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Review

gvSIG: A GIS desktop key for an open SDI

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This paper describes gvSIG project, from its beginning until the current status. This open source project, started as a first approach to become the open source geographic information system of the administration in Valencia region and has become a reference project within the GIS world from the proprietary level applications until open source projects. gvSIG has cross many country borders and chase to reach the status of an "all-in" application, with an integrated behaviour unifying CAD and GIS worlds, vector and raster, integrating local data work with Spatial data infrastructure information and services, two dimensions world with 3D and 4D, building a tool used by GIS users at all levels.

Key words: SDI, OGC, open source, interoperability, desktop clients.

INTRODUCTION

gvSIG started in 2002 when the Regional Ministry of Infrastructure and Transport (CIT) of Valencia started to analyze the process of migrating the whole organization computer system to an open source system. The first phase was to achieve an analysis of different proprietary software applications used in all the organization areas, the main goal of this exhaustive analysis was to find open source projects equivalent to each proprietary application. When studying the GIS applications used in the CIT the conclusion of this analysis was that there was no equivalent in the open source world for these applications, mainly ESRI and Autodesk products, but there were many open source development projects that could be used to develop an open source GIS with big chance of succeeding.

The migration process is aimed to be as transparent as possible for the end users, also one of the goals is to keep network status the same way as it is now, and change as few things as possible. The advantages obtained by migrating every system to open source are numerous; low cost avoiding the license payment, complete independency of any company formats and technologies, untied to market conditions imposed under oligopoly situations, more security and privacy because you own the source code which you can use as you want. Adaptability, modifications and bug fixing is faster due that applications are continuing evolving, quality; open source is being continuously debugged and the last one, and one of the more important advantages, is the use of standards to agree the level of interoperability needed.

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Motivation

The gvSIG client was created within the framework of a large-scale migration experiment, across the entire agency for Infrastructures and Transport (CIT), involving more than 200 users, from commercial proprietary software to free open source software. This included operating systems, desktop office suites, database management software, GIS and CAD. After an extensive user survey regarding the actual needs of the many GIS users at the agency, it was determined that a full GIS was not necessary for 90% of the users. Instead they needed access to spatial data, simple query capability, the ability to overlay and check for consistency, and basic output. Therefore the CIT published a call for tenders to build such as thick client application, with main restrictions being that the software should be open source and available for testing in both Java and C++ versions, and on both Windows and Linux platforms. The winning bid, consisting of a working prototype, has since then been developed into a rather fully-functional GIS client, now in its version 1.1. The development process has been a 4-way effort between the government agency funding the project (CIT), the company selected to implement (Iver), a university consultant on interoperability matters (University Jaume I), and the wider open software developer community.

The analysis of the current software used by the techni-

cians at the administrations showed that there was no equivalent in open source for the GIS and CAD software that fulfilled the requirements The requirements were that it must be an easy-of- use application and also powerful enough to cover all the GIS users needs.

After this conclusion the following step was to find out exactly which were the user requirements, thus, an exhaustive analysis was made to ask users which tools were they using. This was the beginning, the first task, of what will become the gvSIG project. The final report with the GIS&CAD users needs with the evaluation from users lead to the conclusion that 90% of the users utilized 20% of the functionality from the proprietary software, so that was affordable and possible to develop a software solution in open source to share with the rest of the GIS community. The main characteristics of the project inherited from the migration process had to be:

- Platform independent.
- Modular; it must be developed using independent modules adding scalability value.
- License GNU/GPL as the open source license adopted. This license is the one recommended by the Free Software Foundation. More precisely, it refers to four kinds of freedom, for the users of the software:

o The freedom to run the program, for any purpose (freedom 0).
o The freedom to study how the program works, and adapt it to your needs (freedom 1). Access to the source code is a precondition for this.
o The freedom to redistribute copies so you can help your neighbor (freedom 2).
o The freedom to improve the program, and release your improvements to the public, so that the whole community benefits (freedom 3). Access to the source code is a precondition for this.

- It must follow the current standards. gvSIG must be compliant with the GIS standards defined by the Open Geospatial Consortium (OGC). Being compliant with the standards guarantees the interoperability with all the GIS applications.

The first prototype of gvSIG was released on second of October of 2004. During the development process new stable versions have been released constantly, until the current 1.1 version.

