

AN OGC COMPLIANT INTEROPERABLE NETWORK TO DISTRIBUTE GEOLOGICAL MAPS AND DATA OVER THE INTERNET

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KEY WORDS: Web-based GIS, Inter-operability, Metadata, Databases, Geology, Mapping

ABSTRACT:

During the 2003, the Centre of Geo-Technologies (CGT) of University of Siena (Italy) and the Regione Emilia-Romagna Geological Office (RERGO) have developed a system to search, visualize, distribute and share geological information and maps through the Internet.

The aim of the project was to distribute and share the geological knowledge and data collected during the life of the above mentioned office and already available in digital format.

The data to be distributed consisted of a series of geological raster map images and vector map data at various scales. Particularly the raster images represent maps belonging to the series named 'Geological Map of the Emilia-Romagna Apennines area at the scale of 1:10000' produced before the extensive adoption of GISs and the vector data refer to the series of CARG products so far realised by RERGO. All the data have been described by metadata in standard formats following the ISO directives. The whole collection of metadata has been stored in a centralised repository.

The data have been published on the Web using an OGC WMS compliant IMS, particularly the OGC connector within the ESRI ArcIMS, and they can be accessed either by the means of a standard OGC compliant client application or through the provided Web interfaces.

The system is made up of a Metadata Explorer Web Application, of an OGC Web Map Server (WMS) and Web Feature Server (WFS) interfaces and of a series of Web Mapping tools.

The system is supported by an administration module that allows the administrator to manage the user privileges, the content layers to be used for each map, the interface look and feel and functionalities to be used.

1. INTRODUCTION

During the last years the Geological Office of the Emilia Romagna Administrative Region (RERGO) has collected a large digital repository of geological data and maps.

As long as geological data are concerned the RERGO has a series of institutional tasks to perform, namely:

- to survey, update and publish the geological map of the whole regional territory;
- to set rules and lay down methodologies and procedures in order to design and update geothematic (landslide risk, groundwater pollution, etc.), hydrogeological (groundwater body studies and surface drainage network), seismic and geotechnical maps at any scale;
- to promote and organize research activities in the field of renewable resources and exploitable materials;
- to support geothematic and geotechnical data acquisition and maintaining for other Institutions working on the territory;
- to provide data and services for decision makers, environmental planners and other offices and agencies within the same organisation;
- to collaborate with organisations coping with emergency management and disaster relief.

The traditional distribution of geological data by the means paper maps, the visual language of geologists (Asch, 2003), presents high costs of preparation and updating. Moreover a paper map represents a snapshot taken from one or few geologists at a certain time at a scale that is fixed. Geographical Information Systems (GISs) and database driven cartography

can mitigate the updating difficulties and produce seamless geological view of any area within the data extent potentially at any scale. The use of the Web, and the Internet in general, coupled with GISs offers an optimal way to distribute the data to a large public. Obviously making all this possible require a big effort for digital data acquisition and database entry as well as for database maintaining.

Furthermore, managing geological data presents a series of peculiar characteristics to be taken into account:

- the scale is an important factor and generalisation procedures can change the meaning of the data;
- the symbology is usually different among different organisations;
- the legend is the key for reading the map and it is related to the scale of the data;
- the Web is very useful to distribute up to date data but usually geologists need or prefer a paper map.

During the 2003, the Centre of Geo-Technologies (CGT) of University of Siena (Italy) and the Regione Emilia-Romagna Geological Office (RERGO) have developed a system to search, visualize, distribute and share geological information and maps through the Internet.

The aim of the project was to distribute to the professionals and general public the geological knowledge and data collected during the life of the above mentioned office and already available in digital format.

The file format, the spatial and time accuracy, the scale and other properties of this set of data are very heterogeneous and

for this paper two sets of data have been considered representative of the whole repository:

- the Geological Map of the Emilia-Romagna Apennines area at the scale of 1:100000 digitally acquired as a raster files;
- the data produced by the CARG project (the Italian Geological Surveying project aimed to map the whole country at a scale of 1:50000) stored in a vector GIS.

It's well known that today the GIS technology is evolving beyond the traditional Geographic information system (GIS) technology and becoming an integral part of the information infrastructure in many organizations. To fully realize the capability and benefits of geographic information and GIS technology, spatial data needs to be shared and systems need to be interoperable. GIS technology provides the framework for a shared spatial data infrastructure and a distributed architecture. (ESRI, 2003a). The Open GIS Consortium (OGC) promotes interoperability in the field of geographical data through the definition of standard interfaces and implementation guidelines. While it is strongly believed that the use of Web and OGC interoperable principles and standards are very important for the distribution and sharing of geological data, this paper doesn't consider a series of related topics as web cartography principles, generalisation procedures and algorithms, ISO guidelines and quality assessment procedures.

