A COMPARATIVE ANALYSIS OF SOFTWARE PACKAGES ENABLING THE DEVELOPMENT OF SPECIFIC INFORMATION SYSTEMS FOR VARIOUS ECONOMIC SECTORS

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Abstract: *In this study are reviewed history, advantages and lacks of software packages used for the elaboration of GIS projects. In the technological part I will refer to real software packages that are part of Open Source. This study analyses software packages from Open Source category and from the one of commercial software as ArcGIS, MapInfo, Geomedia, MapSys. Category difference between distinct software packages is very high. Despite the fact that researches and conclusions performed in this study refer to Open Source packages, there can be drawn parallels between software of different categories. This research doesn't aim comparison between trade software and those from Open Source category and it doesn't strive to highlight this category of software.*

Key words: *GIS, software, analysis, benchmarking, work.*

1. Introduction

The definition of Open Source software was initiated and developed by Open Source Initiative and it is used to form the license compliance to the necessity of standards applied for Open Source software. The main peculiarities of Open Source software, according to the definition, include free distribution of available source code, and allow the change of source code. Open Source software - one of the most interesting current technological phenomena, owes its quick growth to the internet development, development tools and computer use generally. The key role in the development of software packages belongs to the community of programmers that became specialists under some specific software packages. This software category is successful most often but not always. Usually it is controlled by non-profit organizations but supported by commercial organizations that have a pragmatic interest, taking into consideration this software category as an instrument on competition market. Usually the size of communities and amounts of investments that are used for the development of Open Source software reach thousands developers and amounts of million dollars. Until now Open Source software lags behind the operation systems development, but it has made a huge effort and due to general evolution of communication means, geographical and technological development, access of spatial and GIS development, it was created a favorable environment for the development of this category of software used in GIS. Of course, the biggest manufacturers of GIS commercial software must meet the necessity of GIS projects' implementation and offer an advantageous price to small companies. Also non-commercial software generally have developed continuously especially in the last 4-5 years

(figure 1). The list FreeGIS.org currently covers more than 350 software packages used in SIG from different areas, of which 56 were renewed in the course of last 2 years. Open Source software is created and kept by different communities and companies, groups of enthusiasts and research firms. According to the research of Gilberto Camara and Harlan Onsrud [1] from their survey concerning 70 projects controlled software by individuals, companies and groups were 37, 29 and 4. Out of 29 organizations, 17 turned out to be personal companies, 8 state organizations and only 4 higher educational institutions. Big projects involve a huge number of developers and serious financial investments. (Table1). The very fact of having this information to the public is a positive feature of open source software and is not possible in commercial cases.

Table 1. Characteristics of basic software and of counting the expenses of some open SIG under Project Stats[2]

Project	Codes thousands, (evolution)	Programmers (number of people)	Expenses person/year	Expenses' assessment thousands $ USD
GRASS GIS	737 (42%)	62	200	11000
gvSIG	2162 (20%)	62	609	33495
Quantum GIS	440 (227%)	40	114	6270
GDAL	1035 (67%)	29	337	18535

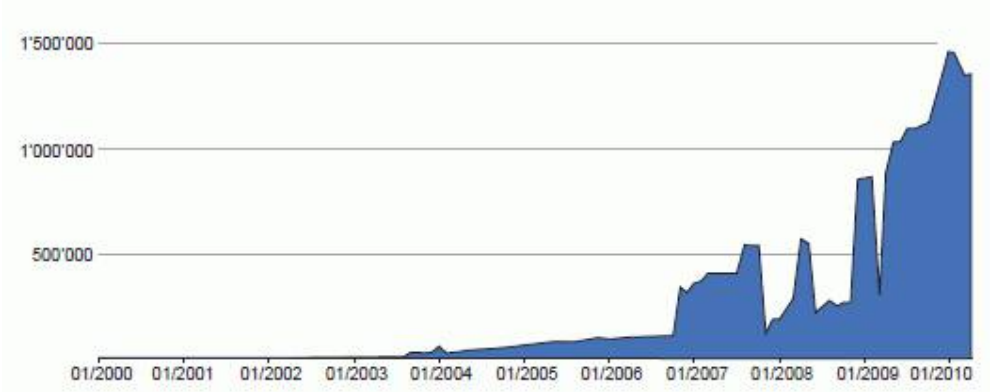

Fig 1. Evolution dynamics of programme base code of SIG QGIS software (Source: Ohloh.net)