Related work

Many open specifications and FOSS projects have been developed for the field of GIS. GRASS (http://grass.itc.it/) is a GIS free software package for raster and vector data analysis that has been around for more than 20 years. Open source geospatial libraries and databases like geotools, postgres (postGis) developments have been reutilized in gvSIG projects. A more recent development, SEXTANTE (http://www.sextantegis.com/) provides a set of tools for spatial analysis integrated as an organized set of extensions for the open source GIS gvSIG (http://www.gvsig.gva.es/). There is an open source project that should be specially mentioned uDIG (http://udig.refractions.net/), which is an open source desktop application framework, built with Eclipse Rich Client (RCP) technology. uDIG and gvSIG projects started at the same time they have different licenses, and differences in design goals, some of the reasons that made not possible the use of uDIG by the CIT.

Functionality

gvSIG. GIS desktop application

Nowadays gvSIG is considered a powerful SDI client. As a GIS application gvSIG is able to work with most known data formats, raster and vector like shape file, dxf, dwg, dgn and most of the geospatial databases like postgis, mysql, oracle, sd It provides most common GIS tools like data loading, map navigation, query map information like alphanumeric information, distance measurement, thematic cartography, legend edition using the most common legend types, labeling, feature selection by many selection types, data tables with statistics, ordering, table relations, table linking, layout manager, geoprocessing tools, CAD, raster processing, etc. Its SDI client condition permits the connection, through the use of standards, to OGC Services like OGC WMS, OGC WFS, OGC WCS, even to proprietary services like ArcIms accessing data and being able to overlap it and combine it in gvSIG map views. Discovery service client is also provided within gvSIG which can be use to localize data resources within an SDI.

Spatial data infrastructure and INSPIRE

The general situation on spatial information in Europe is the fragmentation of datasets and sources, gaps in availability, lack of harmonization between datasets at different geographical scales and duplication of information collection. These problems make it difficult to identify access and use data that is available. Fortunately, awareness is growing at national and at EU level about the need for quality geo-referenced information to support understanding of the complexity and interactions between human activities and environmental pressures and impacts (Figure 1). The INSPIRE initiative is therefore timely and relevant but also a major challenge given the general situation outlined above and the many stakeholder interests. INSPIRE Principles:

1.Data should be collected once and maintained at the level where this can be done most effectively.
2. It must be possible to combine seamlessly spatial data from different sources across the EU and share it bet-

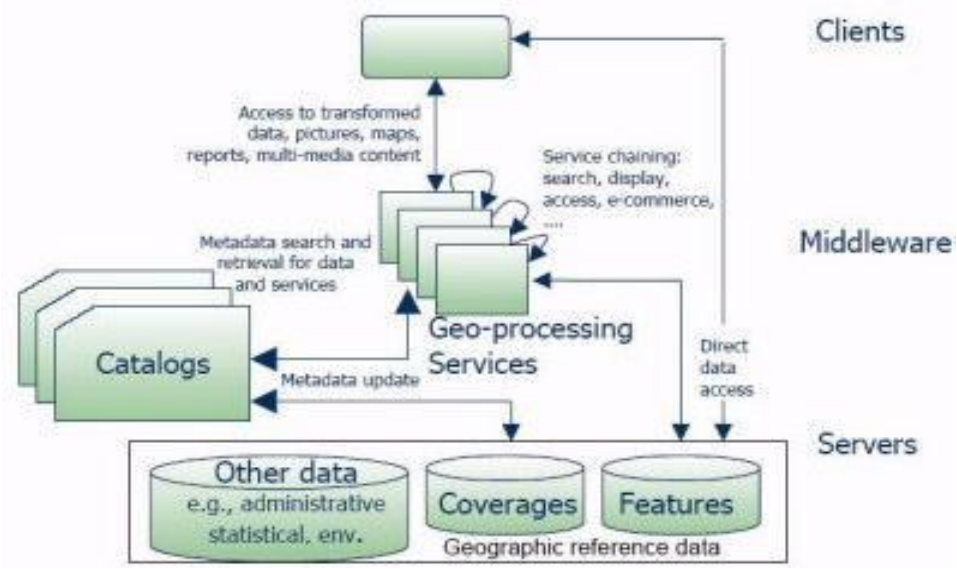

Figure 1. High-level SDI architecture, taken from Smits 2002.

ween many users and applications..
2. It must be possible for spatial data collected at one level of government to be shared between all levels of government
3. Spatial data needed for good governance should be available on conditions that are not restricting its extensive use
4. It should be easy to discover which spatial data is available, to evaluate its fitness for purpose and to know which conditions apply for its use.

gvSIG a standard client integrated in spatial data infrastructures

gvSIG project is developed along with the fact that SDI are becoming the infrastructures being deployed everywhere where users need to share and integrate spatial information. SDI becomes a new paradigm for managing geospatial information. Spatial Data Infrastructure comprises a set of policy and standards activities promoting creation of a geospatial information infrastructure to assist diverse user communities to collect, share, access and exploit geo-referenced information resources (Figures 2).

