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Social Networks – Problems of Security and Data Privacy Statement

Monograph: Geographic Information Systems
(published jointly with Novática*)

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* This monograph will be also published in Spanish (full version printed; summary, abstracts, and some articles online) by Novática, journal of the Spanish CEPIS society ATI (Asociación de Técnicos de Informática, <http://www.ati.es/novatica>).
Current Panorama of the FOSS4G Ecosystem

Jorge-Gaspar Sanz-Salinas and Miguel Montesinos-Lajara

Prodevelop (a Spanish firm) has been using and supporting Free and Open Source Software for Geomatics (FOSS4G) for several years. In addition to being part of the gvSIG development team, Prodevelop develops solutions with free software for the Geographic Information System (GIS) arena and for other areas such as business intelligence and Web applications. At the end of 2006 we began to elaborate, as an internal initiative, a catalogue of FOSS4G software in order to keep our finger on the pulse of the ecosystem of geomatic applications. This involves several objectives, which will be outlined in this article. In addition we present a report summarising the most prominent FOSS4G projects, which we hope will be useful for those starting to work in this discipline.

1.1 Objectives

This work began as an internal research initiative to improve the knowledge of the state of the free GIS software ecosystem, which is often confusing for users and new developers. With the aim of bringing the information to a wider audience and clarifying the current situation, the authors decided to publish this work during the 1st Open Source GIS Meeting in Girona.

The presentation was an immediate success. Many of those who attended the meeting commented that this work had given them a better perspective on the current state of the ecosystem. This encouraged the authors to continue to improve the knowledge of the state of the free GIS software ecosystem, which is often confusing for users and new developers. With the aim of bringing the information to a wider audience and clarifying the current situation, the authors decided to publish this work during the 1st Open Source GIS Meeting in Girona.

1.2 Motivations

The importance of FOSS for geomatic applications is

Keywords: Ecosystem, FOSS4G, Free Software, GIS.

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obvious, the proof being in the quantity of projects, communities, blogs, conferences and other events organised with increasing success. The newcomer can become a little confused as the inherent modular nature of free software means that many projects depend on other projects, and there are many interconnections at different levels. Furthermore, free software projects do not usually use the marketing tactics of proprietary software, and are therefore not so widespread.

The aim of this document is to give the reader a general view of the state of the art in this technology and to provide clues to which projects and products readers may find of interest for their projects. We outline the different projects found both in geomatics and other disciplines that could affect this area. They are separated into server projects and client projects.

We hope that this work will be useful for readers. Of course, it can only be a fleeting image that is inherently out of date, and it is therefore more than necessary to continue with this work over time by following, for example, the FreeGIS [3] or opensourcegis [4] Web pages, as well as the evolution of the official OSGeo projects [5].

2 Server Projects
2.1 Geographic Databases

2.1.1 PostGIS

There is no doubt that the flagship of free database software is PostGIS, the module for PostgreSQL [6], developed mainly by Refractions Research Inc. It provides PostgreSQL with the capacity not only to store geospatial information and fulfill the Simple Features Interface Standard (SFS) [7], but also to carry out geographic analysis operations.

PostGIS is a widely used product, with important international references (see its case studies) [8] and a wide range of both free and proprietary tools. ArcSDE, the of ESRI database access middleware, now supports PostGIS.

2.1.2 MySQL

The most successful database in Web applications is MySQL [9], but it has two serious problems:

1. It cannot be considered completely FOSS, as it is not a totally free product. The company that heads the project, MySQL AB (recently acquired by Sun), offers a dual licence [10].

2. It does not fulfill the SFS standard and is therefore classified (for the moment) as a "container" of geographic information, although the developers are making an effort to give MySQL more functionalities [11].

2.1.3 pgRouting

pgRouting is fruit of the collaboration between the entity that launched the project, the French-Swiss company CampToCamp, and the Japanese company Orkney, which now conducts a large part of the development. It is the best option for network calculations and to analyse graphs on the PostGIS database.

