed of three modules: *Data Wrapper*, *Process Wrapper*, and *Service Publisher*. The first two, the Process Wrapper and Data Process modules, implement the functionality to assist users in wrapping data and tools respectively as standard services according with INSPIRE implementing rules (availability). The third module, the Resource Publisher module, aims at creating service metadata and publishing them in service catalogues (visibility). The Service Framework deploys the new resources in a standard service, under its control and places the resource itself in a central repository at the resource layer that is under its control as well.

We focus here in the Data Wrapper Module which provides the functionality to generate standard services to publish user generated information. Figure 3 shows the Service Framework in detail. In order to share generated information, any stakeholder in an emergency scenario could access the service Framework through a client application, as we showed in the architecture, Within the Service connector the Web Processing Connector assists users to connect to OGC WPS and execute a geospatial process. The result of the process is sent to the ServiceDeployer where the dataWrapped connector publishes this new information as an standard service. The Open Geospatial Consortium (OGC) has published several standards for services: The generated information is deployed in services with interoperable interfaces, such as WebMapping Service (WMS; de La Beaujardiere 2004), Web Feature Service (WFS; Vretanos 2002), and Web Coverage Service (WCS; Evans, 2003). Later on other, any other stakeholder can access this information by means of these standard standards services.

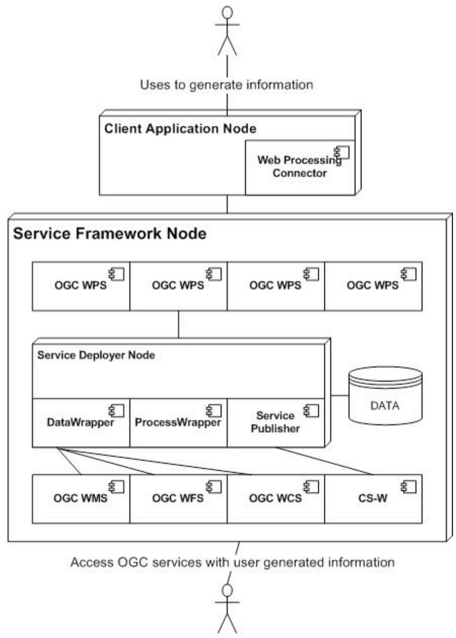

Figure 3. Service Framework node and components diagram

6. USE CASE ON FOREST FIRE RISK MAPPING

In this section we describe our approach illustrating with a use case to share user generated information regarding forest fire danger. This information will be used in decision making when a fire ignition is located.

Once the fire began, the Forest fire danger process (methodology from PEGOF) is defined as the facility of a forest system to spread the fire, and depends on three factors (see Figure 4): , combustibility, slope and weather conditions. The combustibility is the capacity of a forestry system to burn, depends closely on the combustible models used. The slope is the terrain part necessary to get the forest fire danger. Finally, t .current weather conditions such as temperature, humidity and wind, which can be either real measurements or forecasted. Moreover the weather conditions can be use to create a set of synoptic conditions for forest danger maps.

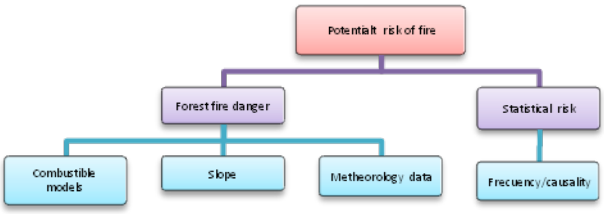

Figure 4. Potential risk of fire mapping process

When a wildfire is discovered and located in the Forest Fire Danger Map, the fire is classified into a level of potential danger, which estimates the amount of resources that should be put in place at the ignition point.

The use case scenario is about sharing information between users acting as consumers but also as providers. Imagine a local authority that has to generate forest fire danger map. These maps come in pdf format, generated by a GIS desktop application. In case of forest fire ignition in the municipality, these maps (pdf documents) are difficult to be discovered by forest fire decision makers, and even if you have access to them many issues arise, like difficulties to review and interpret and incompatible data format with other systems.

To overcome these limitations, and by using the architecture and the mechanisms described in the previous sections, the local authority generates the map by accessing and executing an standard OGC WPS in the service layer of our architecture, the ServiceFramework by means f its component the DataWrapper would assist the user to wrap this map as a available layer in a OGC WMS. This process is transparent to users since no knowledge of WMS publishing and settings are required. In a later emergency another stakeholder could easily discover the published map. Moreover the results of forest fire danger mapping process can be reuse into the potential risk of fire mapping process.

7. CONCLUSIONS

In many environmental domains like disaster management, and mostly in the first phases of an emergency even, an effective access to resources is vital. Creating mechanisms to helps users in automating the standardization and deployment of interoperable resources speeds up this access.

The added value of deploying standardized components well-documented and registered in open catalogues is that they can be potentially reused in other similar scenarios, in contrast to the tendency of building system for a specific type of disaster (Zlatanova et al., 2006).

We have described a methodology that assists users to wrap user generated information as standard services according to the INSPIRE directive increasing the availability of this kind of resources in a distributed way.

The fact of increasing the availability of user generated information by automatically wrapping OGC WPS results as other standard services like OGC WMS and OGC WFS brings out many issues like for instance that there is no simbology created for the maps that will be rendered by the OGC WMS. This automatic manner is a quick way to expose user information as standard services which is important in situations where time is critical like in emergency situation. However in other cases where we need more detailed descriptions of the published information, manually generation of services should be considered.

We have talked about increasing the availability of these user information and we have described the reached interoperability at this level, but we should remark that we talk about the syntactical interoperability and advantages reached by using OGC standard recommended by INSPIRE. At this point we should empathize that interoperability goes beyond fulfilling these syntactic premises. We have no considered any semantics about the information exposed or the metadata of the services their selves

8. ACKNOWLEDGEMENTS

This work has been partially supported by the European project EuroGEOSS and by the CENIT España Virtual project through the Instituto Geográfico Nacional (IGN).

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