To access, share and integrate geospatial information client applications access standard distributed services, those services implement standard interfaces specified by the Open Geospatial Consortium, so the interoperability is reached at all levels. SDI move GIS applications to the SOA (Service Oriented Architecture) where the information, data and services are decentralized and distributed. Integrating spatial data over the Web implies several components and services linked via Internet following the SDI architecture.

According to most SDI definitions such as those of GSDI, FGDC and now INSPIRE, geodata are accessed remotely, and then are either processed remotely or downloaded –or otherwise acquired—for local processing in a client application. This geoprocesing dichotomy, essentially on-line or off-line, is supported by a range of thin to thick clients, ranging in complexity from a simple web browser to a full GIS application including HTTP or similar communication capability. The web services paradigm (www.w3.org/TR/ws-arch/) assumes or allows that the entire information system (spatial in this case) is available as interconnected components available via the web. While this is a laudable goal, in the near term quality-of-service and other interoperability issues are still a concern, and so many end users of geospatial information prefer to access data periodically to save and process locally.

gvSIG application wanted to integrate its powerful geoprocessing functionality and diverse tools into Spatial Data Infrastructures playing an important role, giving users complete access to SDI services and being able to work with this remote information using the power of a rich client. Users benefit is key, users can work with local data and also with all the remote distributed information integrated in the SDI by standard services. gvSIG as a SDI client integrated in the SDI has client interfaces connection to the following standards:

Web mapping services (WMS): Raster and vector data returned as georeferenced map images. WMS produces maps of spatially referenced data dynamically from geographic information. This International Standard defines a "map" to be a portrayal of geographic information as a digital image file suitable for display on a computer screen. A map is not the data itself. WMS-produced maps are generally rendered in a pictorial format such as PNG, GIF

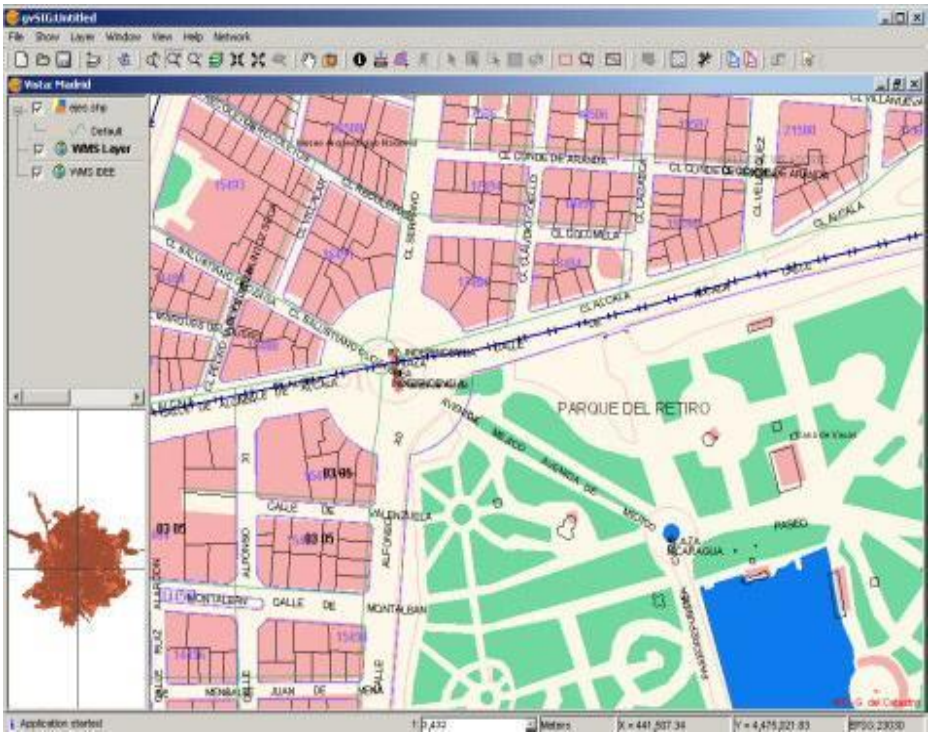

Figure 2. View overlapping local and remote data from Cadastre WMS and IDEE WMS.

or JPEG.