Routes are processed directly in Structured Query Language (SQL) against the database, without using middleware of any kind, offering good output and the possibility of implementing Web services, such as those that Orkney is developing [12].

This project is maturing and currently supports the most common operations: the shortest path problem (with or without heuristic algorithms) and the travelling salesman problem (TSP).

2.2 Map Servers

The publication of geographic information on the Internet has recently been one of the most active areas of FOSS for geomatics for various reasons: commercial products are expensive and difficult to handle, they often require the adoption of other commercial products (middleware), they do not work on all operating systems, they have not been quick to adopt the standardisations promoted by the Open Geospatial Consortium (OGC), and they do not offer freedom of use.

This, together with the standardisation of interoperability services promoted by the OGC, has led to the appearance of projects related to Internet map publication since the beginning of the FOSS movement. The main project is the map server of the University of Minnesota, UMN MapServer.

2.2.1 UMN MapServer

This project was created as scripts for ArcINFO that dynamically generated map images for publication on the Internet. The project was initially financed by the North American Space Agency (NASA), the University of Minnesota and the Department of Natural Resources of Minnesota (MNDNR).

It has evolved greatly and is currently available in two modalities:

- As an executable Common Gateway Interface (CGI), which is the most common use for this map server. It can be invoked from Web pages to dynamically generate images in the most common formats for publication on the Internet (GIF, PNG, etc.).
- As a library. As the server needs to carry out specific tasks, its functionalities had to be "exposed" to different programming languages (especially PHP) in order to carry out tasks with a lot of dynamic content: specialised queries, real-time scanning, etc.

This server’s most remarkable characteristics are:

- Simplicity of configuration and administration.
- Platforms on which it can operate.
- Data access speed.
- The number of vector and raster formats supported.

After three years in versions 4.x, the long-awaited version 5.0 of MapServer was recently released with important new features, such as the inclusion of the AGG library [13], that notably improve map rendering.

2.2.2 GeoServer

This map server forms a part of the new generation of applications developed on the Java 2 Enterprise Edition
(J2EE) platform. The main objective of this new generation of servers is to develop company Web solutions using the latest technologies and the programming language Java. This allows the applications to be used on any application server that complies with the J2EE specification, both free software, such as Tomcat (Apache), JBoss (RedHat) and Geronimo (Apache), and proprietary software, such as WebLogic (BEA) and WebSphere (IBM).

It is the star project in the GeoTools library and was promoted by The Open Planning Project (TOPP) [14]. Outstanding among its aspects is support for the transactional Web Feature Service (WFS-T) protocol, which converts it not only into a map server but also into middleware for standard-based remote editing of geographic information. Versioned WFS [15], proposed to obtain real versioning of maps, is also very interesting.

Version 1.6 includes a security framework called ACEGI [16], output improvements and integration with OpenLayers (see Section 3.2.1). And now there is a version 1.7, in which output, error correction, labelling and other improvements have been incorporated.

2.2.3 deegree

This map server began as a project of the Geography Department of the University of Bonn. Later the company lat/lon GmbH was founded [17] to continue developing the project and provide commercial services based on this platform.

degree is an infrastructure with Java components, able to be used on any server that complies with the J2EE specification and offering a complete set of geospatial capabilities. deegree stands out for its high number of OGC specifications, including WMS, WFS(-T), WCS, CSW, WPS and SOS.

The following characteristics of deegree should be highlighted:

- Large configuration and adaptation capacities.
- Complex installation and configuration that are not at all "user friendly".
- Good output compared with other J2EE servers.
- Wide range of OGC standards (although not always 100% compatible).
- The development community is not very open, although there is an intention to improve this aspect. The test of this is its incorporation as an incubated project in OSGeo.

Version 2.1 was launched this past year. It offers support for new protocols such as CityGML and WTS, a new projection library written completely in Java, and a new graphic configuration tool for the WMS and WFS services.

