CONSIDERATIONS ON OPEN SOURCE GIS SOFTWARE VS. PROPRIETARY GIS SOFTWARE

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Abstract: *Open source software is that kind of software that can be freely used, changed, and shared (in modified or unmodified form) by anyone. Generally, the open source software is made by many people, and distributed under licenses that comply with the Open Source Definition. There are currently several open source GIS software solutions that imposed themselves in GIS environments and gained ground against proprietary GIS branded solutions. The purpose of the present article is to highlight the characteristics of these freeware solutions and some advantages of using them. Also it shows how are implemented these concepts in MSc. curricula.*

Keywords: *sustainable development, environmental issues, GIS, spatial planning.*

1. Main features of OSS (Open Source Software)

The first characteristic is that this kind of software is free and can be modified by the user groups and developers. The main element that distinguishes these products from the proprietary software or shareware is free license, which specify legal rights of users to use, study, change, modify, redistribute and improve source codes. This so-called free license ensure all users access to the source code. (http://www.geotechcenter.org/)

In the last years had been perfected a great number of open source GIS software solutions. There are successful projects like QGIS (QuantumGIS), PostGIS, Grass who have involved both GIS developers and users. There are important organizations as FOSS4G (Free and Open Source Software for Geospatial) and OSGEO (The Open Source Geospatial Foundation) that aim to develop and promote these types of software.

Another main feature is the existence of four forms of freedom for users and only whether a program meets all of these four freedoms can be appreciated that it is an open source software: Freedom 0 - using the program for any purpose; Freedom 1 - studying how the program works and the possibility to adapt it at own needs; Freedom 2 - redistributing copies; Freedom 3 - improving the program and releasing the improvements to the public for the benefit of the whole society.

According to Friedrich, 2014, OSS involves a list of ten criteria that must be met: free redistribution, source code must be included in the program, the license must allow modifications and derived growth integrity of source code base, no discrimination against individuals or groups, no discrimination against further steps, the distributed license, the license must not be specific to a product, the license must not restrict other software, the license must be independent of technology (OSI 2014)

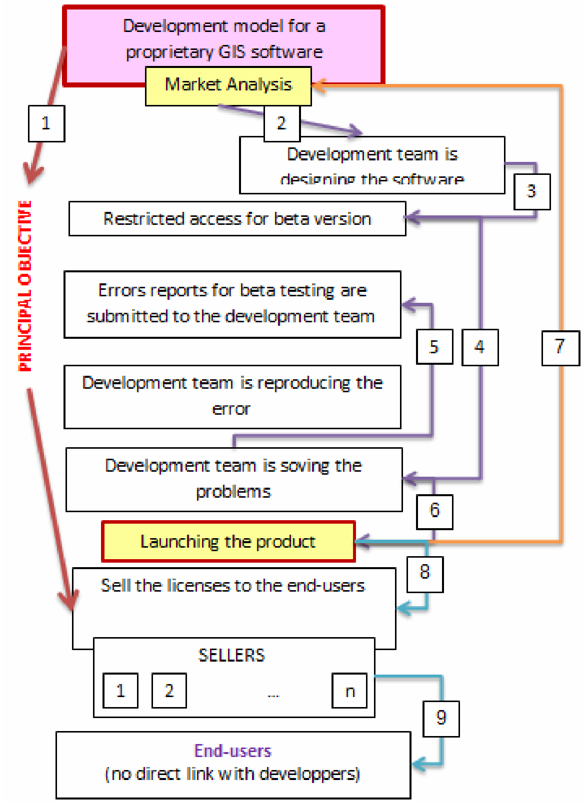
The OS (open source) GIS software products must meet the same criteria and should give users the same four freedoms.

2. Particularities of software development stages

In terms of software development stages there are some differences between the development model of a proprietary product vs. open source product. In Figure 1 are shown the main stages of development.

It can thus be seen that a proprietary GIS software has as main objective the profit maximization. Other features are: planning and subsequent development, the existence of beta testing, achieving development cycles based on a marketing plan, bugs can be solved or not, is indicated to sign long-term maintenance contracts, pay for the upgraded versions.

