EUROGEOSOURCE – The new generation of EU mineral and energetic resources Web GIS Systems using cloud computing

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Abstract

The EuroGeoSource project (EU Information and Policy Support System for Sustainable Supply of Europe with Energy and Mineral Resources) is a three-year project, co-financed by the European Commission under the European Research Area, competitiveness and Innovation Framework Programme (CIP), Theme "CIP-ICT-PSP.2009.6.2 Geographic Information". The main objective is to provide online access to harmonized and INSPIRE compliant data on energetic and non-energetic mineral resources, using web services based on open source standards. The system will permit the users to identify, access, use and reuse in an interoperable and seamless way and for a variety of uses, aggregated geographical information on geo-energy and mineral resources, covering a significant part of Europe (at least 10 countries) and coming from a wide range of sources. The web services will be implemented in the cloud, ensuring performance and advanced portal functionality, resulting in a Google like user experience.

Key-words: *Geo-energy and mineral resources; INSPIRE Directive; GIS data portal.*

Resumo

O projeto EuroGeoSource (Sistema de Informação e de Apoio à Política de Abastecimento Sustentável da Europa com Energia e Recursos Minerais) é um projeto de três anos, co-financiado pela Comissão Europeia no âmbito do Espaço Europeu de Investigação, competitividade e de Inovação (CIP), com o tema "CIP-ICT-PSP.2009.6.2 Informação Geográfica". O principal objetivo do projeto consiste em fornecer dados harmonizados e de acordo com a Diretiva INSPIRE, sobre recursos energéticos e não-energéticos, através de serviços web baseados em normas *open source* (código aberto). O sistema permitirá aos utilizadores identificar, aceder, utilizar e reutilizar de forma inter operável e sem interrupções, para uma variedade de usos de informação geográfica agregada sobre geo-energia e recursos minerais, que abrange uma parte significativa da Europa (pelo menos 10 países) e provenientes de várias fontes. Os serviços web serão executados na *cloud*, garantindo um elevado desempenho e funcionalidade do portal.

Palavras-chave: Recursos minerais energéticos e não-energéticos;Diretiva INSPIRE;portal SIG-web.

1. Introduction

A major problem that Europe is facing nowadays is to ensure its energy and non-energetic minerals supply. Since disruptions and shortages are directly affecting the citizens, and can also have large impacts on economies, as well as repercussions on foreign relations: Energy security is a key thematic in the political agendas across Europe and at the European Commission. Currently, the EU authorities support their long-term policies on the need for oil, gas and minerals, including estimates of the required import from national reports of contributions of member countries. These reports contain only generalized information regarding reserves and production forecasts for a country as a whole and do not allow a fast response to crisis situations and significantly reduce the accuracy of the long-term planning of the geo-energy supply of Europe. Moreover, the way in which data are available do not allow the users to query interactively or combine them with their own spatial data sets for a more complex analysis (Gruijters & Fruijtier, 2011; Gruijters, 2012).

To address this issue the Euro Geo Source (EGS) project in three years (April 2010 – March 2013) will have developeda multilingual (English and the partners languages) web GIS system which will enable Open Geospacial Consortium (OGS) compliant services (OGS, 2008) for the registration of INSPIRE – "Infrastructure for Spatial Information in the European Community" (INSPIRE, 2007) compliant data sets from different countries, as the visualization and overlay of the information layers obtained from distributed sources and spatial analysis. This system will allow users to identify, access, use and reuse aggregated geographical information on geo-energy (oil, gas, coal) and mineral resources (metallic and non-metallic minerals, industrial minerals and construction materials: gravel, sand, ornamental stone), provided by the Geological Surveys from at least ten countries in Europe (Gruijters & Fruijtier, 2011).

The EGS consortium consists of 14 partners (11 Geological Surveys, 1 university and 2 commercial software companies) representing 12 Member States (Fig. 1).