The version in development (2.2) adds support for WPS, and is one of the only map servers that also supports processes.

2.2.4 MapGuide Open Source

The best contribution by Autodesk to the creation of the OSGeo Foundation was the release of this map server in 2006. It has a Web publication system, which makes configuration and management easy, and includes commercial tools for AutoCAD publication.

It makes use of the FDO library to access all kinds of data (shapefiles, ArcSDE, Oracle, etc.). Like MapGuide, it is offered with the LGPL licence, which allows users to develop closed projects on this platform.

Fusion, a development from the Canadian company DM Solutions recently integrated into this project, allows Web administrators to configure a Web mapping application composed of simple widgets.

2.2.5 TileCache

Developed by MetaCarta (the creators of OpenLayers), this middleware caches requests to the WMS map servers so that clients receive tiles that can be visualised without having to go directly to the origin of the data. It could be said that with TileCache the output of the WMS services increases by one or two orders of magnitude. The drawback of TileCache is that few clients use this way of obtaining maps, restricting themselves in most cases to OpenLayers, although the 3D viewer NASA World Wind (described below) is also a possible client.

TileCache began as a prototype or proof of concept to test the capacities of this way of retrieving maps on the Internet and try to bring the user's experience closer to that of the popular Google Maps or Yahoo Maps.

Fruit of a project of the Google Summer of Code in 2007, this software was translated into Java with the name GeoWebCache, although it has less functionalities. As a J2EE application it is easily integrated into business environments where the Java stack is used. GeoWebCache is currently distributed as an independent Web application and also integrated into GeoServer.

2.2.6 FeatureServer

This server software is quite different from the other applications. It offers a very different vector service to that proposed by OGC, although it is compatible with WFS. It makes use of Representational State Transfer (REST) technologies to request geometries or modify those that are in the server. It is therefore a very flexible geometry server that allows simple online editing. Like TileCache, it was proposed by MetaCarta and integrates perfectly as a "user" of the geometries served by OpenLayers.

2.3 Metadata Tools

A catalogue server is an application that allows users to publish a set of metadata about different datasets on a network (generally the Internet). In geomatics, these data would be different types of geographic information: vector and raster layers, digitalised maps or even aerial photographs or maps in analogue format. This catalogue is "presented" as a portal, which allows users to search according to alphanumeric and spatial criteria. Until recently, there were no international standards for generating these metadata, and it was left to the organisation to decide to use proposals such as Dublin Core or the American FGDC format [18]. It
now has international standards such as ISO 191**, ISO 19115 and ISO 19139.

From the server perspective, GeoNetwork is the only tool that is an independent metadata management product. Geonode can also be used as a metadata server, although due to the difficulty of its configuration it is not used as widely as GeoNetwork.

### 2.3.1 GeoNetwork Open Source

This project, financed by the Food and Agriculture Organization (FAO) of the United Nations, has become the reference application for publishing geographic metadata. It is a J2EE application that has both a version for "production" and a test version meant to work in a normal desktop PC (using a very light servlet container called Jetty [19]).

Through a user-friendly Web interface, administrators can manage, upload, import and export metadata. It has a Web viewer that allows users to visualise, in the geoportal itself, the WMS and ArcIMS services found in the catalogue, or map thumbnails and other sources of catalogued geographic data.

GeoNetwork 2.2 has a user friendly interface that uses Asynchronous Javascript And XML (AJAX) technologies, support for clients that use the Open Search protocol [20], as well as support for the Open Archive Initiative [21]. A version of GeoServer with sample data and a desktop tool to facilitate some management tasks is also included.