2. The history of open source software development used in GIS

The history of GIS Open Source software development starts at the end of 70's, beginning of 80's of 20th century and it is associated with the creation in 1978, upon the initiative of the U.S. Fish and Wildlife Service, of GIS MOSS (Map Overlay and Statistical System), which appearance is one of key events that have outlined the future development direction of geographic information system [3]. MOSS is the first interactive GIS, designed to work from mini-computers and it mixes the capacity of working both with rasters and vector data. [4]. At the time, MOSS was used for different tasks, both on US ministerial level and in many state governments and local administrations. [5].

Despite the fact that MOSS appeared first, GIS - GRASS (Geographic Resources Analysis Support System) become more known and widely spread. It appeared as alternative of the commercial product ARC/INFO of ESRI company.

GRASS development started in 1982 having as initiator the US army (U. S. Army Corps of Engineers' Construction Engineering Research Laboratory, CERL) as a closed project. At the initial stage of its development, GRASS was very popular, but because of active actions at ESRI this popularity started to decrease. Later it was discovered that even with a team of professional developers, more units of US army weren't ready to waste energy to work in GRASS, priority being given to products from ESRI which were easier to use. Thus, the US army abandoned slowly GRASS project, development team was dissolved and they had no more meeting concerning this project. GRASS got official status of open software 17 years later in 1999. Currently GRASS has a big number of users and independent developers and it is often met in academic area.

The end of 20^{th} century was marked by the appearance of a number of instruments open source software which is very popular currently. In 1983 it appeared the PROJ4 library, intended for handling cartographic projections, and a set of instruments for work with different GDAL/OGR (1998) formats, that have a key role in modern geographic information systems. [3]

1995 is considered to be birth date of UMN MapServer cartography server [6]. The development of this project was initiated as a project of Doctoral candidate Stephen D Lime [7], who later was supported by NASA. Functioning possibilities of UMN MapServer almost on each platform (Windows. Mac OS, Solaris, Linux), ofer a wide range of possibilities and integration with different data base. The development period has reached maximum levels due to open GIS software development at the beginning of 21^{st} century. During this period took place the development of GIS projects like SAGA GIS (2001) in Germany [8], gvSIG (2003) in Spain [9], international project Quantum GIS (2002) [10]. In 2007 the commercial software created for the GIS analysis and ILWIS remote sensing (Integrated Land and Water Information System) became available officially under the license GNU GPL, being part of Open Source software. [11]

In 2006 aiming to support and to participate in the development of geospatial technologies projects databases, appeared non-commercial Source Geospatial Foundation (abbreviated OSGeo, www.osgeo.org). Besides the development of open projects, under aegis of OSGeo appears a magazine which in February 2014 published volume 13 [12], there are drawn up and distributed didactic materials, there are performed every year international conferences (FOSS4G), dedicated to Open Source software.

3. Technological evolution

Generally Open Source software architecture and especially GIS, is usually a structure of more levels which creates a software stock - a set of interconnected components which represent various levels. Levels from the stock are represented by distinct products which are potentially interchangeable. GIS software can work under open operation systems (e.g. Linux Operation system) and commercial operation systems as Microsoft Windows and Mac OS. GIS Open Source separation on several levels characteristic to open systems is explained through the necessity of patterns development.

The existent GIS software can be divided intro 3 types: web GIS, desktop GIS and spatial database.

GIS desktop – is software designed for cartography, which is installed and launched on PC and allows the user to visualize, chose, update and asses data about cartographic objects and attribute data that accompany them.