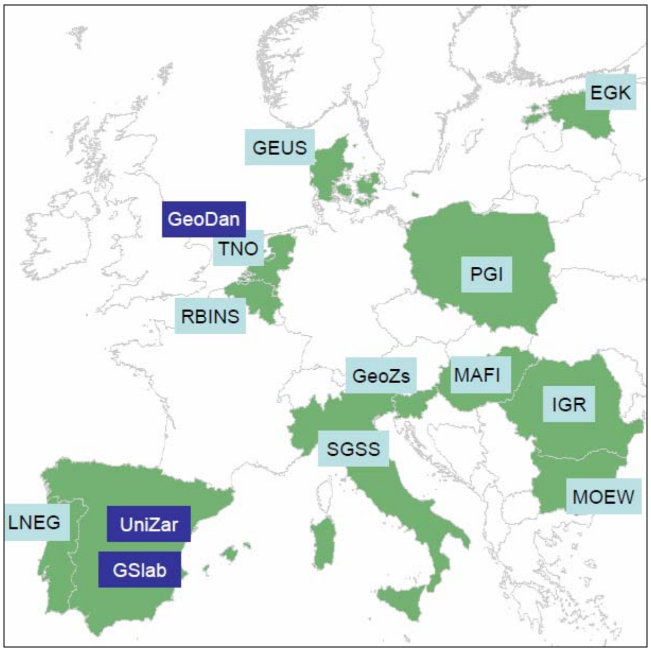

Figure 1–Geographical distribution and key partners of the EuroGeoSource project consortium.

The EGSweb system will provide services that will calculate summary statistics on the fly, and will incorporate tiled maps from other existing services (e.g. One Geology Europe, Corine2000, Open Street Map), and view services for 93 additional geological maps from the Southern Permian Basin Atlas. Furthermore, the system will support both desktop and Android clients (Gruijters, 2012).

2. Project rationale

The built EGS system was structured in 11 work packages which could be grouped in 4 major tasks. The first task was related to the 'environment' of the EGS web portal. This step established the user requirements (Maricq & Piessens, 2011) and the current organizational and political aspects of geo-energy and mineral resources data management in the participating countries (Scharek & Tullner, 2011). In order to achieve a sustainable base for determining the profile and needs of the potential users of the EGS portal, a large number of persons and organizations were approached in 9 countries. In this context, an on-line questionnaire was deemed the best option and was additionally advantageous for ensuring homogeneity of the questionnaire answers, which was essential to have a correct overview of the needs at European level. The questionnaire was sent out to 1041 potential users and the results from 187 respondents were statistically analyzed, creating a basis for use cases for the design of the portal (Maricq & Piessens, 2011).Subsequently, a set of key economic parameters was derived by combining the user requirements with the data available, organizing them into a comprehensive data model (Šinigoj *et al.*, 2011). In the same way, to ensure on the spot feedback from the user community data providers, representatives from the mineral and energy industry, international policy makers and INSPIRE experts were invited to a workshop, where the rationale behind the portal was explained and the first version of the portal itself was presented and discussed (Gruijters & Fruijtier, 2011).

The second task was related to the 'content' of the portal. This will create a format for delivery of the key economic attributes for oil, gas and mineral resource fields and produce a multilingual digital dictionary functionality for the interfaces of the EGS system and legends of the web mapping services.

The third task will design the EGS system and build a trial prototype, which is upgraded to the actual EGS portal. After a robust testing program, an electronic user manual will be produced.

The last task, related with 'communications', has built a collaborative framework by identifying and contacting closed and on-going projects with similar objectives.

3. Harmonization of the geo-resources attributes and the data exchange format

3.1 *EGS Key Attributes*

The most important attributes for the data of energy and mineral resources in the possession of EGSpartners are compliant to the INSPIRE data and with the general rules established by the INSPIRE Directive to set up an infrastructure for spatial information in Europe (Gruijters & Fruijtier, 2011).

The EGS data model was based on the list shown in figure 2 and in the INSPIRE GML (Geography Mark up Language – ISO DIS 19136) data models for the Annex I, theme 4 (Administrative units), Annex II, theme 4 (Geology) and Annex III, themes 20 (Energy resources) and 21 (Mineral resources).

The set of key attributes was grouped in general data of the site, data of location, administrative data, economic data and additional data (Šinigoj *et al.*, 2011). Attributes specific to mineral resources were labeled (M), for energy resources (E) and for both (M&E). Not all attributes are available and accessible for each country. The data were mapped to INSPIRE data specifications (INSPIRE, 2007, 2010, 2011a, b, c) leaving twenty-one attributes that could not be mapped (Gruijters & Fruijtier, 2011).