Web feature service (WFS): Advanced access to vector data. By using the gvSIG WFS client, users can perform data access and manipulation operations on geographic features using HTTP as the distributed computing platform. Accessing this remote vector data allows users to operate and use all the gvSIG tools available to work with vector data, analysis, geoprocessing, thematic legend creation, etc.

Web coverage service (WCS): Advanced access to raster information. gvSIG WCS client lets user access to information from remote WCS and adds this raster data to the graphical view to be overlapped with the rest of information, coming from local or remote datasources, all the raster tools available can be used to work with this remote raster data.

gvSIG as a SDI client permits add, cross-referencing local information, and work with remote layers from diverse data sources in distributed environments and spatial databases and layers provided by remote distributes services that implement any of the proposals of Open Geospatial Consortium.

Besides these services for accessing, visualizing and editing data, OGC specifies another kind of services, services for discovering services and data available in an SDI. These services are very important in order to access data when you don't know the data location. The discovery services implemented in gvSIG are:

Catalogue service: Allows user perform searches looking for cartographic resources, user can search by keywords like name, theme, scale… the catalogue service client shows the metadata returned by the Catalogue Service fulfilling the user search. Accessing these resources can be direct, adding a layer to the gvSIG view with the returned data if the metadata includes the data or a link to a ser-vice serving the data.

Gazetteer service: Is a service with a list of georeferenced terms, ie, a list in which each toponym has information about its geographic coordinates where it is located. Gazetteer service looks for the location of a certain toponym and with the coordinates retrieved by the service the user will navigate automatically to the place in the graphical view which that toponym refers to. Therefore implementing client interfaces for all these SDI Services, gvSIG permits to integrate data provided by these services giving the functionality of a fully rich GIS client.

Integrating advanced CAD tools

CAD application is software for Computer Assisted Design, CAD software (Figure 3) is used in many fields: from architectural and industrial design until cartography edition, *Conselleria de Infrastructuras y Transporte* technicians used the CAD proprietary software (AutoCAD and MicroStation) for cartography edition. In this migration to

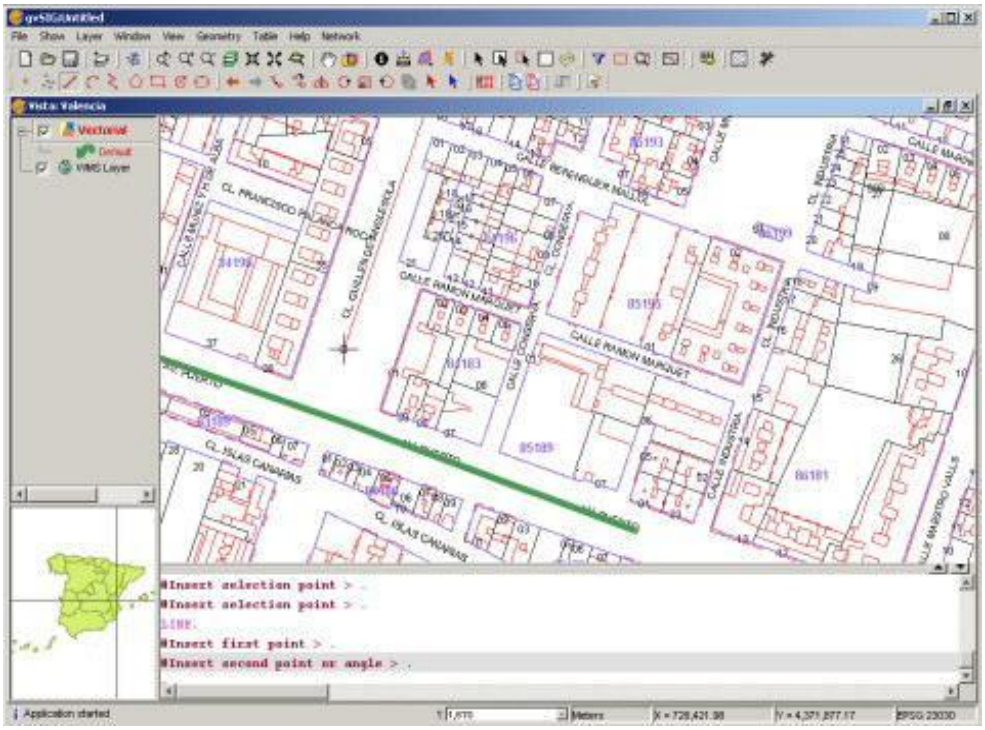

Figure 3. Data editing overlapping WMS Cadastre layer.

to OS, it was decided to integrate such a tools within gvSIG to get rid of the proprietary software and license costs. At this moment started another phase called “Integrating CAD, geoprocessing and topology tools in gvSIG”.

