A 3D WEB BASED GEOGRAPHICAL INFORMATION SYSTEM FOR REGIONAL PLANNING

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Abstract: Managing a territory through web based Geobrowsers requires very interactive and scalable architectures, capable to access vast scale repositories and capable to provide real-time behaviour. This paper illustrates a web-service based infrastructure developed by Graphitech to access geographical information of environmental interest. The paper shows that a 3D Geobrowser, deployed as a web-start application, is used to access a variety of different remote repositories containing a wide range of geographical information at a regional scale. Each user can interactively navigate within the 3D environment and can also interactively send real-time information on environmental features using GeoRSS technology. The paper illustrates how the resulting system is currently in use by an urban planning authority during their daily activities.

1 INTRODUCTION

The process of planning and managing a territory requires a deep understanding of a very large territory, of its problems, evolution and resources. Traditionally this process was carried on with the use of paper-based maps and more recently through the use of GIS (Geographical Information Systems) systems.

The availability of Web-based Geographical Information Systems and more specifically 3D Geobrowsers such as Google™ Earth (Google, 2007), Microsoft® Virtual Earth™ (Microsoft, 2007) or NASA WorldWind (NASA, 2007) has extended the domain of GIS-based application to the web. This has brought to a radical breakthrough in the daily workflow of planners and administrators. In fact the use of geobrowsers has made it possible to use Geobrowser as a new generation of easy to use yet powerful planning tools as they give operators the possibility to interactively access vast amount of territorial data in a very interactive and effective manner.

3D Geobrowsers are today used by a number of administrations both as a working tool (Tang, 2003) and as a platform to make geographical data publicly available to the entire community (PAB, 2007).

The nature of data accessed by Geobrowsers is traditionally static as in most cases Geobrowsers render only static information such as orthophoto, vector data (e.g. streets and houses), as well as 3D objects, (e.g. buildings and trees), which are extracted from a database. However access to real-time data can be of crucial importance in contexts such as emergency planning and management, traffic management etc.

The recent availability of GeoRSS has helped filling this gap by extending the real-time nature of standard Really Simple Syndication – RSS (RSS Advisory Board, 2007) feeds to the geographical context.

This paper shows how the use of GeoRSS has been implemented within an interactive 3D web-based Geobrowser to allow users and operators to distribute information to the wide community of users. The results of the system are illustrated within a real life scenario.

2 THE IMPORTANCE OF REAL-TIME DATA

Access, distribution and processing of real-time Geographical Information (GI) are basic preconditions to support the process of environmental decision-making (De Amicis, 2007). The heterogeneity of information on the environment today available is driving a wide number of initiatives, on both sides of the Atlantic,

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which advocate the strategic role of proper management and processing of real-time or quasi real-time environment-related data within a harmonised web-based IT infrastructure designed to better monitor and manage the environment.

This is proved by several regulatory actions within the international stage, such as the recent INSPIRE directive (INfrastructure for SPatial InfoRmation in Europe), approved by the EU and in force since 15-05-2007 (JRC, 2007). INSPIRE will enforce to member states the creation of a highly interoperable, web-service-based, Spatial Data Infrastructure (SDI), based on ISO and OGC® - Open Geospatial Consortium standards (OGC, 2007) to better support environmental monitoring and planning.

Other initiatives of relevance within the European context have been promoted by the EEA (European Environmental Agency) which plays a major role promoting sustainable development at the EU level through the Environmental Action programs. Most notably EEA contributes to EIONET - European Environment Information and Observation Network (EEA, 2007) to support the collection and organization of environmental spatial data. Further EEA supports EEIS (European Environmental Information System) as well as SEIS (Shared Environmental Information System) to produce and manage software components which will contribute to the forthcoming creation of a web-service based ESDI (European Spatial Data Infrastructure). The importance of environmental monitoring is also emphasized by the other major initiatives such as the Global Monitoring for Environment and Security (GMES, 2007) which represents the EU initiative within GEOSS (Global Earth Observation System of Systems).