GENERAL DATA OF SITE	DATA OF LOCATION	ADMINISTRATIVE DATA
INSPIRE ID of site (M&E)	Coordinates: longitude, latitude (M&E)	licence ID (M&E)
local ID (M&E)	depth below surface (M&E)	type of licence (M&E)
Name of site (M&E)	water depth (M&E)	Name of licencee / operator (M&E)
Name of site (M&E)	geographical location (M&E)	Duration of licence (M&E)
Type of resource (M&E)	Country name (M&E)	Areal extent of licence (M&E)
Year of discovery (M&E)		
status of site (M&E)		
References (M&E)		
Remarks (M&E)		

ECONOMIC DATA	ADDITIONAL DATA	ADDITIONAL DATA
Classification (M&E)	Geological characteristics regional / of field (M&E)	Main type of field (E)
in situ ore / substance reserves (M&E)	Age of host rock / Reservoir rock age (M&E)	Status (E)
Production (M)	Host Rock type / Reservoir rock type (M&E)	Nr of oil producing wells (E)
Period of Production (M)	mineral deposit type (M)	Nr of gas producing wells (E)
Dimension of the deposit (M)	primary comodities (M)	Nr of gas injecting wells (E)
mining method (M)	secondary comodities (M)	Nr of oil/gas producing wells (E)
Oil Initially in Place (E)	main ore minerals / substance (M)	Nr of water injecting wells (E)
Gas Initially in Place (E)	secondary ore minerals / substance (M)	Nr of water/gas injecting wells (E)
Cumulative oil production (E)	(M)	Nr of CO2 injecting wells (E)
Cumulative gas production (E)	hydrothermal alteration (M)	Nr of producing/injecting wells (E)
Cumulative water production (E)	morphology of the deposit (M)	Areal extent of field delimitation (E)
Cumulative gas injection (E)	regional deposit structure (M)	Reservoir depth (E)
Cumulative water injection (E)	dating method of mineralisation (M)	Production strategy (E)
Remaining Oil reserves (E)	age of mineralisation (M)	Installations (E)
Remaning Gas reserves (E)		
Year of reporting (E)		

Figure 2 – Key attributes on EGS portal for mineral resources (M), energy resources (E) or both (M&E). The shaded attributes are additional to the INSPIRE data model (Gruijters & Fruijtier, 2011).

The mapping showed that the connection between the different data themes and the rationale within each theme in INSPIRE is not the most favorable, resulting in multiple references or redundancy when entering data. These insights were reported to the INSPIRE thematic working groups in detail to improve the final versions of the data specifications (Gruijters & Fruijtier, 2011).

Figure 3 describes the relational data model for energy and mineral resources used to implement the EGS data model (Waardenburg & Kerkenaar, 2012b).