### 2.3.2 CatMDEdit

CatMDEdit is a desktop tool for creating and editing metadata, and conforms with the ISO 19115 standard, the Spanish Metadata Nucleus (NEM)1, Dublin Core and the Content Standard for Digital Geospatial Metadata (CSDGM). CatMDEdit was developed by the Spanish consortium TeiDE [22], formed by three working groups from three universities:

- The MERCATOR Group of Geoinformation Technologies of the Technical University of Madrid.
- The Advanced Information Systems Group (IAAA) of the University of Zaragoza.
- The Geographic Information Group of the University Jaume I in Castellón.

This tool is currently maintained by the company GeoSLab and the University of Zaragoza (Advanced Information Systems Group). It is very widely used, especially, although not only, in Spain. The recently launched version 4.0 of CatMDEdit incorporates the latest updates of the ISO standards, a restructuring of the graphic interface and compatibility with GeoNetwork, among other new features.

### 3 Client Projects

#### 3.1 Heavy or Desktop Clients

Desktop tools have traditionally been very representa-

### 3.1.1 gvSIG

This application began as part of the gvPONTIS [23] migration project to open technologies initiated by the Autonomous Government of Valencia.

Currently and in parallel with much development activity, more community openness is being promoted, with improved technical documentation for developers and a control system of public versions, where users can obtain updated source codes.

In short, gvSIG is a powerful local and remote map viewer (2D and 3D) with support for the OGC standards, as well as a tool for publishing maps on paper and in map servers. It has a large variety of vector and raster analysis tools as well as the ability to analyse the functionalities of SEXTANTE2.

Finally, in addition to the main desktop product, a version for mobile devices called gvSIG Mobile has been launched to carry out tasks related to viewing and editing maps in the field using palmtops or smartphones.

#### 3.1.2 GRASS

This is the oldest of all the projects presented in this text. It began before the birth of FOSS as it was initially a project of the Construction Engineering Research Laboratory (CERL) of the US Army Corps of Engineers, started to manage the large amount of natural resources under their care.

Although the software is quite old, its continual development keeps it valid, even though it was designed mainly for use in academia. There are two main reasons for this: first, until recently it could only be used in UNIX environments, and second, its interface is not very "user friendly" for new users (comparable to the ArcINFO Workstation interface).

This has recently changed a little as Quantum GIS (QGis) has added GRASS functionalities as an extension in both its Windows and Linux versions, which converts it into a truly basic user interface for GRASS.

The new version 6.3 of GRASS incorporates improved support for both 2D and 3D networks, with a new graphic interface, and improvements in the 3D viewer for vector geometries and raster data (voxels). Links to other languages are being developed so that GRASS can be used as a GIS back-end component for developments programmed in Python or Perl.

#### 3.1.3 MapWindow

This project is promoted by the University of Idaho and is both a desktop application for viewing and analysing geographic information and an Application Program Inter-

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2 Library of spatial analysis algorithms, developed by the University of Extremadura (Spain) and the Autonomous Government of Extremadura.
face (API) with ActiveX control to carry out specific tasks. It is designed for the .Net platform for Windows, distributed under the Mozilla 1.1 licence, and therefore can be used in both open and closed projects.

The desktop application, as is normal in FOSS applications, makes it easy to add functionalities using extensions or plugins.

During the last year, no new characteristics have been added, but many errors have been corrected and the documentation and internationalisation of the project have been improved.

3.1.4 Quantum GIS

Quantum GIS or QGIS offers a simple and agreeable environment to users with basic needs. Programmed with the QT user interface library [24] and for a long time the only PostGIS editor for Windows, it stands out for its simplicity and speed. Moreover, it is a "user-friendly" interface for GRASS databases. In addition to viewing functionalities, it is also capable of vector and raster analysis, even in Windows. In this last case, natively compiled (without emulation) GRASS functionalities are available for Windows for the first time.

In the recently released version 1.0 the inclusion of links for programming in Python and new GRASS tools stand out.

