Interactive Map for caENTI - Application of the Web Mapping Technology.

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INTERACTIVE MAP FOR CAENTI – APPLICATION OF THE WEB MAPPING TECHNOLOGY

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Abstract: Geographical information systems (GIS) are becoming a common tool in applications that involve spatial objects and relations. In the last years the internet technology is moving GIS towards web based applications, simplifying the interaction between users and GIS, and at the same time reducing the ownership and maintenance costs. In the framework of caENTI we are developing a Web Mapping solution to present selected socio-economic indicators of European Union in the form of Interactive map. Indicators will be presented in different levels of detail (from NUTS0 to LAU2).

In the time of writing this article Interactive map is still in development phase. The development software has been already selected and tested. However the selection and processing of data and metadata is still not completed. Map built on Web Mapping software GeoServer and JavaScript-based web applications (including the Map Tools library OpenLayers) are in the final stages of development.

Key words: Web Mapping, Web GIS, cartography, open source software

1 INTRODUCTION TO WEB MAPPING TECHNOLOGY

Web mapping technology (also: Web GIS (~ Server); Internet GIS (~ Server); Geospatial server) is a technology that enables the remote delivery of maps on the Internet. It includes several processes: designing, implementing, generating and publishing the map. On the user's side web browser is used as a client and usually no software installation is necessary. Maps may be accessed from desktop and portable computers. Web Mapping technology is an important component of a wider system, called Geographic information system (GIS), which is an information system for capturing, storing, analyzing, managing and presenting data which are spatially referenced (i.e. data linked to location).
Web Mapping enables delivery and publication of high-quality interactive maps, data from GIS, and associated metadata, with the ability to query, manipulate, and interact with data. It can display both raster and vector data structures, enabling the dissemination of a wide variety of data types, for example satellite imagery, topographic data, and thematic maps. Maps may also be linked to databases and other information sources, allowing it to be visualized and queried. The system can also be extended to link to other resources and allow multimedia components, like photographs, video, sound etc. to be displayed for particular features of the map.
Web mapping technology uses a server-client technology to exchange information trough the HTTP protocol. Client (i.e. web browser on user's side) requests the map or other information with certain parameters from the server. The server responds with map data and ancillary information.

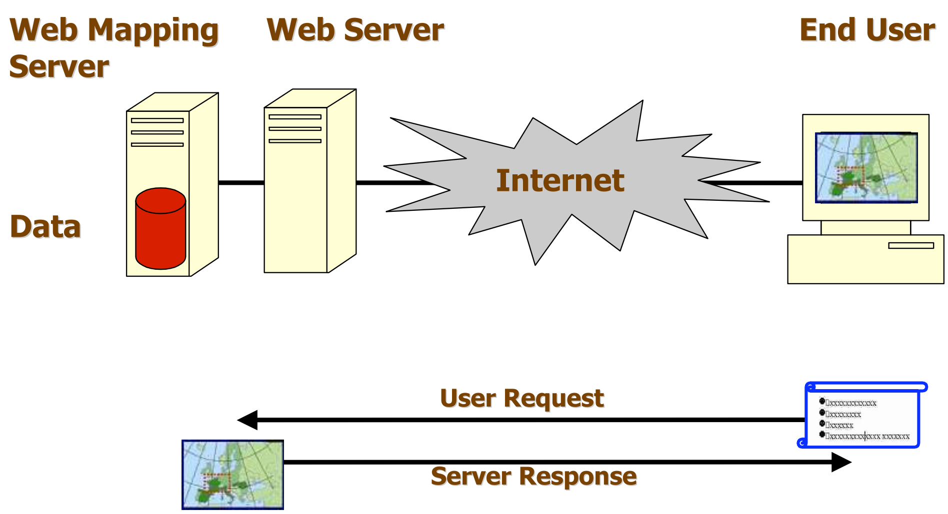

Figure 1: Web mapping system has very complex architecture. It uses server-client technology to transfer user requests to maps as an output.