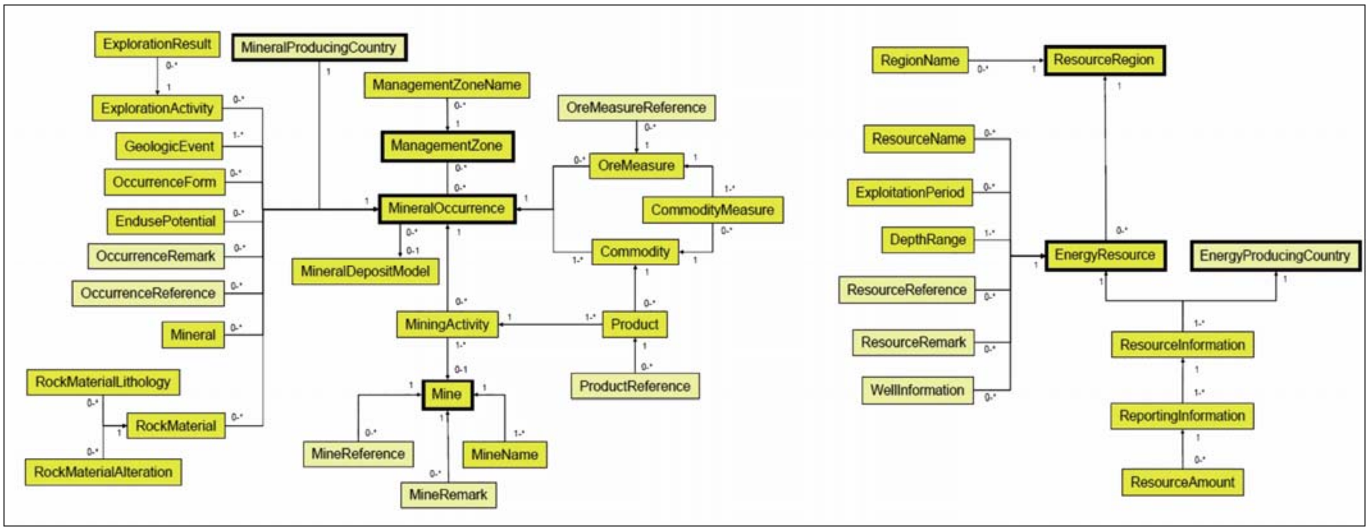

Figure 3 – EGS data model for energetic and non-energetic mineral resources (Waardenburg & Kerkenaar, 2012b).

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3.2 *Portugal – web services implementation*

In order to be able to deliver data to EGS system the Portuguese partner – LNEG, proceeded to update their national geographic information system – SIORMINP – "Information system of Portuguese mineral occurrences and resources", which is a in *MS Access*, which contains information on 2277 mineral occurrences, resources and reserves, and their metadata.

The SIORMINP data base is a relational model in which each mineral occurrence or resource is connected to a wide setoff auxiliary tables, each one containing data for a particular subject. This relational database has the information stored in an organized way in the form of tables, queries, forms, reports and macros, interacting with each other and allowing access to data by different users (Fortes *et al.*, 2005). The main objectives that leaded to the development of this database were:

- To improve the geoscientific, technical and economic knowledge of the mineral occurrences, resources and reserves in mainland Portugal;
- Promote mining development within the national territory by selecting and diffusing information to exploration companies of areas with mining potential;
- Contribute to territorial classification;
- Integration of this database with other information as geological maps, geochemistry data and geophysical data to create a more complete geographic information system;
- Development of a methodology for the definition of occurrences and mineral resources favourability maps using methods of *geographic data mining* (GDM). These favourability maps will be essential tools for mining exploration, management, sustainable development of the geologic resources and mitigating the negative environmental impacts of mining (Fortes *et al.*, 2005).

Since 2005, the SIORMINP DB was integrated in the LNEG's geoportal (http://geoportal.lneg.pt/), which is a spatial data infrastructure of integrated services to support the management and visualization of spatial data, which aims to provide, in a web environment, the georeferenced information related to the different activities of LNEG.

At LNEG's geoportal is possible to query the SIORMINP DB (Fig. 4). This web portal, using spatial information is not only for graphically visualizing the information on a map or showing the attribute information per geographical object in a table or pop-up screen. This has, lead to a user interface where a user can easily "ask" a question that gets answered in different ways suiting his needs.

After adopting the general rules set by the INSPIRE Directive, as well as the acceptance of the EGS conceptual data model (Fig. 3), LNEG up dated their national geographic information system (SIORMINP) and published their datasets using OGC compliant Web services providing their harmonized mineral occurrences and resources data to the project.

