

XGIS Flex: A Free and Open Source Framework for the Development of the Geographic Information Systems on the Web

Mariano F. Pascaul, George Sand
L. Araújo
Geosciences Institute
University of Brasilia
Camp. Darcy Ribeiro –DF– Brazil
{mariano, georgesand}@unb.br

Maristela Holanda
Depart. of Computer Science
University of Brasilia
Camp. Darcy Ribeiro –DF– Brazil
mholanda@unb.br

Edson E. Sano
Inst. of the Environment and
Renewable Natural Resources
SCEN trecho 2 Ed.Sede – DF – Brazil
sano@ibama.gov

Abstract—Geographic Information Systems on the web (web GIS) are currently implemented for different purposes. This paper presents a framework to develop web GIS with free and open source software, for interoperability between different sources of heterogeneous data, as well as the visualization of maps in different formats with components implemented with a Web 2.0 concept. We present two case studies that implemented a web GIS to Japan International Cooperation Agency – JICA together with the Secretary of Planning and Modernization of Public Management by the Government of the State of Tocantins – Seplan-TO and a web GIS for the Brazilian Institute of the Environment and Renewable Natural Resources – IBAMA.

Keywords-GIS; web; Flex; open source

I. INTRODUCTION

A Geographic Information System (GIS) is frequently defined as the combination of a database management system, a set of operations for exploring data, and a graphic display system that is used for geospatial analysis. These GIS analyses have the main purpose of supporting decision making and modeling some of the possible consequences of those decisions [2][4][7][27][30]. GIS environments are also cartographic tools that facilitate creating maps and examining the impact of changes to the maps interactively [14][17][21][26][27].

GIS on the web (web GIS) is currently being developed, and one challenge in that environment is interoperability among heterogeneous databases. For interoperability of the data, web services technology is being used [10]. The standard set by the Open GIS Consortium (OGC) proposes open service architecture of web GIS to support data-interoperability. And, it suggests the use of Geographic Markup Language (GML) based on XML to exchange the data between the web client and the web GIS [13][16]. The REST [22] technology is also used to support interoperability with geographical databases.

For the visualization of maps in an interactive way, Web 2.0 technology is being applied through different components of Rich Internet Application (RIA) [35]. As is observed in [15], this technology is being applied in the

development of web GIS. Web mapping applications such as Google Maps, Google Earth, Microsoft Bing Maps and Yahoo Maps are usually considered good examples of Web 2.0 [10].

In this environment, the free and open source software FOSS community has developed solutions for GIS implementation, database management systems with free spatial extension and high performing map servers. One of the elements that facilitated the distribution and use of these free tools was the standard defined for interoperability between data and the applications used for the development of a GIS [6] [29].

This paper presents XGIS Flex — a framework to develop web GIS with free and open source software, with interoperability between different sources of heterogeneous data, as well as the visualization of maps in different formats whose components are implemented with a Web 2.0 concept. This framework was used to implement two case studies presented in this paper.

The content of this paper is divided into the following sections: 2 – basic concepts about web GIS are presented; 3 – the XGIS Flex framework is defined; 4 – Related Works, analyses; 5 – Case Study, where the architecture was used to develop the GIS for the Japan International Cooperation Agency – JICA in partnership with the Secretary of Planning and Modernization of Public Management by the Government of the State of Tocantins – Seplan-TO and of the Brazilian Institute for the Environment and Renewable Resources – Ibama; and finally, 6 – Conclusions.

II. GEOGRAPHIC INFORMATION SYSTEM ON THE WEB

Geographic Information System on the Web is any GIS that uses web technologies. The simplest form of web GIS should have at least a server and a client, where the server is a Web application server, and the client is a web browser, a desktop application, or a mobile application [5][10].

The architecture of a web GIS is most commonly based on the use of three layers: User Interface Layer, Application Server Layer and Database Layer [3][9][28]. Some authors considered four layers, where the integration layer is added on the web GIS architecture, which is based on web services [32].

The User Interface layer serves as a graphic user interface (GUI) to present the result of spatial data, allowing the end users to interact with the backend services. The Application Server layer communicates with multiple data sources via the data integration layer, and interacts with end users to analyze and manipulate data coming from data provider services. The Database layer of data provider services is a set of remote data provider services for data sharing. Each data provider service offers a set of interfaces through which client applications can pull remote data in and manipulate the data.