3.1.5 SAGA

This tool was mainly developed in Gottingen, Germany. It is a desktop GIS for Windows and Linux with a clear separation between its API and its user interface. In fact, the first has a LGPL licence and the second a GPL licence. This allows the use of "closed" modules without having to worry about not complying with a licence. In the new version of SAGA (2.0) the user interface has been rewritten so it can be executed in different platforms, and therefore is not exclusively for Windows.

This software is especially good for image analysis and digital elevation models.

3.1.6 Open JUMP

The Java Unified Mapping Platform (JUMP) was one of the first desktop GIS projects in Java language. Its remarkable features are its use of the JTS library to carry out some spatial analysis operations and its support for the GML format and the WMS protocol.

This project was led by Vivid Solutions [25], but the company’s policy of accepting external contributions motivated the appearance of a new spin-off project (a fork in the FOSS terminology) known as The JUMP Pilot Project (JPP), which aims to coordinate contributions from different development groups more democratically to avoid duplication of effort.

This is especially important, and many spin-off projects have arisen from this project: DeeJUMP, PiroJUMP, SkyJUMP, Open JUMP Viatoris, among others. In the OpenJUMP wiki [26] you can see the "family" of projects based on Open JUMP in more detail. In Spain the project Kosmo, developed by the company SAIG, stands out for incorporating interesting developments from other projects into the JUMP platform.

3.1.7 OSSIM

This is not a very well known project that was born more than 10 years ago in United States intelligence and defence programmes. Dedicated particularly to the analysis of raster images, it consists of libraries, console tools and graphics, and is therefore a technology on which various types of applications, such as Minerva [27], have been developed.

Current development is centred on OSSIM Planet, a 3D viewer for the publication of 3D information in a collaborative and distributed fashion.

3.1.8 OrbisGIS

OrbisGIS is a recent project promoted by the French Research Institute on Urban Sciences and Technics (IRSTV) and offering a powerful and versatile analytical tool. The application is mainly for developers and researchers with a high technical profile, as it offers a programming and query console (SQL) in the user interface able to make queries to vector and raster data sources.

3.1.9 uDig

Like JUMP, this project was initiated and financed as part of GeoConnections [28], a Canadian project dealing with the infrastructure of spatial data. It has been developed in Java by the Canadian company Refractions Research Inc on the development platform of RCP applications for the Eclipse project. Its main objective is to offer a desktop client that supports most local and remote data sources, and especially those based on OGC protocols, such as WMS and WFS.

Support has recently been added for the CQL query language, error correction, interface improvements, the Mac OS X Leopard and the creation of scratch layers. Version 1.1 was finally launched after 14 release candidates. uDig is becoming more functional as it establishes collaborations and unites forces with other projects, such as JGrass and SEXTANTE.

3.1.10 World Wind

World Wind is a FOSS project of 3D visualisation for NASA that is like Google Earth but with a much more "scientific" orientation. It is distributed under a NASA licence comparable to LGPL.

Although it does not have Google Earth maps, Microsoft Live maps can be obtained with a plugin. It is designed to attractively visualise all kinds of information (including temporal information) for end users, although it has not been as successful as Google Earth.

Although the initial version was written in C# (and therefore only worked with Windows), in 2007 a new development kit (SDK for the programming language Java) was launched to visualise 3D geographic information in a sim-
ple way, supported by World Wind technology. This new development means that World Wind can be used in all kinds of platforms, which converts it into a library in which specific solutions are slowly appearing.

3.2 Light Clients
As Internet use has become more widespread, map servers have appeared together with Web applications that present their contents. At first most of these materialised as ad hoc developments and therefore the same problems were solved over and over again.

This situation naturally led to projects that try to provide a set of common components, generally in the form of Hyper Text Markup Language (HTML) documents and applications written in JavaScript, that provide developers with a base on which to perform specific applications. Projects based to a greater or lesser degree on server code, basically PHP or Java, have also been cropping up.