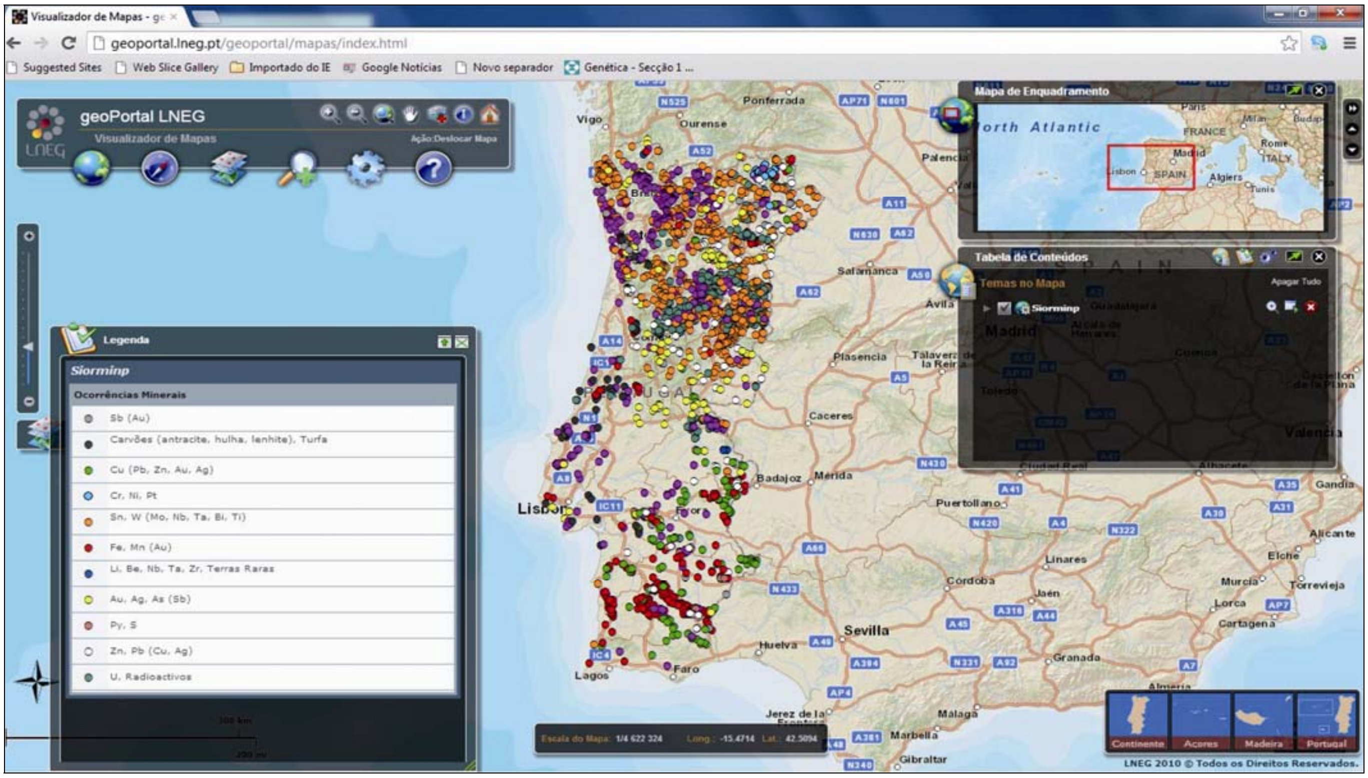

Figure 4 – Map viewer with all 2277 mineral occurrences and resources in mainland Portugal.

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In order to provide harmonized data, a toolset was built to facilitate the implementation of the services which can be used to deliver the local datasets in the required harmonized format. This toolbox is explained in a cookbook which describes the services to be delivered (INSPIRE compliant Web Feature services) and the steps required to implement them. To implement these services, a set of open source software products that enables the partners to get their services up and running, have been used (Waardenburg & Kerkenaar, 2012b).

The selection of this software products was mainly due to their capability of being able to work together, in order to perform the transformation of data stored in the relational database to the INSPIRE compliant GML that is used to exchange information between the partners and the central system. The selection process resulted in the selection of Postgre SQL to implement the relational database, Post GIS to spatially enable the database and Deegree to implement the required download (WFS) service because of the following reasons (Waardenburg & Kerkenaar, 2012b):

- Deegree is the only software product able to handle complex data models as well as GML 3.2 output, both required by INSPIRE;
- While the option exists to use other databases, Postgre SQL/Post GIS are most commonly used in combination with Deegree. Community support, in case of trouble, would be easier as there is more experience with this configuration.

After completing these implementation steps, LNEG's web server is operating at: *http://eurogeosource.lneg.pt.*

4. EGS architecture

The EGS portal provides easy access to mineral and energy resource information. This information is delivered to portal through web services. To simplify the implementation process of those services and to meet the portal requirements with respect to performance, query ability, accessibility and availability, the system architecture provides a central layer where information is cached and optimized. The services required by the portal and external clients are built on top of the central layer (Waardenburg & Kerkenaar, 2012a).

In order to accommodate the desired functionality and performance of the EGS portal the architecture of the EGS system is divided into three layers (Fig. 5) (Gruijters & Fruijtier, 2011):

- Data/Service provider layer – containing components responsible for delivering data to the central services layer;
- Central EGS service layer – providing the services that are required by the consumer layer and for caching the data delivered by the provider layer;
- Service consumer layer – containing components that consume EGS services (the EGS portal and external client applications).