3 STATE OF THE ART

Within the scientific community the importance of interactive with 3D environments for environmental planning applications has been stressed by different authors (Bishop, 2005). Access of real time data is essential to environment and risk management (Laurini, 2005). To this extent a number of international initiatives have tried to reach a mature standardization level for real-time environmental data. Most notably OGC® has proposed the first version of the standard called SensorML (SensorML, 2007), thought to support real-time sensor data.

Quite recently RSS (Really Simple Syndication) has been recently extended in an effort to use the concept of feeds within a geographical-aware context. GeoRSS was thought to add geographical dimension to simple RSS XML based messages capable to contain information related to an event and related data such as author, title, text, abstract etc.

At the moment three versions of GeoRSS exists:

- the W3C version, supporting geo-referenced points
- the so-called Simple GeoRSS, supporting heights and areas
- The GeoRSS GML also known as Pro GeoRSS a further extension supporting geometrical content through formalization in GML mark-up language (GML, 2007).

None of them has reached the full status of a mature standard.

4 THE APPLICATION SCENARIO

The work presented emerged from a precise requirement emerging from the local public administration. This required a client-server software infrastructure to be used by technicians, engineers, administrator to access the vast geographical dataset which constitute the latest Urban Plan of the provincial of Trento in Italy. The project, which has been commissioned by department of urban planning, has brought to the creation of a set of web based services, available throughout the public network of the provincial offices, to access and interact with geographical information.

From the technical point of view the project has brought to the development of a client-server architecture where several 3D Geobrowsers access in real-time a number of repositories containing the geographical data. The architecture of the client application has been based on the WorldWind libraries from NASA which have been extended to cope with the specific requirements of the provincial authority. The server applications have been developed with the aim of creating a very fast infrastructure capable of serving a large amount of clients at very high speed.

For this the project has brought to the development of a set of classes capable to pre-process and compress the data available from the provincial plan according to an optimized data structure which is then sent via the network and then used by the client application.

The main challenge of the project was set by the sheer size of the dataset to be accessed by operators. In fact the urban plan covers the entire province territory, one of the widest in Italy, with a total surface of 6.200 square kilometres at very high resolution yielding several hundreds of Gigabytes of data to be made accessible over the web. In fact the base for the visualization of the territory is an orthophoto with a resolution of 1 pixel per square meter, covering the entire surface of provincial territory. Further geographical information is structured in more than 130 layers dealing with a number of different themes such as:

- Data of environmental interest, such as protected areas, hydrograph information, natural parks, natural reserves, lakes, skiing areas, agricultural areas, glaciers etc.
- Data related to infrastructure, such as power lines, streets, layers, airports, sewage etc.
- Data of interest for urban planning, such as public infrastructure, administration borders, areas to be used for dwelling, industrial areas etc.

5 TECHNICAL DEVELOPMENT

The work presented in this paper has followed a service based architecture (see Figure 1) and it has been completely developed in Java on both client and server side, thus ensuring maximum portability.

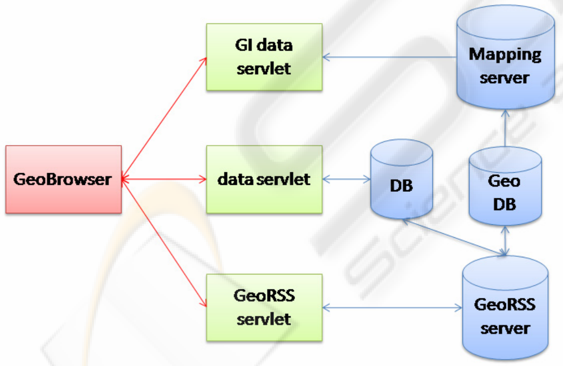

Figure 1: The system architecture.

The client application, which makes use of the WorldWind libraries (NASA, 2007), has been deployed as a Java Web Start. This way operator can start the application with no need for installing any specific software.