The project has been managed following the standard stages for designing and implementation of Geographical Information Systems (Harmon and Anderson, 2003). The following section cover the aspects of needs and requirement definition, the third describes the data and the fourth introduce the system architecture. It follows the description of the Web applications and interfaces and finally the conclusions are given.

2. NEEDS AND REQUIREMENTS

2.1 Users categories and needs

The data must be distributed and shared between a large set of user groups. During the user need definition stage the users have been subdivided in two categories: internal and external users.

The internal users are represented by all the staff of the region and partners that are supposed to make an advanced use of the data and to participate to an enterprise GIS structure that, through the management of the privileges, allows users to access, update and share the data.

The external users are all the users data for a large set of purposes but maintaining.

Internal users access to the enterprise GIS through of Internet in order to:

- insert newly acquired data into the repository;
- maintain the existing data;
- use the data for decision making purposes;
- administer the system.

The external users need to access data published in order to perform their daily activities and decision making process.

From this perspective the data are used for:

- decision making process;
- integration with other datasets;
- evaluation of environmental parameters;
- risk assessment procedures;
- derivation of thematic maps;

2.2 Data requirements

Considering the high level of heterogeneity of the sets of data making up the repository (scale, accuracy, file format,...) and the large number of user accessing the data must be described accurately by the means of metadata. In order to accomplish the data sharing with the largest public as possible it has been decided to use ISO standard for geographical metadata.

2.3 System requirements

Considering the importance of data to be available and online for the major part of time the system should assure an high availability configuration.

The system must be scalable and preferably portable.

2.4 Software requirements

The software should be as much as possible integrate with the previous GIS and Web applications made by the RER as well as respect the choices previously made by its IT Department.

In consideration of the large and heterogeneous group of users the software should support as many platforms as possible and be vendors independent for the final users. The latter target has been achieved adopting the specification of the OGC consortium and implementing an OGC compliant interoperable interface on the top of the system.

3. DATA AND METADATA

It has been already said (see par. 1) that for this paper two datasets have been considered representative of the whole repository and then used for system prototyping.

The Geological Map of the Emilia-Romagna Apennines area at the scale of 1:100000 is a map series made up of 151 sheet and it was available in a digital raster format. The raster data acquisition was carried out by the CGT during a former project aimed to distribute the maps through a series of 4 CDRoms .

The CARG project is the official geo-thematic mapping Italian project. It is aimed at the surveying of the whole Italian territory at the scale of 1:100000 and at the final production of a map series of more than 600 sheets at the scale of 1:50000 as well as of a Geographical Database where information layer are stored in vector format following a database rigid database scheme described in (Cara et al., 1993).

The whole set of data, raster, vector, databases and services have been described by the means of metadata. Even if the Italian GIS community seem to have already taken his own way towards the adoption of the ISO standard for metadata definition (ISOTC211) the data have been described for both the ISO and FDCG standard. Moreover, in some cases, the standard structure of metadata have been extended to include into the description of the data a series of information not required for the standard but compulsory for the metadata requirements of these data made before the advent of the metadata standards. This is the case of the CARG project data which have their own metadata structure well described and adopted by the CARG community from the beginning of the project in the 1988.

The modality of introduction of this information into the ISO metadata scheme, as well as the definition of the procedures to evaluate data quality parameters required in the ISO specifications are among the main current issues in the CARG community, but they have not been taken into account in this paper. For more information see (Fantozzi et al., 2001).

The metadata of the whole set of data, compiled accordingly to ISO specification, have been collected and stored as XML files in a central repository.

4. SYSTEM ARCHITECTURE

4.1 Description of the physical system

The system is based on a server client architecture and in particular a n-tier logic architecture based on n-tier logic component ((Peng and Tsou, 2003). It consists of (fig. 1):

- a Web server (WS);
- a Map server (MS);
- a Print server (PS);
- a Database server (DS).

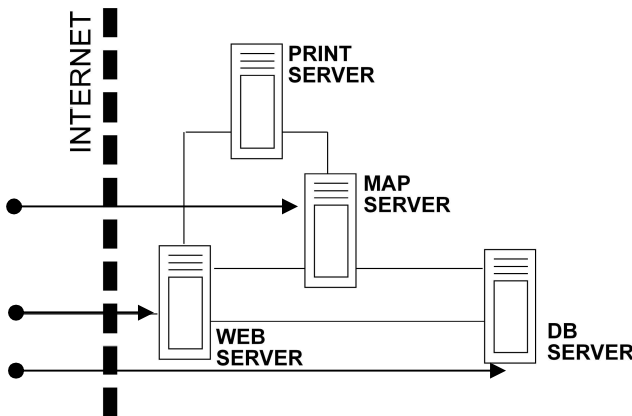


Figure 1 - Physical architecture

The above described structure is only the basic configuration and in order to guarantee for high availability more server should be integrated into the system to assure redundancy of services and data. Availability, as well as performances of the system, have not been considered of primary importance for this project and it has been considered that this aspect should be better managed by the IT Department.