Web mapping system has very complex architecture. However on conceptual level four basic components are found:

- *Data*: This is essential component of the system! Data can be vector or raster type, stored on data-server in variety of different formats, organized as files or databases.
- *Map / Mapping software*: Web mapping software is server-side program that can dynamically produce a map out of the Data according to the client's request. Map is composed of data-layers, displayed in selected projection, rendered in defined manner.
- *Map Tools / Web application*: Map Tools contain user tools to manipulate and explore the map as well as to retrieve textual information. Map Tools are delivered in the form of HTML and web-scripting-based Web application that is used as a wrapper around the Map.
- *Client / Web browser*: On user's side ordinary web browser is used as a client to open the Web application and explore the map. No other additional software is required; some solutions however require download of additional plug-in component for the browser.

The first three components are present on the server side and the fourth one on the client side.

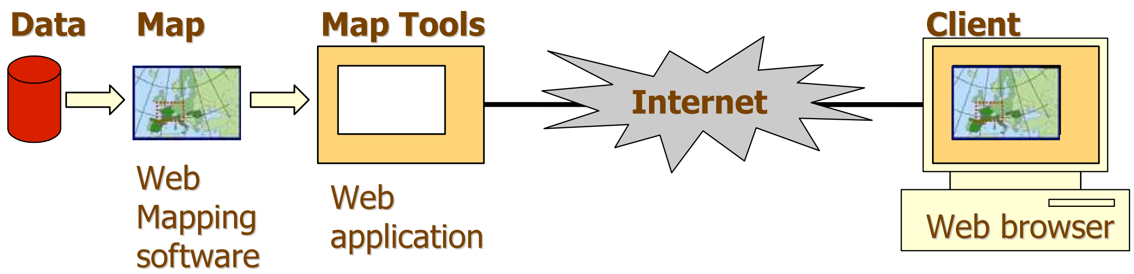

Figure 2: Logical components of Web mapping system.

Interactive map, based on Web Mapping technology, is a very powerful tool. First, it is dynamic tool. End user can interact with it; can “speak” with it to display the map – and also contextual information – that he wants. This is the most important advantage compared to the static, pre-prepared maps that are basically static images. Second, it is highly visual tool, and graphical presentation can outperform normal textual or tabular information. Last but not least, it is very simple to use, only basic computer skills are required for the end user to be able to get all the capabilities.

2 OBJECTIVES OF WEB MAPPING FOR CAENTI

Main objective of the Web Mapping within the caENTI framework was to design an Interactive map of Europe for visual representation of selected caENTI indicators. Interactive map has to be built on standard Web Mapping technology (section 1). The work was divided into four subtasks (which follow the conceptual division of Web Mapping system, described within section 1):

- Selection of appropriate software for Web Mapping and for Map Tools (section 3).
- Data: Obtaining and processing the geographical and attribute data to be presented together with its metadata (section 4).
- Map: Preparation of a Map with the selected Web Mapping software (section 5).
- Web application: Preparation of a Web application with the help of selected Map Tools library (section 6).

It has to be stressed that the interactive map has not been completely finished at the stage of writing this paper. Therefore some items described within the following sections are still in the development phase and might change in the final form.

3 SELECTION OF SOFTWARE

The selection of software has been focused to the so called open source solutions (as opposed to the closed source). Open source is development methodology, which offers practical accessibility to a product's source (goods and knowledge). In the computer world it is commonly applied to the development of source code for software which is made available for public collaboration, and it is usually released as open-source software. We are convinced that open source solutions are more suitable for scientific and research use, since they are free, they are vendor independent, and since they can be upgraded by additionally developed modules (either by the user or the community). On the other hand, however, more skills are needed on developers’ side for the installation and development of the application.

