TOWARD A FREE IMPLEMENTATION OF A MODEL OF GEOSPATIAL INFORMATION MANAGEMENT TO WEBMAPPING APPLICATIONS. COMPONENT OF ANALYSIS

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ABSTRACT

Based on the wide use of geographic information systems (GIS), and their impact on decision-making processes in organizations of several kinds, the present paper aims to establish the bases an overall general model of geospatial information management -based on international interoperability standards- , whose computational realization should be the basis for the development of custom GIS applications to fit under the principle of technological sovereignty in Cuba and support of the Spatial Data Infrastructure of Republic of Cuba (IDERC). It is presented in an explicit way the technological architecture to support the proposed model in web mapping applications and the computational implementation of two plugins for the analysis component.

Keywords: analysis, model, web mapping

1 INTRODUCTION

The introduction of the increasing technological advances in communications, the development of powerful computing resources and in particular the release to the market of powerful software for storage, analysis and representation of geographic information, enable the modeling in a digital environment virtually any phenomenon capable of being referred spatially.

While there are several definitions of Geographic Information System (GIS), most agree that its main elements are the hardware, software, data and applications used by users to manage, analyze and deploy geographically referenced information.

Just as accessing other information via the Internet or the local network, it is also possible to use this one to access geographic information and work with it in a GIS. In the present context, it is not reliable to depend only on a GIS with local data as files on the same computer on which you are working, because it is necessary to operate with remote data. Networking is the way to disseminate all kind of information including geographical information.

Web mapping applications refers to the process of designing, implementing, generating and displaying or offering geospatial data through the World Wide Web (Mitchell, 2005); to provide to a Web browser viewing or editing capabilities of geographic information makes these systems to reach a different audience and opens new possibilities. While a desktop GIS it is mainly intended for more specialized users.

In recent years efforts in Cuba have been focused primarily on the development of GIS applications as well as in the implementation of the Spatial Data Infrastructure of the Republic of Cuba (IDERC, from its Spanish acronym), combining the efforts of several companies, research centers and universities in general. Despite the efforts and the progress made by various institutions in the development of this kind of applications, technologies associated with GIS which are used in the country come from different suppliers - mostly private companies -, have created a technological dependency unsustainable over time.

For these reasons, the design and implementation of solutions based on open source alternatives represents an ongoing challenge for the professionals of this field in Cuba, because of the impact of these technologies in the processes of decision-making in organizations whose field of action is of vital importance for our society.

Taking into consideration the defined elements are presented a set of questions that constitute the main motivation of this research:

2. MODEL OVERVIEW

In the overall conception of a model concerning spatial information management are identified three main components. That are significantly affect by computational geometry, these components enables the implementation of several kind of applications as shown in figure 1.

Data Storage: mainly refers to the way in which geographic data are organized, either by digital mapping or geospatial database.

Information representation: primarily involves the representation of data such as roads, elevations, water systems, etc., mainly in vectorial format and / or raster, plus the way the information in thematic maps for analysis is presented.

Geospatial analysis: refers applying statistical, geometric or other technical analysis on geographically referenced data.

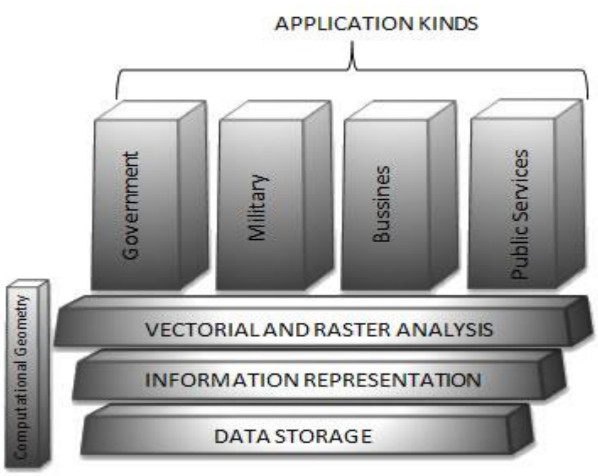

Figure 1. Abstract view of model of geospatial information management.