Some projects have arisen as complements to the UMN MapServer, and are intimately linked to it, as they only work when integrated with it. Given the diversity of map servers, this dependence is disappearing from the clients. During the last year, the convergence of many of these projects and the sharing of components has been remarkable. Projects such as Ka-Map, MapBuilder or MapBender are integrating (or analysing) Open Layers to offer functionalities in the style of Google Maps. For example, this situation has led to the discontinuation of the MapBuilder project.

3.2.1 OpenLayers
OpenLayers is a light Web-GIS client constructed with JavaScript classes, without any dependence on specific map servers. It offers a simplified user interface that handles WMS and WFS services transparently for users and developers. OpenLayers is widely used because it is simple to use, has tile and cache support and provides access to maps of Google Maps and Yahoo Maps.

The OpenLayers developer community, although not large, is currently one of the most active in the field of free GIS projects.

It was initially developed and then released by the United States company MetaCarta. Currently, in addition to MetaCarta, it is promoted by Schuyler Erle, OpenGeo and CampToCamp.

3.2.2 Ka-Map
This is an API programmed primarily in JavaScript, with some components written in PHP to take advantage of the functionalities of UMN MapServer (known as MapScript).

This library can be used to generate applications that make intensive use of map tiling as well as asynchronous technologies that accelerate map loading enormously. It is possible to use precache in the server against MapServer, based on a finite set of scale and tiling levels, so that accessing maps is the same as accessing already existing files (as occurs in Google Maps).

Ka-Map was originally developed by DM Solutions, which is one of the main development organisations of UMN MapServer, as a complement to this map server. Ominiverdi later joined the developer team.

The developers of Ka-Map collaborate in other projects, mainly OpenLayers. They are currently in the process of fusing the two, so that OpenLayers JavaScript map components can be used in Ka-Map 2.0.

Outstanding developments during the last year include the creation of a new user interface, an experimental WPS interface and user authentication.

3.2.3 Mapbender
This Web-GIS client is built with JavaScript, and offers a configurable user interface that does not depend on a specific map server and is meant to be a geoportal client of OGC services. It currently supports WMS, WFS(-T) and WMC services. It includes quite complete support from users, groups and OGC services (OWS). A characteristic that differentiates Mapbender is its capacity for navigator-based client editing using WFS-T.

It has been developed by a group of programmers and companies which have mainly come together around the WhereGroup service provider, located in Bonn, Germany. The head of the project (Arnulf Christl) is currently president of the OSGeo Board of Directors and member of the OGC Architecture Board, and a prominent FOSS4G activist.

The following incorporations have been made during the last year: KML support, new interface platforms, WFS improvements, feature encoding, translucency, personalisation, catalogue interface, search module and a compressible directory tree. Changes in the publication procedures, code documentation and publication cycles also stand out.

3.2.4 MapFish
MapFish, mainly developed by CampToCamp, was developed to bridge the gap left by MapBuilder (a project recently discontinued by its developer community), with a rather different orientation. In reality it is two components: one client component and one server component.

The server component, programmed in Python, PHP or Java, can be used (although not compulsorily) for map printing and editing tasks, among others (depending on the implementation).

But where MapFish stands out is on the client side. The project aims to integrate OpenLayers with the component library for JavaScript called ExtJS. Therefore, much richer applications can be created in the interface than those currently performed with OpenLayers. It seems that these two components will be completely separated, and the client will be relaunched as a new project with the name GeoExtJS.

4 Component Libraries
4.1 JTS (and Ports)
The Java Topology Suite (JTS) is a library that provides support to 2D topology functions, fulfilling the Simple Features Specification for SQL of OpenGIS. JTS is used in many GIS projects based on Java, such as JUMP, gvSIG,
Geotools, and GeoServer. It has therefore become a reference project in the Java-GIS world in terms of creation, validation, integration and topology query operations.

One of the relevant characteristics of JTS is that it offers operators (functions) and robust spatial statements (the correct answer is guaranteed numerically). The spatial operators allow spatial functions to be carried out between two geometries to return new geometries (Buffer(), Union(), ...); the spatial statements offer Boolean answers to questions related to the topology of geometries (Intersects(), Touches(...)).