The main goal was not implementing a standalone CAD application but integrate the required CAD tools within gvSIG, these tools let users edit cartography data rigorously. In this way users didn’t need to edit cartography data in CAD programs, create topology and then analyze these data in GIS applications, but with these tools everything was integrate in the same application, all the technologies needed are available in gvSIG. The last version released of gvSIG incorporates the functionality for vector data edition, users can modify, create and delete elements, users can edit, for instance, a shape file, a layer from a spatial geodatabase or a CAD-format file. As one of the main goals of the project is to create an easy tool for the end users, the CAD extension incurporates a command console typical element in CAD software, so users do not have to change habits or invest much time learning a very different environment, but gvSIG project tries to maintain tools as much similar as possible as the ones users are used to, adding tools like help tools, grid tools, command stack, complex element selections… gvSIG provides tools for inserting elements like points, polygons, lines, ellipses, etc., and tools to modify its rotation, symmetry, … Next versions will include frequently used CAD tools like lengthen, cut out,…

At the end of 2006 two new project started developing and integrating new functionality into gvSIG. This new functionality was firstly related to raster data, the goal being to add functions oriented to remote sensing and morphometry, and secondly, new advanced functions for vector data including networking, geo-codification and OGC Service publishing.

Integrating advanced raster tools

Now gvSIG provides some tools typical of raster GIS. With the current version we can add some of the most common formats to work with raster information, georeferencing images, set image transparency, adjust bright and contrast, highlight, etc. The number of raster tools (Figure 4) will increase in two years from now; there is a plan to integrate gvSIG as a raster GIS in environments such a remote-sensing and morphometry.

GvSIG will keep adding new raster functionality like visualization and visual analysis like histograms, masks, colour tables, image processing like map algebra, transformation functions, image fusion,… spatial analysis functions like statistical functions, DEM generations, surface interpolation, image profiles, and time and spec-tral analysis functions. In the same way gvSIG aims to integrated both: raster and vector worlds, implementing an advanceed module to vectorize and rasterize data. A para- llel project of huge interest is the project being developed by SEXTANTE team, SEXTANTE (Sistema Extremeño de Análisis Territorial) is a project developed by the University of Extremadura and financed by Junta de Extrema-