Following the purpose of migration to free software was realized an analysis of existing technologies for computational implementation of the model presented above, reflected in Figure 2 an architectural high level view of the main elements that make up each of the model components. Over a data access layer are orchestrated a set of digital mapping services and as proprietary information of the application domain, which provide the upper layers of the interaction mechanisms required to build the view of end users and well exposed main selected technologies.

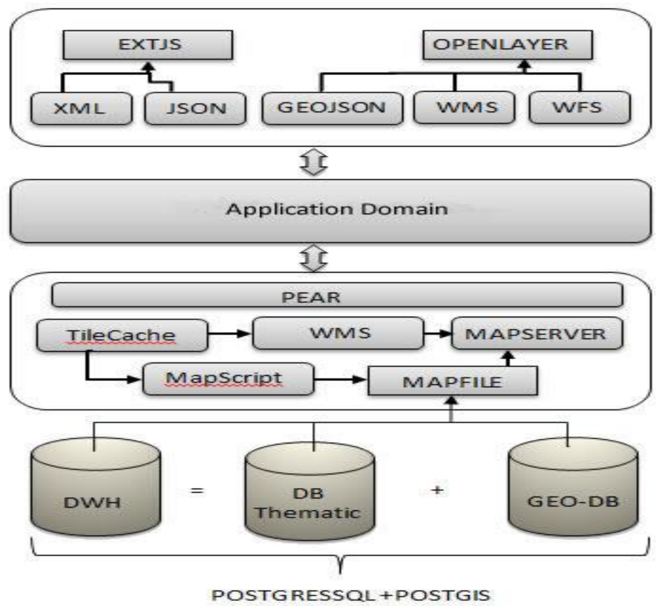

Figure 2. High level view of architecture of computational implementation of model.

In this case stand out as fundamental:

- Linux as operating system.
- Apache as Web server application.
- PostgreSQL and PostGIS spatial extension as manager databases.
- MapServer as Web server maps.
- PHP and Javascript- with ExtJS library in designing the user interface - like programming languages.

The implementation of the corresponding services of the application domain layer was implemented using an object-oriented and component based -

called plugin in this paper- architecture ensuring scalability and reusability as shown in Figure 3.

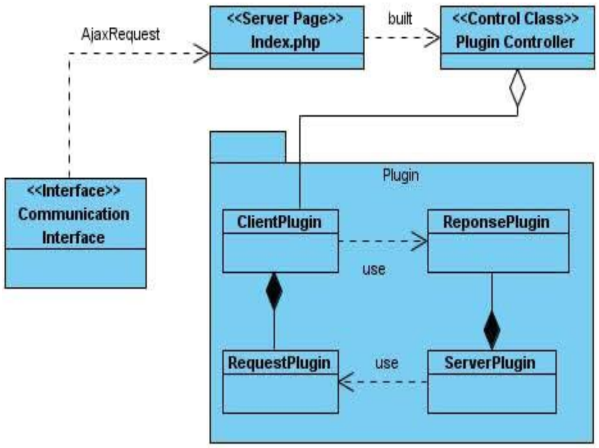

Figure 3. Architecture view of Application Domain.

3. APPLICATION DOMAIN IMPLEMENTATION.

It is here where the main contributions in this stage of the work presented, developing the functionality for creating thematic maps and geometric analysis.

3.1 CREATION OF THEMATIC MAPS

The characteristics of thematic maps come from qualitative and quantitative data. In a qualitative map are shown the spatial distribution or the situation of a group of nominal data, one of its features is that in this kind of maps it is impossible to determine the relations of quantity. The data representing these maps are punctual, lineal and of surface (Aguirre et al, 1998):

The quantitative map is very used to represent all kind of themes such as social, economic and environmental benefits at a national, regional and local level. Different entities require representing quantitative information geographically referenced, specialized and accurate.

Quantitative maps are the result of the application of quantum and experimental sciences, supported primarily on descriptive statistics. These maps generally represent punctual, lineal or area distribution data, even the combination of them.