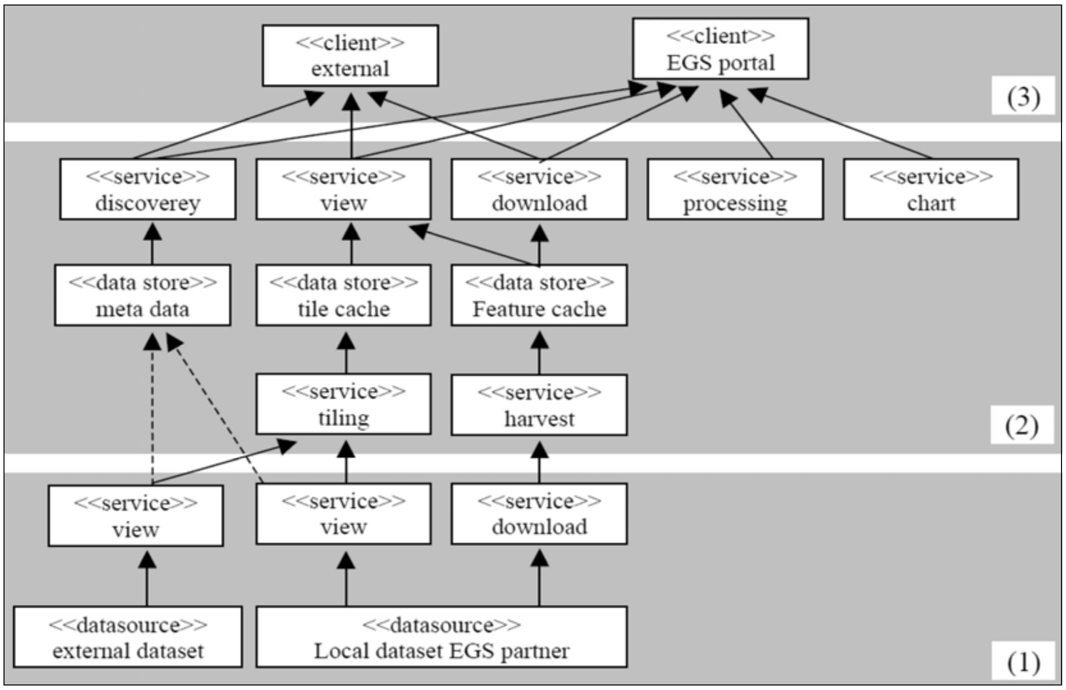

Figure 5 – The EGS architecture with (1) data/service provider, (2) central EGS and (3) service consumer (Gruijters & Fruijtier, 2011).

This conceptual architecture of the EGS system was based on (Waardenburg & Kerkenaar, 2012a):

- INSPIRE recommendations;
- Architecture of existing systems;
- EGS functional and non-functional requirements derived from a number of use cases.

The harmonized EGS data will be harvested at regular intervals, during 'low activity' hours and stored in the feature cache data store. Furthermore, the data providers can manage the harvesting. Also non-harmonized data, provided through Web Map Services (WMS), could be used to generate tile caches at regular intervals. The user can see when the latest update of the data was performed. In this way the user gets access to reliable, accurate, up to date information from the data providers, without having to wait for all the services to load at the portal.

5. Technology Description

5.1 *Services*

The harmonized data model is implemented at the Geological Surveys of EGS consortium and is based on and tuned with the INSPIRE themes geology (INSPIRE, 2011a), mineral resources (INSPIRE, 2011b), energy resources (INSPIRE, 2011c) and administrative units (INSPIRE, 2010). In order to distribute and portray the data three types of services are used. One service for filtering and requesting the data itself (Web Feature Service – WFS), one for discovering the data (Catalog Services for the Web – CSW) and one for portraying the information as a geographical map (Web Mapping service – WMS). Furthermore translation services will be implemented to translate the geological and user interface terms to different languages, as well as processing services to aggregate information. In order to ensure interoperability between the Geological Surveys and the different system components, all interfaces are based on open standards from the OGC and the INSPIRE specifications, but additionally also on standards such as GeoJSON (Butler *et al.,* 2008) and Rest (Fielding, 2000) resulting in a better integration of the system components in other information systems (Gruijters & Fruijtier, 2011).