Regarding OS GIS the main objective is to create a software enable to solve a certain problem. There isn’t a fundamental difference between "end user" and the "developer", the product is not sell by intermediaries, communication is good between developers and users, troubleshooting of bugs are faster. In an OS project, if developed product is preformatted then project fails, being used as long as it is useful, accessible to all interested



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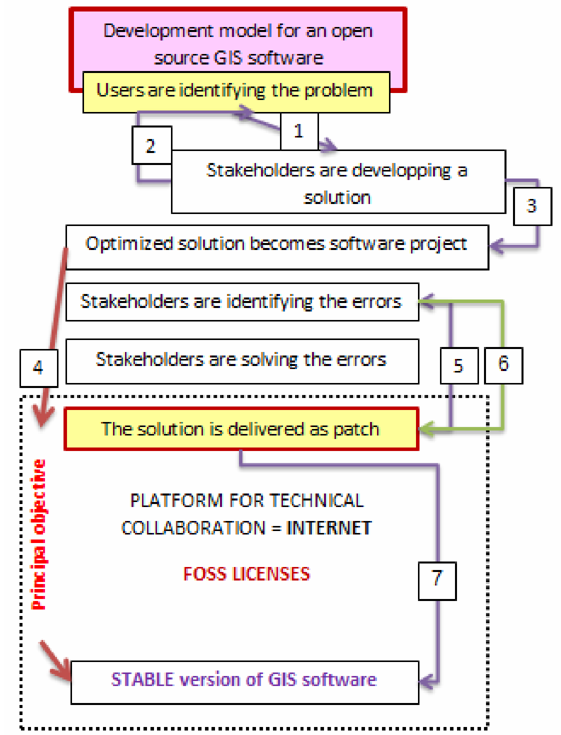

Figure 1 – Development model for proprietary GIS vs open source GIS software
(adapted from http://www.geotechcenter.org/)

3. The trend of using OSS at international level

At European Commission level, there are two strategic components for internal use of OSS: to continue to adopt formally (through the Product Management procedure) the use of OSS technologies and products where a clear benefit can be expected; to consider open source software solutions alongside proprietary ones in IT procurements.

In figure 2 can be seen that OSS has become a major component of the EC's software base.

There are currently several open source GIS solutions (Tsou, 2011) which can be categorized as follows:

1. Basic Desktop GIS - providing the basic functions (input, display, spatial analysis, spatial and textual queries).
2. GIS software for remote sensing
3. 3D GIS visualization tool
4. Other tools (GIS web mapping server, tools and programming libraries, spatial databases)

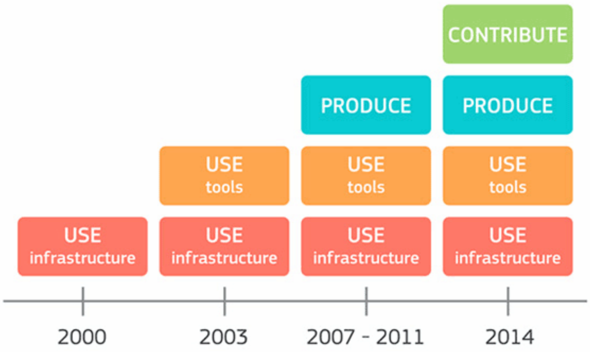

Figure 2 - Evolution in the use of OSS at the European Commission (http://ec.europa.eu/dgs/informatics/oss_tech/index_en.htm)

OSGEO (Open Source Geospatial Foundation) aims to develop quality open source geospatial software, including the creation of standards, curricula and supporting FOSS4G. (Free Open Source Software for Geospatial) The directions in which OSGEO are involved are the following: conferences, publications, website, geodata and - not least - in education. The main OSGEO Projects is presented in Figure 3.

As OS GIS main software solutions can be mentioned:

- PostgreSQL/ PostGIS - Spatial Database (http://www.postgresql.org/ ; http://postgis.refractions.net/)
- GeoServer - Server for Online Publishing/ Data Sharing (http://geoserver.org/display/GEOS/Welcome)
- OpenLayers - Web Application Programming Interface (API) (http://openlayers.org/)
- GRASS - (Geographic Resources Analysis Support System) (http://grass.osgeo.org/)
- OSSIM - Advanced remote sensing & image processing (http://www.ossim.org/OSSIM/OSSIMHome.html)
- QGIS - Quantum GIS - Desktop GIS (http://www.qgis.org/)

- GDAL, OGR - Translator library for geospatial data formats (http://www.gdal.org/)

PostgreSQL is a relational object-based database according with the Open Geospatial Consortium standards and can be connected with ArcSDE, providing security for both spatial and non-spatial data.

PostGIS supports the spatial component of the PostgreSQL server, allowing it to be used as a backend spatial database for GIS, like ESRI SDE.

PostgreSQL (http://www.postgresql.org/) and MySQL (https://www.mysql.com/) successfully manage information in a database system for land administration. GeoServer is used for editing and dissemination of spatial data using open standards, publishing of any data sources such as shapefiles, SQL Server, PostGIS, DB2, Oracle, WFS, TIFF Images, MySQL, allowing integration with existing APIs (Application Programming Interface) (Google, Yahoo, etc.) and communication with ArcGIS Server.