III. XGIS FLEX FRAMEWORK

The XGIS framework was developed to be a free and open source option for the platforms developed in Flex. The XGIS enables the navigator for use in RIA and high performance Web 2.0 concept environments. There is interaction with OGC standard web services, such as WMS, WFS, WFS-T e WCS, REST, as well as files such as GPX, KML, SHP and other formats including JSON and GeorSS. With XGIS, it is possible to visualize data from different web services. It is not aim of the XGIS to offer web services. Besides visualization, the XGIS has some functionality, such as, extract data from many formats, measure distances, area and several graphics. In the next section, each one of these functions is shown through the components.

The XGIS is strongly linked and integrated to the Map Server Geoserver (Java), which is a high performance interactive map server as presented in [25], having interoperability of the open source with multiple connectors for the sources of data such as PostGIS, Oracle, SQL Server, DB2, SDE, shapefiles and others. With this framework it is also possible to visualize data coming from other map servers, such as ArcGIS Server or MapServer and fuse services, such as, Microsoft Bing, OpenStreet Maps (OSM), Yahoo Maps and others.

A. XGIS Flex Framework Components

The XGIS Framework has various components. These components were developed based on the architecture presented in [23]. Figure 1 presents the components, where the XGIS framework components are represented by strong lines, and dashed lines are presented for the software used in the web GIS environment. Each one of the components of the framework is described below.

The GPX, KML and Shapefile Overlay Component enables the opening of shapefile files and their attributes, providing the overlay of geometries available in .shp files in the web Flex environment. The constant attributes in .dbf files are presented in a tabular format and related to the correspondent geometry. The features that can be viewed are: line, point, or polygon. If the set of files is projected in a system distinct to the map base, the inclusion of the compacted file .prj is necessary for the system to complete re-projection. This component reaches a large quantity of Garmim brand GPS field equipment users and, therefore, this was strongly recommended in the development of this component, which makes the overlay of files downloaded directly from equipment of this type possible. All of the

waypoints available to track overlays of a line are presented, in which the initial point is presented in green, the path in yellow and the end in red. The attributes given to the paths are shown in a floating table. The KML Overlay is a component that provides the opening and comparison of the routes generated in Google Map platforms, and also in simple files in KML format; the available attributes in the file referenced are also presented in splints through floating panels.

The Vectorization component class serves the vectorization and release in distinct database formats, such as lines, points and polygons. Algorithms for the calculation of the area and perimeter are also used in the class; the user can opt to save the designed features on a local disc in JSON format or directly in the database. When drawing, it is possible to add or edit new vertexes and exclude former ones or all polygons, lines or points drawn.

The Export Data Component is totally integrated with Geoserver Java map server. Through this component, it is also possible to make the selection and later export and download layers or a part of them in diverse formats such as shapefile, csv, pdf, xls, kml, kmz, jpg, png.

The Navigation and Data Tabs Component is a presentation component, in which formatting grids were built with the aim of improving the visual aspect of register lists extracted from the database. There is frequent interaction between the navigation and consultation of attributes related to the geometry visualized.

The Treatment of Geographic Database Component aims at adopting the tool of a set of classes capable of treating incoming information from the interface, which will be sent to the database. With this tool one can select which type of database will be used and the classes will be the interactions necessary for a correct treatment of distinct types between the manufacturers of DBMSs. Treatment of geographic features is a set with the minimum rules necessary to avoid classical errors at the moment of vectorization, such as the creation of polygonal ties.

The Charts are tools for which geographic database tables, or simply web services about them, can be chosen by way of selection boxes, from which one can select numerical attributes and vectorize an area on the screen resulting in charts. These are interesting analytical tools for statistical data, however with geographic presentation and selection. Taking advantage of the available functionality in the SDK Flex, the following types of graphics were used: lines, columns, bars, pizza, candlestick and areas.

Media Overlay is the component responsible for the overlaying of videos, photography and documents over maps, for the most part, representing a strong Web 2.0 concept. For the development of this component, it was necessary to map and treat the types of media data available in the main DBMSs on the market so that the consultation and overlaying of these on the maps become possible.

B. XGIS to Develop web GIS

The XGIS framework was designed to be user friendly. If the user of the XGIS is not a software developer, he or she

will still be able to customize an application easily and quickly, needing only to edit XML extension files. With the configuration files in XML one can define which map services can be used, in which tables it will be possible to edit data, titles and subtitles of the system, logotypes or brands, data subtitle, symbols, and the individual configuration of each component developed.