Common requirements of webGIS and desktopGIS applications

GIS software products must allow concurrent and direct access (without operations of import/export or conversion) to the data of GIS vector and raster or to data received from the

standard web services OGC – (OGC Web Feature Service (WFS), OGC Web Map Service (WMS)).

In order to facilitate the system maintenance, storage of own data created via purchased GIS software products, it has to be created a relational performing database (SGBDR from categories Oracle, MS SQL or their equivalents) and in a single format: the graphical component of information has to be stored in the same database with alphanumeric, not separately as graphic files.

GIS software products must guarantee the correct access to GIS data, irrespective of coordinate system associated to these data.

GIS software products must allow automated calculation of coordinates between systems of coordinates (international, national and/or local, whether they are predefined in application or defined by the user).

Later development of GIS software products (additional functions or specialized user interfaces) must be done by standard development environments (programming), specific to Windows environment or its equivalent, without additional costs for specialization in programming languages of owner type.

GIS software products must allow:

- simple interrogations based on alphanumeric attributes;
- spatial interrogations with operators of: proximity, neighborhood, inclusion;
- connectivity to large volumes of data and operation in the same window, map of multiple data sources from distinct institutions;
- definition of thematic maps;
- displaying images (Satellite, aerial survey);
- creation / display of labels;
- possibility to define geographic areas as spatial filters for the control and / or simplification data access;

GIS software products must offer the possibility of displaying image raster layers with effects of transparency. These layers must allow visualization under an image raster layer of other raster or vector information.

GIS software products must be able to offer additional functionalities by installing extensions / plugins.

4. General description of some GIS software packages of open source type

Geographic Resources Analysis Support System (GRASS)

The last version GRASS 7.0 is a modular system that offers access to more than 300 modules and provides the possibility of working with 2D and 3D vector and raster data and it is comparable with ESRI ArcGIS ArcInfo products. Due to the lack of convenient graphical interface the use of GRASS is limited and it is used more often by research and higher education institutions. Until recently the second reason that impedes the use of GRASS was incompatibility with operation system Microsoft Windows without the use of emulators Linux or Unix. But this thing disappeared with the advent of 6.3.0 version.

Quantum GIS (QGIS)

The development of QGIS started in 2002 with a group of enthusiasts. The purpose of this step was the creation of a simple and fast viewer for geographic data for operation system like Linux. In the same time, during the project's development, it appeared the idea of using QGIS as simple interface for GRASS, getting analytical and other functions of GRASS software. Currently a group of QGIS programmers has solved the initial issues and work to

develop functional possibilities which have exceeded long time ago the possibilities of a simple viewer.

User-friendly Desktop Internet GIS (uDig)

The main purpose that led to the elaboration of uDig was the creation of software that would allow to view and to edit data directly from database or with the help of web networks. The development of uDig started in 2004-2005 at the initiative of Canadian company *Refractions Research Inc.* uDig is written in Java language (using the Eclipse platform), which initially was concentrated on work with vector data. But in 2007 a team of uDig developers joined Jgrass developer team which started to form in uDig possibilities with vector data. Very often uDig is used as access interface to PostGIS database. There are 2 drawbacks due to Eclipse use. The first is relatively large volume of software and the second is graphic interface which is very similar to programming environment, that is why it can be perceived as one very difficult to use for a simple user.

Generalitat Valenciana, Sistema d'Informació Geogràfica (gvSIG)

It is probably the most complex project, if we take into consideration the financial amounts that were invested in it. The purpose of its elaboration was to create a system that would offer the possibility of substituting ESRI ArcView 3.x in municipal state organizations. The initiator of this project is the Ministry of Transportation from Valencia (Spain) that started it, due to the decision of switching all regional organizations to computers that work under Linux operation system. The development of gvSIG started at the end of 2003, having as initial partner IVERA JSC Company (Spain). The project joined some higher education institutions and other companies. gvSIG can work with vector and raster data but it also can work with geospatial data that are stored in different databases.

System for Automated Geoscientific Analyses (SAGA)

From its name results that it has scientific roots. First module for SAGA was elaborated in 2001 in the Department of Geography of University of Gottingen (Germany) and it aimed work with raster data.