JTS has been developed by Vivid Solutions in parallel with other related projects, JCS (Java Conflation Suite), an API for combining two geospatial datasets into one with little manual intervention.

As it has been totally developed in Java, JTS has been transferred to other environments to be used easily from other programming languages. The project GEOS (Geometry Engine - Open Source), which is the result of the migration of JTS to C++, stands out and has been used (until the present) in projects such as PostGIS and GRASS. This project, has also recently joined the OSGeo Foundation, and therefore is in incubation.

Another fairly widespread port is that directed at .NET, known as NTS (.NET Topology Suite). There is also another JTS port for .NET, known as GeoTools.NET, that is not (as is sometimes stated) a port of the GeoTools project.

JTS was financed by various public organisations in Canada, and the GeoConnections program stands out in particular (for supporting the expansion of the Canadian IDE known as CGDI). It was initially developed by Vivid Solutions (like JUMP).

4.2 GDAL/OGR

The Geospatial Data Abstraction Library (GDAL) is a library in a set of command line utilities for translating from geospatial raster formats. It is developed in C++ and supported in a wide range of platforms (Linux, Windows, MacOS X and Windows CE to a lesser degree).

Currently GDAL is the reference geospatial raster data access library in the FOSS panorama, and is used in a very wide range of projects (MapServer, gvSIG, GRASS, QGIS, among others).

GDAL contains a subproject known as OGR. The OGR Simple Features Library is an access library and a set of command line utilities for reader access (and on some occasions desktop access) to the vector file format.

GDAL/OGR was the result of the personal efforts of Frank Warmerdam, and the library has been progressively enriched with various financial contributions. Logically, GDAL/OGR has become part of OSGeo, and is now an upgraded project. It has gone from a model known as benevolent dictator to a project with a management committee. Both GDAL and OGR are quite active projects that continually incorporate new characteristics. With the incorporation into OSGeo the library has been depersonalised to form an open community with decision-making bodies.

The strong connection with projects such as MapServer (with which they share developers), as well as GRASS and QGIS, stands out. We can also highlight the use of GDAL in projects such as gvSIG, OSSIM, MapGuide/FDO, GeoTools, PostGIS and GEOS. Due to the licence that GDAL has, it is currently used for the main proprietary GIS products.

4.3 PROJ.4

PROJ.4 is a management library for map projections that emerged as a reprogramming of old United States Geological Service (USGS) utilities, implemented in C by Gerald Evenden in 1990 for this organisation. PROJ.4 is basically used for reprojection functions between different coordinate or reference systems.

PROJ.4 is a reference library within the FOSS panorama for geographic information systems, and is the reprojection motor of the current main projects (GDAL, MapServer, PostGIS, gvSIG, GRASS, GeoTools, etc.).

At present this library is mainly maintained by Frank Warmerdam, who is also responsible for GDAL/OGR. Although Gerald Evenden continues to be linked to the project from a cartographic point of view, he does not participate in developing the code. G. Evenden maintains a simplified version in the project libproj4.

PROJ.4 remains fairly stable: over the last years, developments have been limited to correcting bugs, adding a few new projections and improving data movement.

4.4 GeoTools

GeoTools is a Java library for the manipulation of geospatial information meant to be used in other Java applications, both servers and clients. Rather than a final user application, it consists of basic components for building applications. It offers access to many vector data formats (Shapefiles, PostGIS, MySQL, Oracle, ArcSDE, Geomedia, among others) and raster formats (GeoTIFF, ArcGrid, among others), and meets various OpenGIS specifications (WFS, SLD, Filter Encoding, among others). GeoTools collaborates in the GeoAPI project to implement the interfaces defined in this project.