As shown in Figure 1 as soon as the application is started this starts to make a number or requests to a set of server-side application deployed as servlets. These are capable to provide access to a wide range of data necessary to administrators and planners to operate ranging from vector data, to geo-referenced images to GeoRSS feeds.

Specifically, requests include standard Web Map Service (WMS, 2007), in order to access imagery of the territory as well as rasterized geo-referenced vector information (see Figure 2). The data is requested to the repositories through WMS calls which are received by a servlet which takes care of forwarding the request to the relevant repository and back to the client. The servlet responsible to manage the repositories has been developed in order to pre-process geographical data rendered by a standard UMN map server (UMN, 2007) at multiple level of resolutions, to compress it and to store it as binary within an optimised data structure at the server side.

Pre-processing of static imagery provides a very consistent increment, in terms of performance, if compared with direct queries to a map server. Benchmarks have shown how the developed architecture is capable to return geo-referenced images as result of a WMS query more than ten times faster than relying on standard UMN map server to resolve WMS requests.

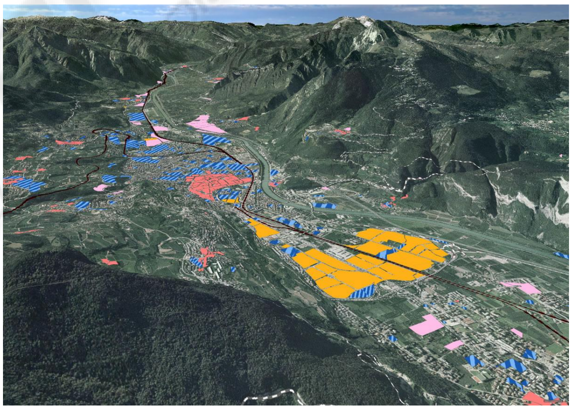

Figure 2: A view of showing images of the territory and rasterized vector information.

Several operators at the same time can thus use client applications to access a number of different repositories containing the data relative to the urban plan of the entire Province.

Furthermore it is possible to manage the history of the development of the territory by providing access to previous edition of the urban plan. This becomes an extremely useful feature as it allows both versioning of different planning choices as well as overlapping of different planning solutions.

This architecture, currently being used by the planning department in their daily activities, has been further extended to support access to real-time data by using GeoRSS feeds.

Several factors have brought to the choice of using GeoRSS. First GeoRSS feeds, for their very nature, are an ideal technology for syndication that is to distribute information to a wide range of users through different means. The main advantage of GeoRSS is therefore to facilitate re-distribution and widespread access to data through a subscription-based approach.

For this the client functionalities have been extended to allow user to interactively create a new real-time event by generating a new GeoRSS feed. This is done by selecting the proper option on the GUI and by clicking on the position within the 3D scene where the event is localised. The user can then add textual information on the nature of the event.

Further taking advantage of the GeoRSS support for GML geometries the user can send also other geometrically-related information. As illustrated in figure 3 the created GeoRSS feed in fact can contain further XML geometrical description of geo-referenced geometrical content described as GML - Geography Mark-up Language (GML, 2007).

Figure 3: The logical structure of the GeoRSS GML feed generated by each user.

This allows sending geometrical geo-referenced data to users with the textual information specified within the RSS content tag. As a result the user can draw geometries directly within his/her web-based Geobrowser.

As illustrated in Figure 4, a polygon can be drawn directly within the 3D scene thus identifying areas characterised by a certain feature, for instance showing the presence of pollution or road congestion. The region of interest can be either directly sketched within the 3D scene, retrieved from a geo-database or simply loaded through a shape file.

The importance of operating directly within a 3D environment is essential as the nature of layout of the terrain can have profound impacts on planning activities (for instance when planning a new road).

As soon as the geometry is confirmed the user can submit the feed with associated description and geometry which is then sent to the central server (see Figure 1). Here the feed is processed by a servlet which in turn stores it within the database.