It should be clear that this architecture represent the physical structure of the node managed by the RERGO. Obviously, the other nodes of the interoperable network may use a different architectures.

4.2 Software architecture

The software architecture show the distribution of different modules on the physical components.

Considering the presentation tier a large series of client application are available to be used:

- the Web browsers used to access the WS for both Web pages and web mapping;
- OGC WMS and WFS compliant clients;
- Database client applications.

The software managing the logic tier consists of a Web Server and Java Container (Apache + Tomcat), a Web mapping software (ESRI ArcIMS) and of a PDF maker application.

The Web Mapping application and it has been configured as a three-tier architecture and integrated with an OGC WMS and WFS compliant top layer.

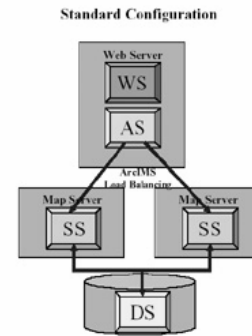


Figure 2 -ArcIMS three-tier configuration (courtesy of ESRI)

The data tier is managed by a client-server database and a GIS gateway, in particular Oracle 8i and ESRI ArcSDE.

This software architecture, even requiring a quite complex administration and management presents a series of advantages. The users having different needs can access the system at various level using a large set of client applications. Internal user can access the database through the GIS gateway, other nodes of the network can access the system through the OGC interfaces, everybody can visualize the maps by the means of a standard browser.

Moreover the spatial database system, in the meaning of DBMS plus Middleware (Shekhar and Chawla, 2002) allows to manage versioning and user privileges.

In this way data are maintained in a single database and made accessible from all the users and application who have the permission.

5. DESCRIPTION OF THE WEB MAPPING APPLICATION AND OF THE METADATA EXPLORER

5.1 Metadata

Metadata have been made available to the users through a Metadata Explorer Web application.

Users can search metadata either for keywords or attributes or for geographical extent.

The metadata have been also organised in a hierarchical structure that can be easily browsed.

The system integrates a gazetteer and a search map to facilitate users in finding metadata of data regarding to their area of interest.

The metadata XML files are presented through the Web by a simple interface but, since the system made use of XSL to render the XML file content, it is quit easy to use the proper style for each kind of metadata or application.

In the case of Web map services available online it is possible to visualise the data in a standard Web mapping interface integrated into the metadata explorer environment and providing simple browsing tools.

The metadata explorer integrates an authentication system that allow the metadata manager to decide what metadata any single user can access.

5.2 OGC WMS and WFS compliance

The system provides for two OGC compliant interface accessible using any WMS and WFS compliant client application. The OGC WMS interface running on the top of the Map server allows users to access the data and maps as images

and to stack images from different services in order to make the needed thematic map.

The OGC WFS interface running on the top of the Map server distributes data as a GML file, therefore users can integrate or import these data and their attribute into their own GIS application.

5.3 Web Mapping application

The Web Mapping application has been implemented following a modular approach and it is made up of the following software modules:

- an HTML based Web Mapping Interface;
- a flexible map tool to be integrated into the other Web pages;
- a paper map preparation wizard allowing users to prepare printed paper maps and atlases;
- an administration module allowing to define new maps, to manage user privileges and authentication.

The standard HTML based interface is a set of HTML pages and JavaScript functions allowing users to access predefined maps using a web browser. This software modules is founded on the ESRI ArcIMS HTML based interface. The standard code coming with the software has been customized and integrated in order to:

- integrate into the map layers any OGC images produced by a standard OGC WMS;
- improve the printing functionalities so that paper size and resolution can be defined by the users;
- translate the messages, controls and other text of the GUI in Italian language.

The Flexible Web Mapping Tool (FWMT) consists of a set of Java Server Pages allowing users to integrate both maps and a map interface in almost any web pages. This tool is URL-driven and specifying a set of parameters into the URL allows users to set interface and map extent and position into the pages

The FWMT support the visualisation of OGC layers and it is based on the code implemented for a previous project carried out by one of the authors in the field of emergency mapping and makes use of ArcIMS as map engine.

The paper map presentation wizard consists on a set of PHP pages allowing the users to set paper size, scale and layout of the desired final map produced as a PDF file and delivered through the Internet.

6. CONCLUSIONS

According to the final product and to the brief testing experience so far carried out it is believed that Web mapping techniques together with the adoption of OGC specification and standards seems to be an optimal solution to distribute geological data and maps to a large and heterogeneous public.

The authors think that the ongoing adoption of ISO standard and the growing interest for National and European Spatial Data Infrastructure will provide a really interoperable and multi-disciplinary environment.

Without any doubt a series of issues remain to be considered and solved. It is the case of the high costs of Web Mapping and Spatial Database software, of the band width and computing power needed to run effectively some distributed application and last but not less important the usability of the mapping environment for common users.

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