The developed plugin is based mainly on working with expressions belonging to the classes of the maps layers which are being used. It allows the work with various formats such as ESRI Shape (.shp), MapInfo (.tab, .mif), GML and Postgres / Postgis, this latter being used as native to the general module.

The figures 4 and 5 show some of the results obtained with the use of the developed plugin.

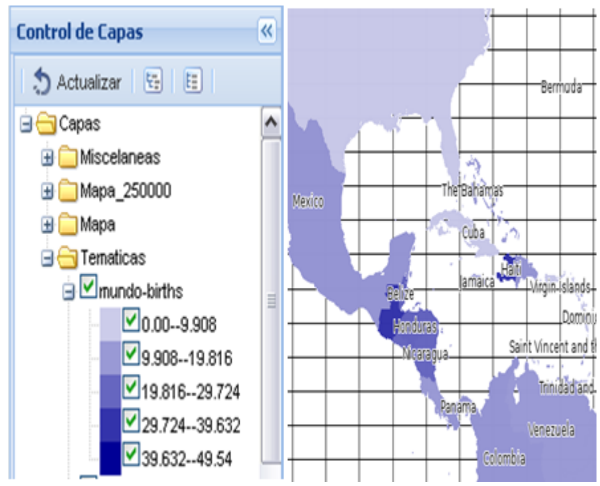

Figure 4. Generated Choropleth map showing.

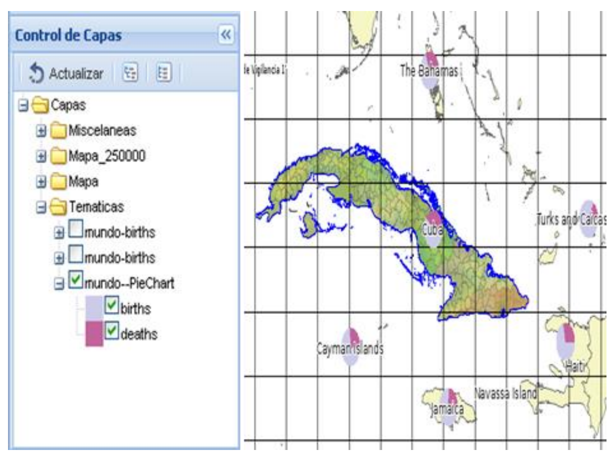

Figure 5. Generated map with graphic.

3.2 GEOMETRIC ANALYSIS

For the geometric analysis plugin of the module, a generic algorithm was designed which was independent of the coordinate system and/or projection in which the data resides. On which subsequently can be implemented a set of basic geometric algorithms, which help to build more complex analysis algorithms (Olaya, 2011) (Haining, 2003).

The proposed generic algorithm in (Ramón et al, 2012), take into account the property of bijectivity of the cartographic projections. So if working in projected coordinates is possible to obtain ellipsoidal coordinates for the reference ellipsoid of the beginning. Hence the idea presented is as follows:

- If you are working in a projected system then you can work with algorithms for planar coordinates or algorithms for ellipsoidal coordinates after a previous transformation of planar coordinates to ellipsoidal.
    - This decision may be taken by the user in case it is an expert, by default it would work converting ellipsoidal coordinates.
- In case it is not working on a projected system then it could work with algorithms for ellipsoidal coordinates.

This generic criteria for geometric analysis in GIS was selected as a base to accordingly design the algorithms used to calculate distance, perimeter, azimuth, areas and buffer zone. Basically, were proposed for the distance in the plane the classical Euclidean formulation, and in the case of spherical distances the Haversine formulation because they present more computational stability. Subsequently linked both proposals according to the presented generic variant (Ramón, et al, 2012).