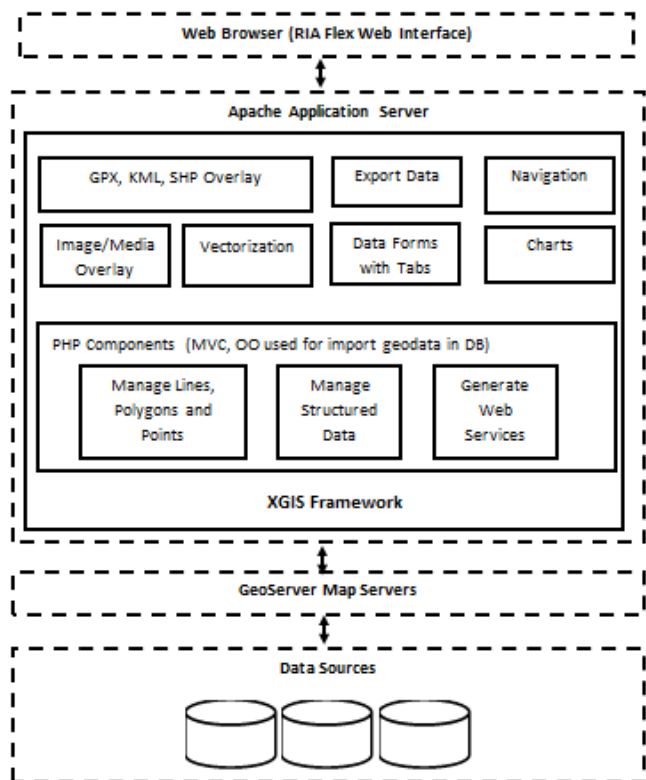


Figure 1 – Components of the XGIS.

Figure 2 lists a piece of the code of the XML file of the configuration of layers to be shown on the spatial interface with tags already configured.

```
<?xml version="1.0" encoding="UTF-8"?>
<camadas>
  <camada>
    <name>Estados</name>
    <url>http://corredorjalapao.seplan.to.gov.br:8080/geoserver/jalapao/wms</url>
    <layers>jalapao:estados</layers>
    <projection>EPSG:900913</projection>
    <format>image/png</format>
    <maxExtent>-180,-90,180,90</maxExtent>
    <version>1.1.0</version>
    <visible>true</visible>
    <transparent>true</transparent>
    <tiled>true</tiled>
  </camada>
  <camada>
    ...
  </camada>
  ...
</camadas>
```

Figure 2 – XGIS Configuration File.

Besides being able to quickly implement an interface of interactive maps, another feature of the framework is in the

engine of web service for the interaction between the web forms projected in the Flex environment and different types of databases. The engine was built in PHP language and treats connections with the SGBDs MySQL, PostgreSQL, SQLite, Oracle and SQL Server and its spatial extensions, thus, it is possible to have a programming language for developing new components that interact with textual and geographic data. In case the user of the Framework does not want to use the PHP motor incorporated, he can use whichever programming language he wants to Interact with the maps: C#, Java, Phytion, among others. The tools just need access to the data via web-services that can be easily available in other languages.

The layer of data presentation always exhibits a standardized layout, as shown in Figure 3, making the use of the application easier. This characteristic is possible because the components that were developed in Flex using ActionScript follow the MVC—Model, Vision and Control model [36]. The developer has only to design the form using a graphic environment and make it available to the web service corresponding to the database tables he or she wishes to interact with using and extending the set of codes developed. It does not matter which DBMS the user uses, it's merely necessary to alter the data that pertains to the connection, such as user, password, IP address and type of DBMS to be connected.

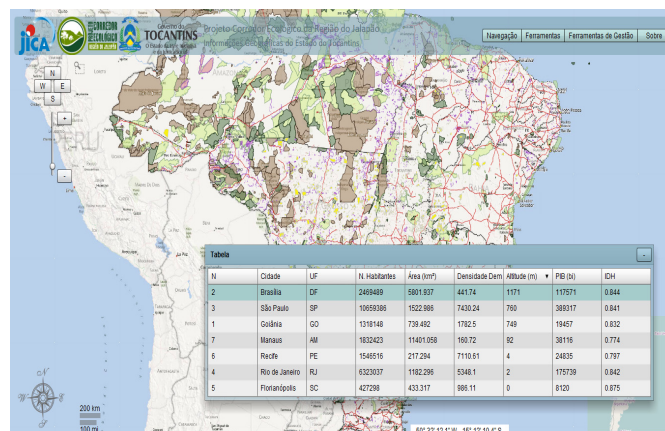


Figure 3 – XGIS Standard Layout.