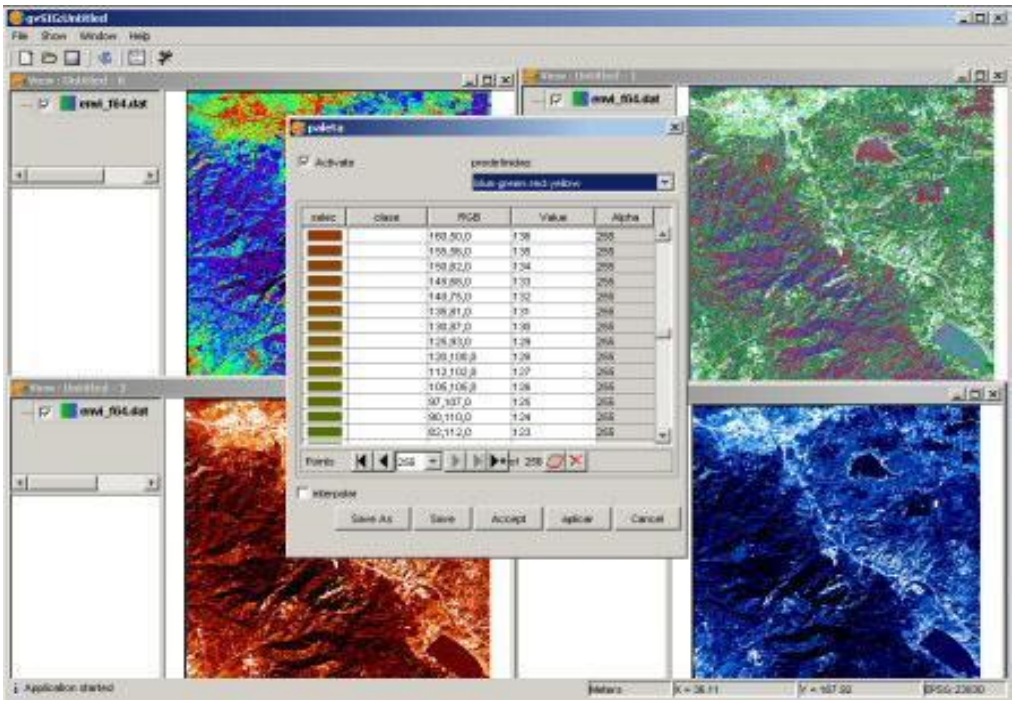

Figure 4. Colour tables applied over an Envi image.

dura. It used the SAGA SIG core but now has migrated all functionality to gvSIG. The SEXTANTE

Extension of gvSIG is available for download, including functions oriented to morphology and hydrology fields. The next phase is migrating to gvSIG the SEXTANTE module about forest administration. All available functions are listed in the gvSIG web site documentation.

Integrating other advanced tools

Another advanced module being developed is vectorization/rasterization which allows data conversion between these two data types (Figure 5).

As mentioned in the introduction, the main goal of gvSIG was addressing requirements of most technicians at the Conselleria. This has been achieved with gvSIG version 1.0. The small percentage of advanced users at the Conselleria will have their needs met in future gvSIG versions. Advanced modules will include things like network topology creation, best route calculation, normalization, data geocodification, wizard for statistical charts generation and report, OGC service publishing wizards, etc.

Conclusions and future work

gvSIG is now an European Commission project. It is a long term R+D+I project with funds to work in the integration of new functionality in the next few years. Further - more gvSIG's own nature, an Open Source GIS, lets collaborators number grow constantly. At the begin-ing the main collaborators were three organizations: CIT, IVER and University Jaume I. Now the project is suppor-ted by many government agencies and private compa-nies that are providing support at national and interna-tional level (Figure 6). These entities include: Instituto Cartográfico Nacional de España, Laboratorio Nacional de Geomática, IRSTV from France, Cartheme in Swit-zerland, el Instituto Geográfico Agustín Codazzi de Colombia, Join Research Centre from the European Commission, Instituto de Desarrollo Regional de Alba-cete, Universidad Politécnica de Madrid, Universidad de Alcalá de Henares, Universidad Politécnica de Valen-cia, Prodevelop, Fujitsu, Andago and Confederación Hidrográfica del Guadalquivir.

Nowadays it is has been successfully installed in more that 400 work places in the Generalitat with satisfied technicians who work with it and help to make improvements with their comments. Outside the regional government the mailing lists grow daily having in the users' list more than 900 users, in the developers' list more than 500 users, and more than 400 in the international list.

gvSIG has been successfully used in SDI deployments at all levels as entry points to the infrastructures, applications that have been customized for every user needs, to see some applications examples with their main characterristics:

Gobierno Vasco Viewer. GIS Client.

Valencía Urbanística. GIS for query and analysis for urban planning of Valencia City.