In the case of the area of polygons in the plane it is reported in the specialized literature a very efficient algorithm for solving it with complexity O(n), where n is the number of vertices. The algorithm uses the incremental technique, based on the calculation of the areas of the triangles formed by three vertices of the polygon starting from a fixed vertex (Chen, 1996). In the case of simple spherical polygons, the most widespread version is presented by (Bevis et al, 1987), which presents a constraint during digitizing of polygons and in case of being omitted it imposes a complexity of O (n log n) to the algorithm. For this reason, as one of the main contributions we designed a new algorithm that eliminated this restriction and maintained a complexity O(n) (Ramón et al, 2012).

4. RESULTS AND DISCUSSION

As principal results at this stage of this work, it has a conception of a general model of management of geospatial information and the description of the architecture for its computational implementation based on free technologies. That will allow

- Reduced costs of production in the updating and management process of geospatial information.
- Increased efficiency in the production of geospatial information.
- Reduction of the scheduled time for the policies implementation of the computerization and migration to free software of data and applications.

Following the specification of architecture presented were developed two plugins for component of analysis. In the case of plugin for creating thematic maps, it allows integration of geospatial data stored in Postgres / PostGIS with alphanumeric information stored in external sources such as Excel or other databases that this related with the data displayed. Being this the main innovation in a systems of this kind, since generally the existing solutions, mainly the free and open source applications only allow data theming stored with the cartography and not in external sources (Ramon, et al 2011)

For plugin of geometric analysis as was mentioned was developed a new algorithm for the area of simple spherical polygons arriving to the following theorem:

Theorem 1. The area of a polygon may be computed, taking into account the coordinate system in which it is, on a time O (n), where n is its number of vertices.

To verify that the results in a real practice correspond to the theoretically obtained results, a set of tests were made to compare what difference there was among the results of the proposed algorithm for the calculation of spherical polygons area, and the results shown by the algorithms currently implemented in geographic information systems with open and close source code respectively, Figure 6.

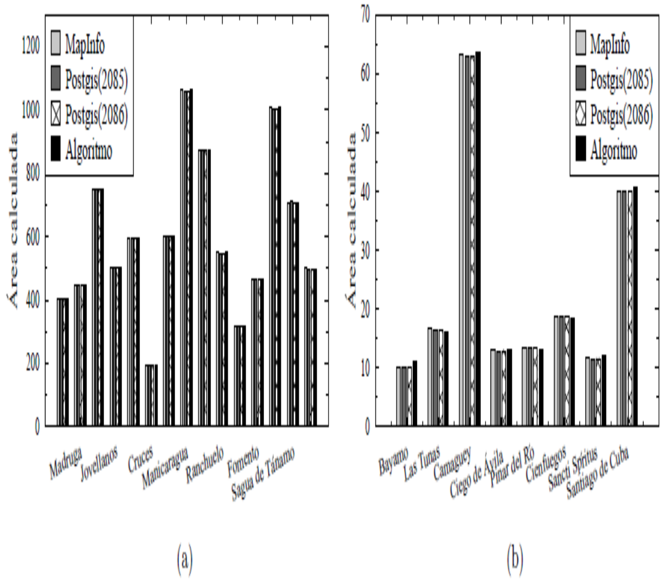

Figure 6. Obtained results over scale mapping based on 1:500 000 (a) and 1:100 000 (b).

5 CONCLUSIONS

As the most important topics and concluding it is remarked that:

- The specification of architecture presented with free tools and technologies, besides complying with OpenGIS specifications established by the OGC and consistent with the policies of migration to free software and technological sovereignty which drives our country, makes easy to respond efficiently and effectively to the needs of geospatial information and support of the IDERC, and the current requirements and perspectives of the national market, economic growth, the country's readiness to achieve military invulnerability.

- With the implementation of a plugin to generate thematic maps, it is ensured the creation of these from statistic data provided by the users and the selected geographic base. This, together with the techniques used for multidimensional analysis of data generated as a result of all transactions that take place in daily activity, is useful as a support for decision-making processes.

- The generic algorithm designed to perform geometric analysis - specifically for calculating the area of a polygon - which is independent of the coordinate system and/or projection in which the data resides, ensures comparable results to traditional variants while reducing the response time to requests, because the calculations are performed in an O(n) order - where n is the number of vertices of the polygon in question - in any case.

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