	Open source Web Mapping solutions	Closed (proprietary) software Web Mapping solutions
price	Free	normally 10.000 – 20.000 EUR
installation and use	more skills are needed	relatively easy
own modules	can be added	cannot be added
includes	mapping only	mapping and tools
other	Independent	vendor dependent
examples	Geoserver, UMN MapServer	ArcIMS, MapGuide Enterprise

Table 1: Comparison between open and closed source Web mapping software solutions.

In search for highly standardized solution we followed the recommendation, given by two main non-profit open-source geospatial organizations:

- The *Open Geospatial Consortium* (OGC): It is a non-profit, international, voluntary consensus standards organization that is leading the development of standards for geospatial content and services, GIS data processing and exchange.
- The *Open Source Geospatial Foundation* (OSGeo): It is a non-profit non-governmental organization whose mission is to support and build the highest-quality open source geospatial software.

OGC is responsible – among other well known standards (GML, KML ...) – also for a very important standard for delivery of maps across the Internet. This standard is called *Web Map Service* interface standard (WMS). WMS provides a simple HTTP interface for requesting geo-registered map images from one or more distributed geospatial databases. A WMS request defines the geographic layer(s) and area of interest to be processed. The response to the request is one or more map images (returned as JPEG, PNG, etc.) that can be displayed in a browser application. OGC specifies also Styled Layer Descriptor (SLD), XML-based coding scheme for describing the appearance of map layers. A typical use of SLDs is to instruct a WMS of how to render a specific layer.
In section 1 it was stated that on conceptual level map is distinct from the data which composes the map. Also, the tools for exploring the map are distinct from the map itself. This concept is followed by the standards and software that are developed by OGC and OSGeo, respectively. Therefore, following proposals from OGC and OSGeo, we had to find two separate software modules to build the Interactive map for caENTI. Among the tested products (GeoServer, MapBender, MapServer, OpenLayers and Open Source MapGuide) the following two products were selected:

- for the Web Mapping software: *GeoServer*
- for the Tools software: *OpenLayers*

GeoServer (currently in stable version 1.6.4.) is the most standards compliant open-source Web Mapping server. It is built upon the GeoTools Java code library for geographical data and OGC specifications. GeoServer runs on all major operating systems and will work with almost any Web server. It allows publishing of geospatial data in the form of maps using the OGC's standard WMS (version 1.1.1) and also publishing of actual data, supporting OGC Web Feature Server (1.0 and 1.1), and OGC Web Coverage Server (1.0) specifications. GeoServer reads a variety of data formats, including Shapefiles, PostGIS, Oracle Spatial, ArcSDE, DB2, MySQL, GeoTIFF, GTOPO30 (some of them can be edited via the WFS-T). Through the standard protocols it produces KML, GML, Shapefile, GeoRSS, Portable Document Format, GeoJSON, JPEG, GIF, SVG, PNG and more. As far as the speed of map delivery is concerned GeoServer (from version 1.6 on) is said to become very comparable with its older and more known competitor UMN MapServer.
OpenLayers (current in stable version 2.6) is an open source JavaScript library for displaying map data in web browsers. It provides an API for building rich web-based geographic applications. It enables easy incorporation of maps from a variety of sources into same application. It has support for OGC WMS layers, navigation, icons, markers, overview map, and layer selection.

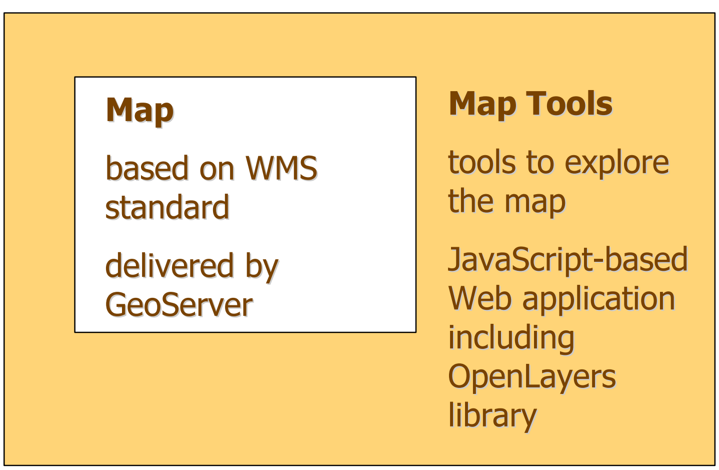

Figure 3: Schema of selected software.