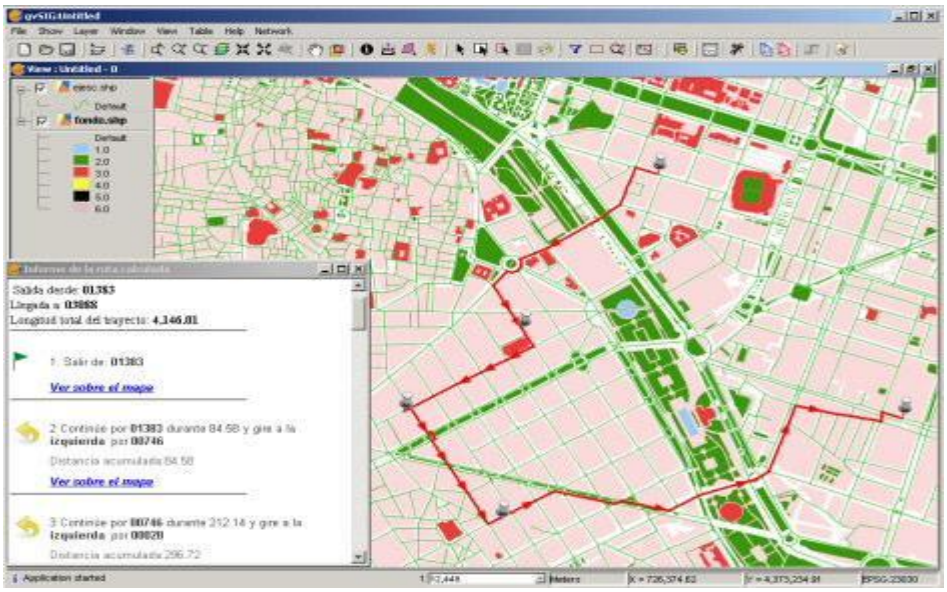

Figure 5. Route calculation with gvSIG.

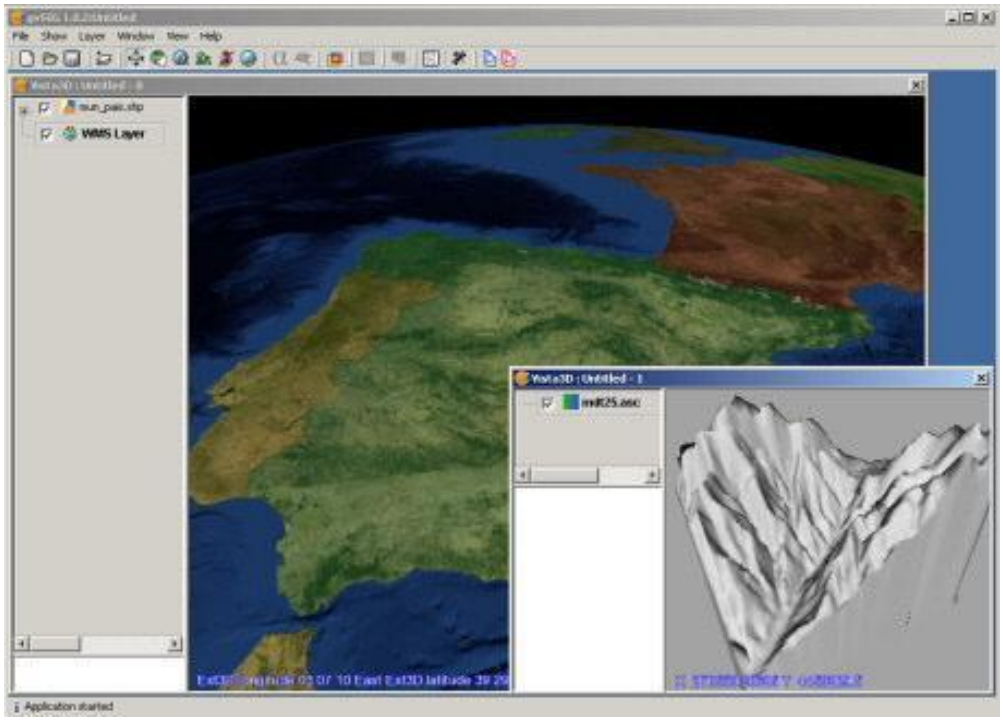

Figure 6. 3D Extension

Cabildo de La Palma. Open source SDI with gvSIG and SDI client. Management application for classified activities over gvSIG.

Caudales máximos. Application for querying maximum water volume. CEDEX (Centro de Estudios y Experimentación de Obras Públicas).

Conselleria de Cultura, Educación y Ciencia de la Comunidad Valenciana. Application for geography courses and teaching in secondary school.

Confederación Hidrográfica del Guadalquivir. Real-Time monitoring of Cuenca Hidrográfica del Guadalquivir.

IGN Gazetteer.

Agencia Extremeña de Vivienda. Edit tool for urban

planning of Extremadura municipalities.
Ronda. Municipality GIS
CIS: Coastal Information System
SIAPAD/PREDECAN. SDI of the Andean region.
As current developments that will be include in future releases:

Publishing: geospatial information in WMS, WCS and WFS.

Metadata Manager: semi-automatic metadata extraction, edition and metadata publishing in Geonetwork Catalogue.

Geo-statistics.

Raster Analysis tools (pilot published).

Network Analysis tools (pilot published).

3D and Animation extension (pilot coming soon). gvSIG Mobile (prototype completed).

Extended simbology (prototype completed).

GIS 4D, temporal dimension.

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