GeoTools is the base of other projects, among which GeoServer and uDIG stand out. The project has a very open development model, and the development heads (a project management committee) actively collaborate in other related projects: GeoServer, uDIG, GeoAPI [29] (designed to offer access interfaces based on ISO/OGC standards of geometry models) or GeoWidgets [30] (creating widgets or user components for GIS applications that are independent of the graphic toolkit).

GeoTools, over 10 years old and the result of an initial project of the University of Leeds, has evolved to become an open project and is integrated into OSGeo.

The most remarkable recent improvements are the addition to the model of simple geometries and GeoAPI filters, CQL (Common Query Language), integration with OpenOffice, support for Raster, NetCDF, DB2 and Musid, and the creation of Swing widgets.
4.5 Batik

Batik is a Java library that offers support for handling Scalable Vector Graphics (SVG) data [31]. It is therefore not a library exclusively for GIS, but given the widespread use of SVG as a format for vector maps, it is often used in all kinds of GIS projects, such as libraries (GeoTools), desktop products (gvSIG, Jump...) and servers (deegree, GeoServer...). Batik allows SVG data to be used for visualisation, generation or manipulation.

Batik is a subproject of the project Apache XML Graphics project [32], together with Apache FOP and Apache XML Graphics Commons, subprojects that are usually used together with Batik. In fact, the different subprojects share developers.

Basically bugs have been corrected and partial support for SVG 1.2 was added last year (complete support is expected in Batik 2.0).

4.6 WKB4J

This is a very specific library for reading WKB (Well-Known Binary) information from one data origin and translating it into a geometry model based on Java objects. It is most commonly used to translate information from PostGIS, which is much faster than translating from WKT (Well-Known Text). It allows translation into JTS, PostGIS Java and OpenMap.

This project is at a standstill, but it continues to be used in other projects.

4.7 FDO

FDO is the other large project by Autodesk, initiated when Autodesk became part of the world of free software. It is a vector and raster data access library used for MapGuide Open Source. It has the same objectives as the OGR library, and aims to establish an abstraction layer in different data formats. It has different providers such as ArcSDE, Oracle (in the paid version) or even GDAL. Like MapGuide, it is distributed under a LGPL licence. Written in C++, it works in both Windows and Linux.

Currently FDO, as well as Autodesk, is promoted by a community that is external to this company.

4.8 MonoGIS

This is a Spanish project promoted by the company TAO (now T-Systems). It was built taking advantage of some of the more relevant FOSS projects of the .NET panorama, such as Geotools.NET, Net Topology Suite and OGR/GDAL. A development API and a WMS server are cur-

Figure 1: Relationships Between FOSS4G Projects.
rently available. It is distributed under a LGPL licence. As its name indicates, it has been developed on a Mono platform, the free version of the .Net platform, and therefore works both in Windows and Linux.

This library is being used in an apparently abandoned project called Appomattox [33] to build a desktop application designed especially for the Linux Gnome desktop, although it also works in Windows.

5 Conclusions
In this text we have revised the most important projects currently in the panorama of free geometric applications, both those that work on the side of the server and those that use the servers’ services as light or heavy clients.

It can be seen that the panorama is wide and varied. There are mature time-honoured projects that continue to develop, as well as new projects that emerge to fill a niche not previously created, and others that have been abandoned in favour of revitalising other projects.

This diversity shows that there is room for innovation, without abandoning the robustness to deal with any necessity in the most demanding areas. We only have to look at the cases of successful implementation of many of the proposed solutions in this article to realise that free GIS software is a reality not only in among amateurs or in university environments but also in the areas of business and public administration.

As can be seen in this figure, there are some key projects in the FOSS4G panorama, such as GDAL or GeoTools, used for many of the desktop and server applications. However, although it could be said that there are tribes related to the programming languages (mainly C and Java), this does not exclude interesting interactions between projects in both languages. These interactions emerge mainly out of the maturity and contrasting efficiency of some projects, so the developer teams make the effort to make the components compatible with both languages in order to obtain benefits in their applications.

References