IMPLEMENTATION OF THE XGIS FRAMEWORK

Some free and open source libraries were used for the development of the XGIS components. The highlighted libraries described below are among the libraries used.

The SDK Flex [1] has a set of components available, including: buttons, list boxes, tree-views, data grids, text control objects, layout containers, graphic components, animations, status applications, modal dialogue boxes, among others. The Openscales libraries [18] were also widely used and an extension of the majority of the classes of the library, as well as the creation of new components and classes.

Other sources and free components written in ActionScript were used and organized within the XGIS

framework, such as, file reading components of extension shp, shx and dbfs and, of the watermark insertion in the application [31].

The PHP components manage the entrance of vectoral data that are sent by web interface such as lines, point, polygons and projection systems. Textual data are also controlled, making not only the presentation of information over maps easier, but also the insertion, alteration, exclusion and consultation of the same directly from the data base.

IV. RELATED WORKS

Different tools for aiding in the development of web GIS with free and open source software are found in the literature and there are proprietary tools with closed sources. Some of these tools are presented as follows.

The ESRI makes an API for Flex [8] available for developing web GIS with web 2.0 characteristics, however, it is a proprietary closed source framework. A negative point is the strong linkage existing between the ESRI framework and map services originating from ArcGIS Server servers, also proprietary and costly to implement.

Google has an environment available for development in Flex, Google Maps API for Flex [12], however, it is also proprietary. The great advantage of this environment is the popularity of its base maps, which have excellent quality since Google invests heavily in the acquisition of cartographic bases, and the service provides very high performance as well. The negative points are the low quantity of available functions, presenting itself more as a compiled library to be incorporated to another Flex application and its proprietary source is unalterable.

The i3Geo [24] is a web software based on a set of other free software, mainly Mapserver. The main focus is the availability of geographic data and a set of tools for navigation, analysis management, on demand map sharing, and management. It is strongly linked to MapServer, free standard web services management software OGC, but from the first generation not high performing nor created for editing geographic data via web, as is Geoserver.

Four libraries are considered free frameworks for web GIS development written in JavaScript: OpenLayers [19], GeoExt [11], OpenScale [18] and MapFish [20]. Each one of these is described as follows.

OpenLayers is a JavaScript library accessed as API, however, with an open source and one that currently presents as a library used mainly for the support and inclusion of maps on web pages, this is because of its versatility, able to adapt to diverse languages and modern web browsers. Another advantage is in the capacity of mash-ups between sources such as Google Maps, MsBingMaps, Yahoo Maps, OSM and others.

GeoExt presents itself as a JavaScript Toolkit for Rich Web Mapping Applications that is basically an OpenLayers library, but with resources that raise the level of the applications developed, making them closer to a desktop application, while still in a web environment. It is a recent project, still in its first versions.

Openscales is a framework written in ActionScript 3 with an LGPL license type. Its libraries are widely used in our

solution, but are limited to support the navigation maps. Classes used in the framework presented in this paper have been extended, the engine optimized and many additional components were created.

MapFish is a framework to be developed from the web applications written in Python. These new classes present functionality for the construction of applications of the web mapping type. MapFish makes a Java Script toolbox available composed of Openlayers, GeoExt and ExtJS.

Unlike the libraries listed above, the XGIS is a full framework for developing web GIS since it interacts manipulating textual and spatial data from different DBMSs, besides dealing with the rendering of maps and pictures, and interacts as a tool Web 2.0 RIA with photos, georeferenced video and documents. The main idea of XGIS is the possibility of accelerating the development of GIS applications for web environments that are easily integrated and do not require programming knowledge to implement, and always maintain a good visual presentation.

V. CASE STUDY

The XGIS framework was used in different GIS, as we can see in [33][34], among others. In this article we present two systems that we consider the most complete in terms of use of framework functions, described as follows.

Description

The Framework was recently tested in the implementation of the two web GIS. The first, the JICA - Japan International Cooperation Agency, together with the Secretary of Planning and Modernization of Public Management of the Government of the State of Tocantins – Seplan—TO in the implementation of the Monitoring System of the Ecological Corridor of the Jalapão Region. The second one was implemented at the Brazilian Institute for the Environment and Renewable Natural Resources – Ibama making a new interface of maps from SisCom -- Shared System available, of which, among others, is responsible for the availability of information in embargoed areas.