The main purpose of SAGA is to analyze topography, soil mapping and to solve issues that are connected to data view. SAGA is written in C++ language and it offers the users a convenient interface.

The initiator of the project was in the past University of Hamburg.

The user's documentation is very good and it leads to the gradual development of international community of users. Thus, downloading instructions for use in the period 2005-2008 years increased from 700 to 1300 in one month.

Integrated Land and Water Information System (ILWIS)

ILWIS was created by the company ITC from Enschede city (Netherlands) in 80's. It is used to work with vector and raster data and it is designed for a wide group of questions starting with image analysis till erosion modelling. 3.0 version is very well documented. (2001 year of publication). Currently the main coordinator of the project is the German company *52° North* GmbH, but ILWIS works only under Microsoft Windows system.

Table 2. Comparing software GIS open source basic and some commercial software

		Open Source						
		GRASS 6.4.0	**QGIS 1.4**	**uDig 1.1**	**gvSIG 1.9**	**SAGA 2.0.4**	**MapWindow 4.7**	**ILWIS 3.4**
Licence		**GPL**	**GPL**	**LGPL**	**GPL**	**MPL**	**GPL**	**GPL**
Formate vector read	SHP	+	+	+	+	+	+	+
	GML	+	+	+	+	-	-	-
	DXF	+	+	-	+	+	+	+
Formate vector write	SHP	+	+	+	+	+	+	+
	GML	+	+	+	+	-	-	-
	DXF	+	-	-	+	-	-	+
Formate raster read	JPEG	+	+	+	+	+	+	+
	GeoTIFF	+	+	+	+	+	+	+
	ECW	+	-	-	+	+	+	+
	Arc/Info Grid	+	+	-	-	+	+	+
Formate raster write	JPEG	+	+	+	+	+	+	+
	GeoTIFF	+	+	+	+	+	+	+
	ECW	+	+	-	-	+	-	-
	Arc/Info Grid	-	-	-	-	-	-	-

5. Advantages

Price

Certainly the most attractive option of open GIS software is the license price which usually is absent. It has to be mentioned that open source must not be perceived as free of charge and the first clause of open software definition states that the software distribution, either paid or free, is the authors' choice (http://www.opensource.org/docs/osd). Nevertheless so far the majority of Open Source software used in GIS is distributed absolutely free of charge. An example not often met is ZigGis extension that allows work with PostGIS database in ArcGIS Desktop. The initial code of this software is distributed freely for the personal use and studies but the software used for commercial purposes requires license acquisition.

Despite the big difference between the price of the license to commercial and Open Source software it must be taken into consideration that the total amount of the product and ownership of open software isn't null. Regardless the type of software in the price there must be included installation costs, technical support, training and other related costs. The advantage of open software is the lack of difference between production and use cost. While the price of open software production is formed like the commercial ones, the formation of price for the user differs.

A good example of price difference is the project for the implementation of QGIS open software led by the Government of Solutorn (Switzerland). According to a preventive calculation, the savings based only on licenses was 150-200 thousand US $, but the implementers were forced to spend almost 30 thousand US $ for the software finalization.

Great freedom towards the author

Open GIS, as open software generally reflect the current trends of reducing reliance of software users on their authors (so-called vendor lock-in). Obviously, this problem is relative because a prolonged experience of software use, both open and closed, leads to the creation of technological lines which price can be much higher that the development of new software.

However in terms of open software, its users are given the opportunity to make the necessary changes by themselves.

Old and new refusals of ESRI to serve certain programming languages (VBA, VBA6 for ArcGIS) and programme packages (Arcview GIS 3.x) are rational from the point of view of manufacturers. This step offers the possibility of concentrating all forces to develop perspective directions. Although these steps from ESRI company can create complaints from users.

Development pattern. Open source offers possibility to develop GIS more intense, generally due to the high level of modularity. The development becomes simpler due to the presence of already existent programming components that are used actively in open GIS development. For the interface it is also used QT offering the possibility of working with more vector and raster formats– GDAL/OGR geometric operations, usually made under GEOS/GeoTools library, lately some projects are incorporated in others, components less complex, necessary in GIS. As example can be mentioned relocation of inscriptions (PAL), transformation of projections (Proj. 4), high level reproduction and others.