4 DATA PREPARATION

Spatial data is essential for successful application of any GIS system in general and Web Mapping application in particular. The important data issues are of quantitative (contextual richness, completeness) and qualitative (accuracy, categorisation, data formats, methods of obtaining data, metadata) nature. Partners of the caENTI framework were well aware of this since they have prepared a large set of data. The collected data is from different sources, thus of different quality and completeness.

4.1 The NUTS standard

The Nomenclature of Territorial Units for Statistics, (NUTS; for the French *nomenclature d'unités territoriales statistiques*) is a code standard for referencing the administrative divisions of countries for statistical purposes. The purpose is to have a single code for each administrative division, and to identify each administrative level. The standard was developed by European Union and thus covers only the member states of the EU in detail. At the moment, Eurostat establishes NUTS codes for the 10 countries that joined the EU in 2004, but they can be changed in the future. The NUTS divisions do not necessarily correspond to administrative divisions within the country. The different levels are determined by minimum and maximum thresholds for the average size of regions, like in table 2.

Level	Minimum	Maximum
NUTS 1	3 million	7 million
NUTS 2	800 000	3 million
NUTS 3	150 000	800 000

Table 2: Thresholds for individual NUTS levels.

A NUTS code begins with a two-letter code referencing the country, which is identical to the ISO 3166-1 alpha-2 code (except UK instead of GB for the United Kingdom). Then, each level adds one number as in table 3.

Country	NUTS0	NUTS1	NUTS2	NUTS3	LAU1	LAU2
Belgium	BE	BE1	BE11	BE111	-	BE11100001
France	FR	FR1	FR11	FR111	-	FR11100001
Hungary	HU	HU1	HU11	HU111	HU11101	HU111010001
Spain	ES	ES1	ES11	ES111	-	ES11100001

Table 3: Coding of different NUTS/LAU levels.

Each numbering starts with 1, as 0 is used for the upper level. In case the subdivision has more than 9 entities, capital letters are used to continue the numbering.
There are four levels of NUTS defined, with two levels of local administrative units (LAU) below. Before July 2003, LAU1 was called NUTS4, and LAU2 was NUTS5, later the terms NUTS4 and NUTS5 were officially abolished by regulation, although they are sometimes still in use. For each country, the number of levels depends on its size. LAUs are established by Eurostat and not by European Union.

4.2 Attribute data

Through the caENTI a vast number of socio-economic indicators for all European Union countries were obtained for different levels of detail. For the Interactive map, it was decided to limit the levels of details as well as number of presented indicators. The levels of details to be presented are: NUTS0, NUTS1, NUTS2, NUTS3, and LAU2 (only for 4 pilot countries: Belgium, France, Hungary, Spain). As far as the indicators is concerned, in the initial implementation of Interactive map only 6 of them were selected:

- Total population
- Density of population
- Active population
- Unemployment rate
- Net income available for household
- Average size of household

The indicator data for levels NUTSx were collected by the members of caENTI project team. The obtained indicator data differs in considerably in several parameters. It differs in year of validity of data. In a lot of cases we lack indicator data for some spatial units and/or for some levels NUTSx/LAU2 – in such case the corresponding indicator cannot be followed completely throughout the complete EU and/or all levels of detail. In the table 5 already processed data is highlighted in green. Please note that the table shows the situation in the August 2008, when the work is still in progress.

	EU countries	Belgium	France	Hungary	Spain
Indicator / Level of detail	NUTS0, 1, 2, 3	LAU2	LAU2	LAU2	LAU2
Total population					
Density of population					
Active population					
Unemployment rate					
Net income available for household	not for household, but total for spatial unit	few units only			
Average size of household	just few countries in level NUTS0 only	few units only			

Table 4: Obtained and processed indicator data (marked with green).