5.2 *Cloud Computing*

Cloud computing is one of the most important technological trends of the coming times. The technology and architecture that services and development models offer cloud computing are key points of the research and development of GIS technologies.

Cloud computing is the use of computing resources (hardware and software) that are delivered as a service over a network (typically the Internet). The name comes from the use of a cloud-shaped symbol as an abstraction for the complex infrastructure it contains in system diagrams. Cloud computing entrusts remote services with a user's data, software and computation. There are many types of public cloud computing (Monaco, 2012).

End users access cloud-based applications through a web browser or a light-weight desktop or mobile appwhile the business software and user's data are stored on servers at a remote location. Proponents claim that cloud computing allows enterprises to get their applications up and running faster, with improved manageability and less maintenance, and enables IT to more rapidly adjust resources to meet fluctuating and unpredictable business demand (Oestreich, 2010; Baburajan, 2011).

Thus, although the data of energy and mineral resources available in the EGS portal come from services and databases installed at the different participating Geological Surveys, cloud computing is used to fulfill some basic requirements, both non-functional and functional. Typically the non-functional requirements are the performance, availability and the scalability (Gruijters & Fruijtier, 2011). The system is available for both desktop and android clients, and has demonstrated satisfactory performance, even operating on a 3G network. The system supports searching for occurrences of commodities throughout Europe. If all the data is available on distributed servers, such a query will have to be executed at every geological survey, resulting in a high risk of low performance. The implementation in the cloud facilitates an optimised search index, speeding up performance and reducing the risk of having actually inaccurate results if local services are down or unreachable (Gruijters & Fruijtier, 2011; Gruijters, 2012).

The system also uses cloud computing to compute so called tiles of the WMS services. A typical WMS setup is only able to support a very limited number of concurrent users and requests per second as it creates a map per request, often resulting in poor usability if many users are accessing the system or if the system is over-requesting the individual WMS. Another reason to pre-create and store tiles in the cloud is because other existing map services are used (e.g. One Geology Europe) that only support the geographical coordinate system ERTS89. While this coordinate system is very useful for exchanging information, it is a very poor coordinate system for portraying geographical maps (Gruijters & Fruijtier, 2011).

6. Sustainability

The main problem faced by many applications developed within the framework of EC-funded projects is maintenance of the applications once the project and Community funding has ended and often applications that require maintenance of a central database start to deteriorate upon project completion. In order to ensure the sustainability of the Euro Geo Source portal after the end of the project the final demonstration system will have a distributed structure, based on web services. This means that every participant will implement the required data delivery web services and supporting software on top of their existing national geo-database applications. This approach, in line with INSPIRE recommendations, will ensure proper updates of the data sets as well as technical maintenance of the web data services distributed at the data provider sites. The distributed national data services will be maintained as part of the normal workflow of the hosting Geological Surveys that constantly maintain and improve the quality of the national data repositories.

At the end of the project the central Euro GeoSource application will be installed at a site of a commercial web application hosting service provider. One of the partners will take on the role of the application hosting provider. The system maintenance contract will be signed with the application hosting provider for a period of at least three years following the end of the project ensuring its sustainability.

7. Conclusions

The design of the EGS portal permits to understand how distributed web services are indeed essential to search, provide access, use and re-use INSPIRE compliant data. But to keep the performance of the portal acceptable, cloud computing is necessary (Gruijters & Fruijtier, 2011).

The development of additional functionalities, providing the user with aggregated information forms the EGS data model, is an important asset of the portal: instead of only providing harmonized data per country, it will integrates the data on the European level, making it possible to address European supply and policy issues (Gruijters & Fruijtier, 2011).

Once a critical number of geological surveys are connected to the system, the EGS portal will be an indispensible tool that will benefit exploration companies and organizations at regional, national and also at European level working on securing the supply of both mineral and energy resources.

Acknowledgements

The EGS project consortium consists of 14 partners (11 geological surveys, 1 university and 2 commercial software companies) representing 12 Member States: Belgium, Bulgaria, Estonia, Denmark, Hungary, Italy, the Netherlands, Poland, Portugal, Romania, Slovenia and Spain. All participating countries and the dedication of the staff involved made the project a success. We acknowledge their contribution, without which this paper would not have been made possible.

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