The complexity of licensing, when different components use between them licenses that very often are incompatible can lead to a development slowness and distribution of software products.

Innovations. If there is a high rhythm of development, attracting programmers from all over the world and high modularity stimulates the innovating character of open software. Here the integration of new technologies that are not sufficiently processed dosn't encounter impediments but frequently they are welcomed. As example there can be mentioned PostGIS

spatial database supports that appeared not long time ago in commercial software MapInfo and ArcGIS. Open GIS have been working with these databases at least for 4-5 years. Quick growth of functionalities can influence reliability and usability of applications, but this can be balanced out by additional testing by a big community of users that can send as answer the needs and deficiencies in case of different open or close software. .

Long-term monitoring of the situation. Many of the benefits of open software listed above may also refer to commercial software in terms of their actual selection. But if the user is on the market for some time, then total control over long-term software products can offer only open software.

6. Current issues

Functionality and performance. Reduced functionality is the key problem of open GIS that impedes their wide implementation and it is due to early age and lack of development and support. As example of reduced functionality can be mentioned the lack of implementation of raster data storage (the development is done for PostGIS-WKTRaster), exoticism of formats (GIS GRASS that work efficiently with personal raster and vector data), insufficiency of WINDOWS operation systems supports (as GIS GRASS). Open GIS face difficulties in work with big settings of data, existent symbols and very often they are limited in their functionality for the production of high quality cartographic products. Although some open GIS try to reproduce the interface of some commercial GIS (e.g. gvSIG and Arcview GIS), generally in this regard they are at the beginning and are a little complicated and quite difficult to describe comparing to the commercial solutions that are created on user's request.

Table 3. Comparison of Open Source basic software and commercial software of functional parts for the elaboration of simple projects

	GRASS	QGIS	uDig	gvSIG	SAGA	MapWindow	MapInfo	ArcView	MapSys
Common data									
Version	**6.4**	**1.5**	**1.2**	**1.9**	**2.0.4**	**4.7**	**10.0**	**9.3**	**10**
Compatibility with Windows OS	+	+	+	+	+	+	+	+	+
Compatibility with Linux OS	+	+	+	+	+	-	-	+	+
Single file of the project	+	+	-	+	+	+	+	+	+
Relative links	-	+	-	-	+	+	+	+	+
Search of lost data sources	-	+	-	+	+	+	+	+	+
Variety of different data in a single project	-	-	+	+	+			-	
Symbols									
Symbols in an external file - vector	-	+	-	+	+	+	+	+	+
Symbols in an external file – raster	-	+	-	+	+	-	-	+	+
Layers' groups	+	+	-	+	-	+	-	+	+
Transparency - vector	+	+	-	-	+	+	+	+	+
Transparency– raster	+	+	+	+	+	+	+	+	+

Legend type – map classification for rasters	+	+	-	-	+	-	-	+	+
Legend type – unique significance of the vector	+	+	+	+	+	+	+	+	+
General map									
General map with vector layers	+	+	-	+	+	+	-	+	+
General map with raster layers	+	+	-	+	+	+	-	+	+
Saving map's general settings in the project	+	-	-	+	+	+	-	+	+

7. Conclusions

Open GIS are in the stage of development but they disserve attention in sustainable development, providing considerable savings in licensing policy, desire of innovation and efficiency of development by finished code use. The benefit of using these types of software is obvious for non-profit enterprises and small projects, organizations that have many branches in cases it is sufficiently reduced their functionality. From another point of view open GIS are a new competitive fighting tool which income doesn't come from software sales. Using open software there can be done considerable savings and can be increased the competition. Regardless this fact several deficiencies of open GIS software described in this study prevent their immediate integration in organizations as basic GIS software. An important step in the development of this field is a pillar project that would demonstrate degree of readiness of open GIS in a real project.

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