4.3 Vector data and cartographic specification

Geographical vector database was obtained from EuroGeographics. We obtained data for different level of detail: NUTS1 to NUTS3 and USE1 to USE6. All data were reprojected to the selected projection (see below) and exported to shapefile format. Shapefile, although being native format of ESRI and its ArcGIS software (and thus being propriety), is probably the most widespread format for spatial vector data. Shapefile groups spatial data, attributes and projection information together in such a way that no mistake is possible with the correlation between them.
The entire vector database, obtained in WGS 84, was reprojected to the selected projection, which is Lambert Conform Conic (LCC) on datum ETRS 89. The LCC projection was selected for several reasons. First it gives balanced representation of all European countries as far as surface area is concerned, giving minimal distortion also on Scandinavia and Great Britain. Datum ETRS 89 was selected to comply European datum recommendations.

4.4 Combined data

Geographical vector data and indicator data were linked with the identification key being the NUTS code (see section 4.1). As a final result we had:

- shapefiles for whole Europe with 6 indicators as table attributes for NUTS levels 0, 1, 2 and 3, respectively.
- 4 shapefiles with 4 indicators as table attributes for level LAU2 for pilot study areas in Belgium, France, Hungary and Spain, respectively.

4.5 Metadata

Metadata is data about data. It is of extreme importance, since it gives qualitative parameters of the data itself. As any map, also interactive map should deliver basic metadata about the data that are presented on the map. The actual set of metadata for Interactive map is still in discussion in the time of writing this article. Final solution should not be far from the proposition of this minimum set of metadata: short description of data, owner of data, source of data, year of last update/year of validity of data, and optionally also spatial entities covered, entireness and thematic accuracy.

5 MAP DESIGN

The preparation and design of the map was done in the selected Web Mapping software GeoServer. The final look however is configured later within the Web application (see section 6). To design the map the following steps were taken:

- installation and configuring of the GeoServer,
- pre-processing and reprojecting of the data (described within section 4),
- uploading of the data to the GeoServer, and
- rendering of data-layers by implementing OGC's XML-based coding scheme Styled Layer Descriptor (SLD).

When those steps were taken, the GeoServer was ready to accept the HTTP request according to WMS standards. As a response GeoServer returns a layer (as a part of a map), either layer's legend or layer's feature information.
For every available combination of indicator and NUTSx/LAU2 level a separate layer was prepared.

6 WEB APPLICATION

Web application combines the Map with needed visual and contextual tools for exploring the Map. For the mapping tools implementation the open source library OpenLayers was selected. Since OpenLayers is a JavaScript library, JavaScript was naturally selected to be main design language of the web application. To build the web application the following steps were taken:

- graphical design of the web-page,
- composition of the Map from WMS layers from GeoServer using the WMS requests GetMap, GetLegend and getFeatureInfo,
- implement needed tools from the OpenLayers library, and
- design and implement proprietary tools if they are not available within the OpenLayers library.

Implemented OpenLayers tools are (all OpenLayers tools a graphical design was changed from the default one):

- Different zoom and pan tools: These are tools to change the geographical area that is shown on the map by changing the scale of the map (zoom-tools) and by moving the map (pan-tools). The following tools were implemented: Zoom Slider, Zoom In, Zoom Previous, Zoom Next, Zoom to Full Extent; Pan Arrows, Pan Hand.
- Current scale and current cursor position on the map (x, y) in selected projection (see section 4.3.), given in 'meters'.
- Overview map: small map in which rectangle shows the extent that is presented on the main map
- Identify tool: displays attribute data (indicators) of all layers of the clicked point on the map

Implemented proprietary tools:

- Selection of indicator and level of details NUTSx/LAU2 to be presented on the map. The legend corresponding to the indicator is also displayed.
- Zoom to country: tool that enables direct zoom to each EU country.