Specifically, in the case of the application of the Framework for JICA and the Government of the State of Tocantins, the set of components facilitated the integration of data from different sources. Both institutions dispute spatial data basically in file format, the majority being shapefiles, satellite images in TIF and geographic data in Oracle database with spatial extensions. Nonetheless, the creation of a geographic database with data already validated using PostgreSQL with spatial PostGIS was decided upon.

In this case, the entire application was customized and implemented in one day, having been necessary the creation of the web map services from the distinct sources of data using Geoserver and, later carry out the appointments within the application using the extension files XML. Other files from the same extension were also configured, aiming at altering the logotypes, brand names, title, and subtitle of the application, addresses of services and dynamic captions, among others.

Evaluation

Figures 4 and 5 show two screens taken from the navigation of the application implemented. Figure 4 shows the web GIS with vectoral data only and some of their listed layers dynamically charged by a Geoserver server. The components, “Navigations and Data Tabs”, “Layers” and “Menus” are instanced together to the central motor of map navigation.

Figure 5 shows the result of a query in a vectoral database overlaid on the matrix data; they are basically images from the Alos satellite, Avnir sensor and images from the Microsoft Bing catalogue. The “Layers” component was used executing methods such as GetFeatureInfo for retrieving data regarding the layer selected, also it is possible to carry out queries using this same component by way of geographic selections, by simply selecting the area on the screen over which one you wish to research and

automatically the parameters are passed on by queries to the interactive map servers.

The result of the queries will always be a grid when the result obtained is greater or equal to two registers. In the Ibama case study, differently from the application implemented for the Jica with geographic extension of just one State, the application used the total extension of the country. The tools for generating graphics were activated and configured aimed at turning the application into a support system for making decisions in terms of the information related to the deforestation and embargoed areas.

Figure 6 shows a screen of the system implemented in the Center for Remote Sensing of the Institute at the moment of consulting georeferenced photography and videos. In this consultation, the components “Navigation and Data Tabs”, “Treatment of Geographic DataBase”, “Charts”, “Layers” and “Media Overlay” are active over the navigation motor.