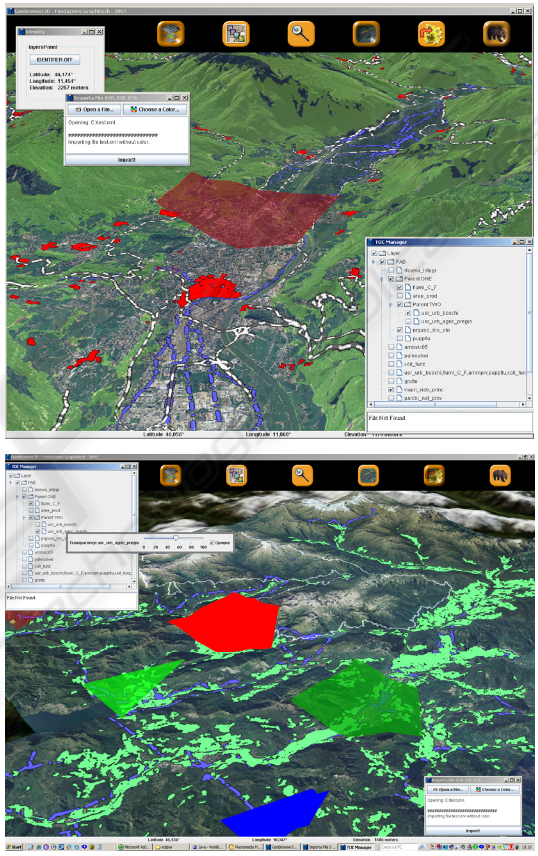

Figure 4: Two screenshots of the system. (TOP) the user has identified an area (in light red) characterised by traffic congestion. (BOTTOM) The client has received and rendered several feeds which are shown as polygons draped on the terrain.

At this stage the new feed is notified to all other users registered with the relevant topic, graphically represented by a further layer within the web based Geobrowser. As a result all users will be able to see the new geometry and by clicking on it they will be able to read the related information.

A further advantage of this approach is that information can be searched according to their geographical position as well for their content. The user in fact can, at any time, use a standard query-based approach to enquiry the central repository for any specific feed.

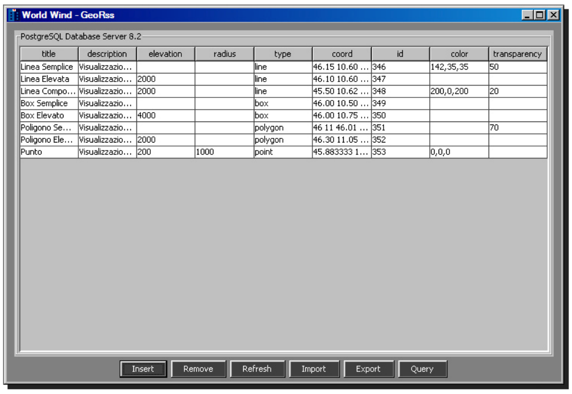

Figure 5: A screenshot of the query interface.

6 CONCLUSIONS

The work described in this paper clearly emphasizes the global need for suitable web-based IT tools for geographical information capable to better support environmental management. Access to web-based real-time information within 3D geo-referenced environments can potentially yield to increased prediction of disasters, better protection of human lives and reduced cost caused by environmental threats.

This paper has shown the detail of a web-based architecture used to access interactively a variety of themes and real-time information at a regional scale. The resulting infrastructure has been deployed in a real life context and it is used, during the daily activities of the planning department of a provincial authority in Italy. This clearly shows how these web-GIS 3D technology are paving the way for a brand new way of managing geographical information of public interest.

This is in line with a number of international initiatives to provide web-service-based planning tools capable to exploit environmental geographic data. Most of these initiatives are being carried on by OGC® and it represents an effort on harmonization with a number of emerging ISO standards. This is an emerging trend which is fuelled by international regulations such as the European INSPIRE directive. This trend is fostering research and development in a number of key fields whose results will converge into the creation of an interactive, networked software infrastructure capable to provide collaborative management and decision support, in an integrated way, in the context of environmental support at the EU level.

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