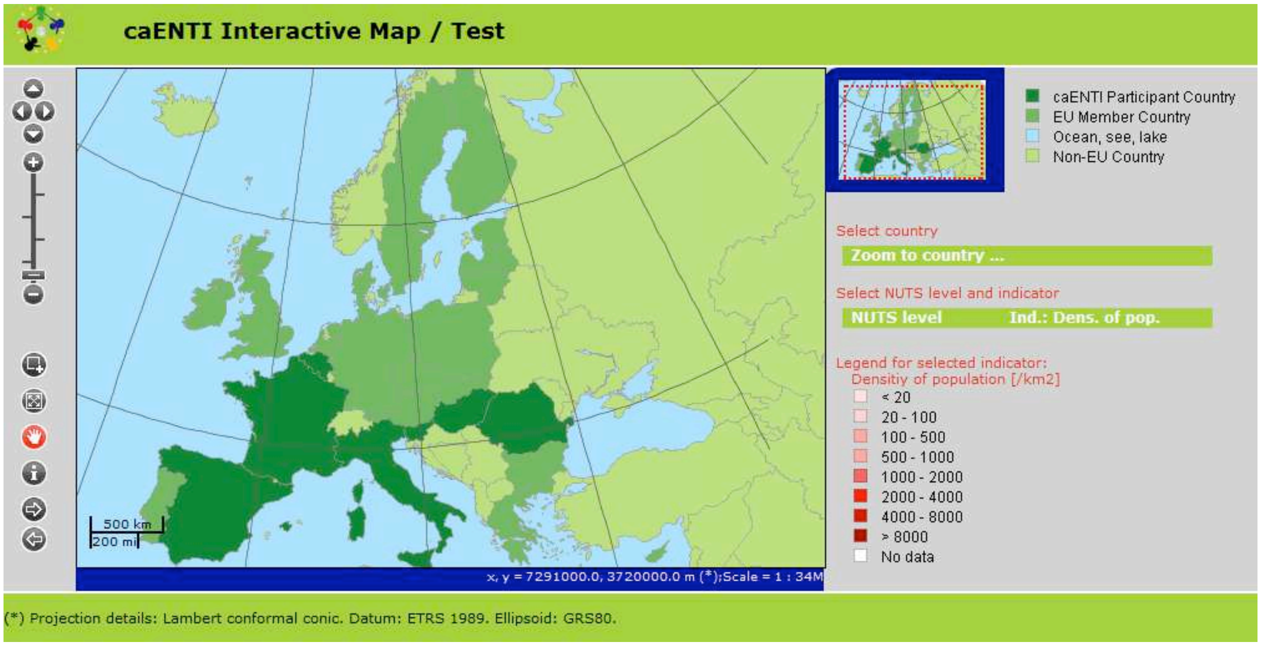

Figure 4: One of the development phases of Web application. Map is delivered by Web mapping software GeoServer, tools are written in JavaScript.

7 CONCLUSION

In its final form the Interactive map of caENTI will enable visual presentation of 6 selected socio-economic indicators for EU countries in different levels of detail from NUTS0 to LAU2. The proposed solution is based on the open source Web mapping technology; the selected software tools are GeoServer (for Web mapping) and JavaScript-based library OpenLayers (for Map tools). The caENTI Web mapping portal will be simple to use and the end user will need just standard compliant web browser and only basic computer skills will be required.

At the time of preparation of this article the interactive map was still in the development phase. Several things were still extensively discussed, such as metadata service, output possibilities and security. Also the end location of the system was not yet established, while the test implementation was running fully in the location of Scientific Research Centre of the Slovenian Academy of Sciences and Arts. Nevertheless it can be said that Interactive map has a potential to become very powerful tool for technical teams of the caENTI member groups and the whole European community to get appropriate visual and contextual information, thus it can become very important aid for analysis and research.

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