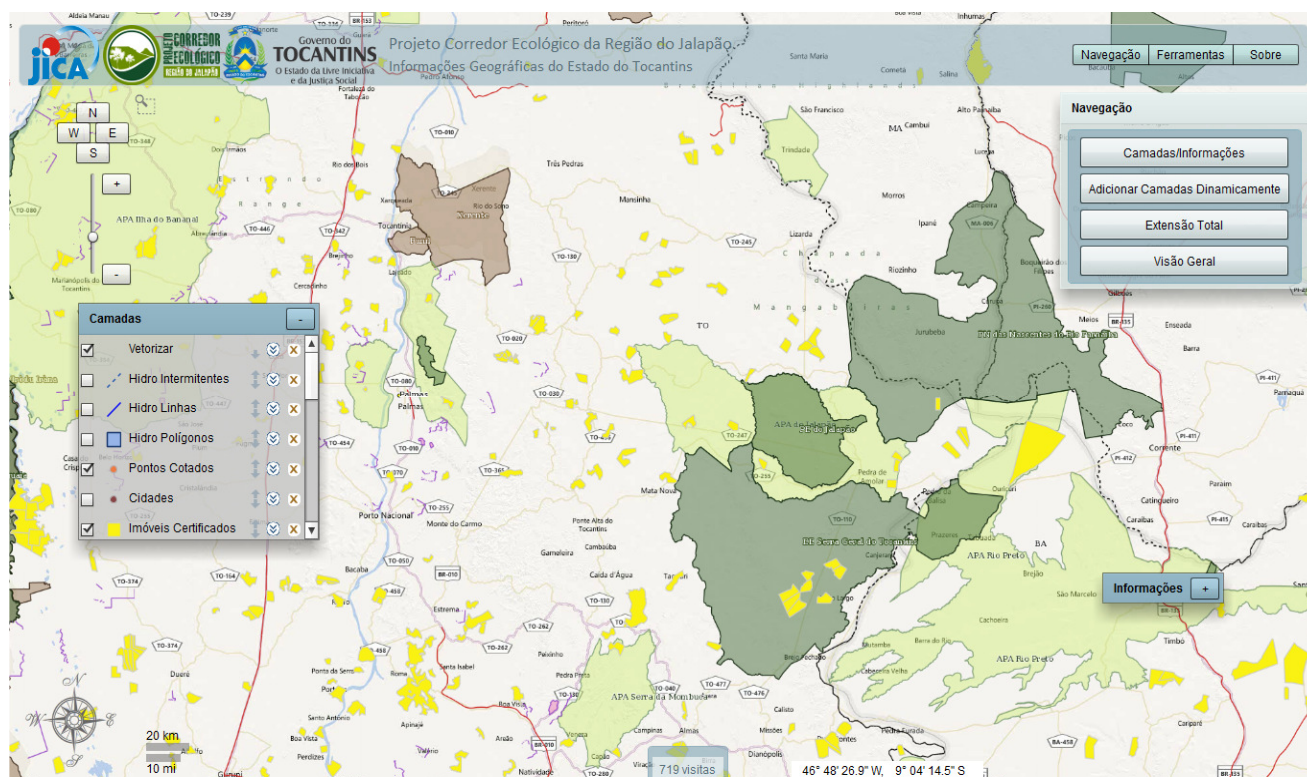


Figure 4 – Basic Navigation.

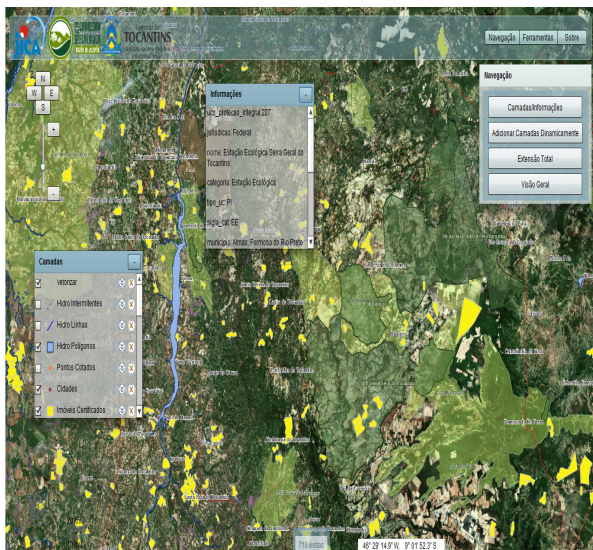


Figura 5 –Raster Navigation and Spatial Query.

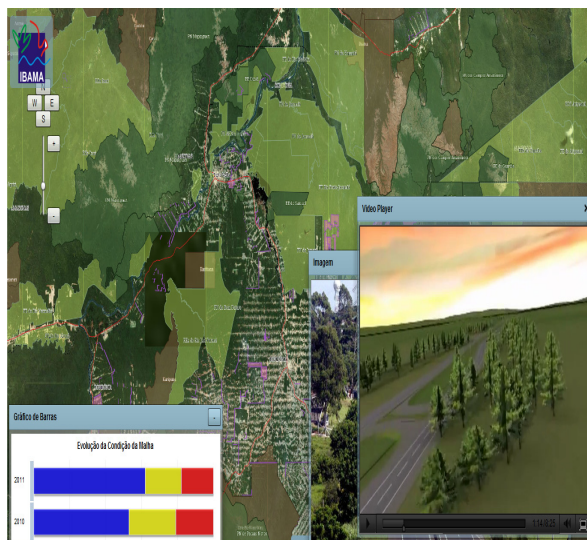


Figura 6 – Ibama Interface with Video Interaction/ Image.

VI. CONCLUSION AND FUTURE WORK

Architecture presented in this paper proposes a tool of rapid implementation and availability of web GIS, with a set of services made available that can easily integrate data of structured systems, such as consumption of information originating from diverse data sources. Textual and vectoral data can be easily manipulated, making not only query possible, but also the insertion, alteration and deletion of information directly in different types of market SGBDs.

The visualization of different media, such as videos, photography, documents and tables originating from map databases was one of the examples of Web 2.0 architecture functioning that impressed users because of its high performance.

The next steps include the development and integration of a 3-D environment, to be written using SDK Flex and OpenGI, to the Framework map environment, as well as, integration with social network tools, also using ActionScript and integration with mosaics and 360° photography and panoramas obtained through Gigapan robots. For the test phase in the 3-D environment data originating from laser profiling will be done through the collection of aerophotogrammetrical material in Brasilia in 2010.

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