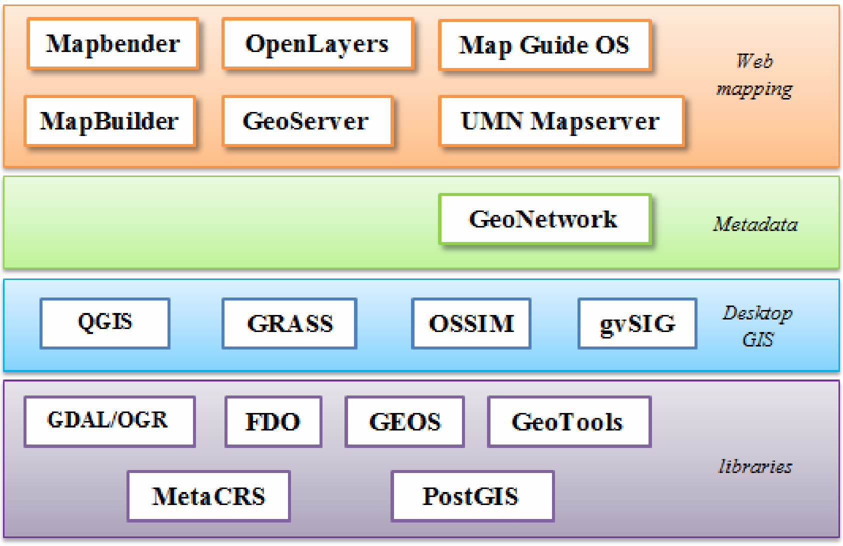

Figure 3 – The main OSGEO Projects (adapted from Behr, 2013)

OpenLayers is an open source JavaScript library for displaying map data in web browsers, providing API for creating web-based geographic applications similar to Google Maps and Bing Maps.

GRASS is a free and open source GIS software suite for geospatial data management using and analysing, image processing, graphics and maps producing, spatial modeling and visualizing. It is used in academic and commercial purpose around the world, as well as by many Governmental agencies and environmental consulting companies, being a founding member of the OSGEO.

OSSIM is a powerful suite of geospatial libraries and applications, used to process imagery, maps, terrain, and vector data.

QGIS (previously known as "Quantum GIS") is a cross-platform free and open source GIS desktop application that provides time viewing, editing, and has analysis capabilities.

As interest from users of GIS OSS, a good barometer is statistical analysis, the results of which are shown in figures 4, 5, 6, 7.

The improvement of QGIS and ArcGIS in the latest versions, there are highlighted the situation of Figure 8.

4. Land Administration Domain Model and OS GIS

Authorities who are responsible with land administration information systems must taking account of OS GIS software as well as LADM (Land Administration Domain Model) (ISO 19152). In the land administration and cadastre systems domain the relevant authorities / agencies must decide whether to use open source or proprietary software . (Zein, 2015) Kepes (2013) is emphasizing that proprietary software is prefered because businesses still favour it.

LADM is about that part of land administration that is interested in rights, responsibilities and restrictions (RRR) affecting land (or water), and the geometrical (geospatial) components thereof, being a conceptual model, and not a data product specification. The LADM standard serves to enable communication between involved persons (information managers, professionals, and researchers) within one country and between different countries, being relevant in the determination of required attributes and in setting responsibilities on maintenance of data sets in case of implementation of LADM in a distributed environment with different organisations involved (Lemmen, 2015).

LADM will support the progressive improvement of cadastres, including fit-for-purpose cadastral requirements. Land administration data must be documented for building up a trusted and reliable land administration with a basic role for transactions and establishment of new land rights in a land administration.

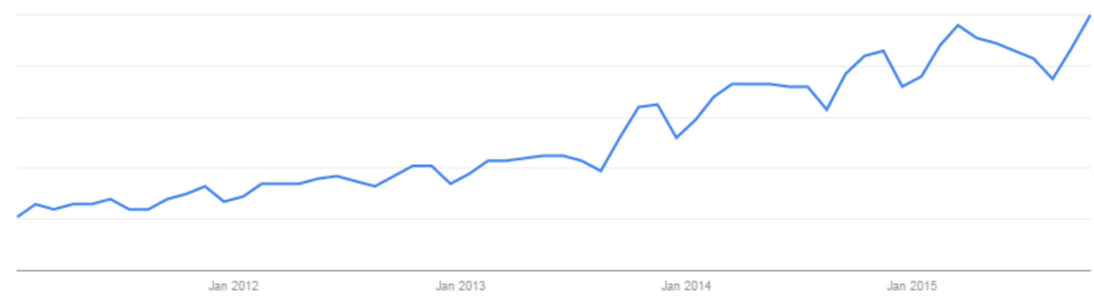

Figure 4 - QGIS Search Requests (ian 2011 – oct 2015) (Google trends)

Figure 5 - Normalized Distribution of QGIS Search Requests (Google trends)

Figure 6 - Normalized Distribution of ArcGIS Search Requests (Google trends)

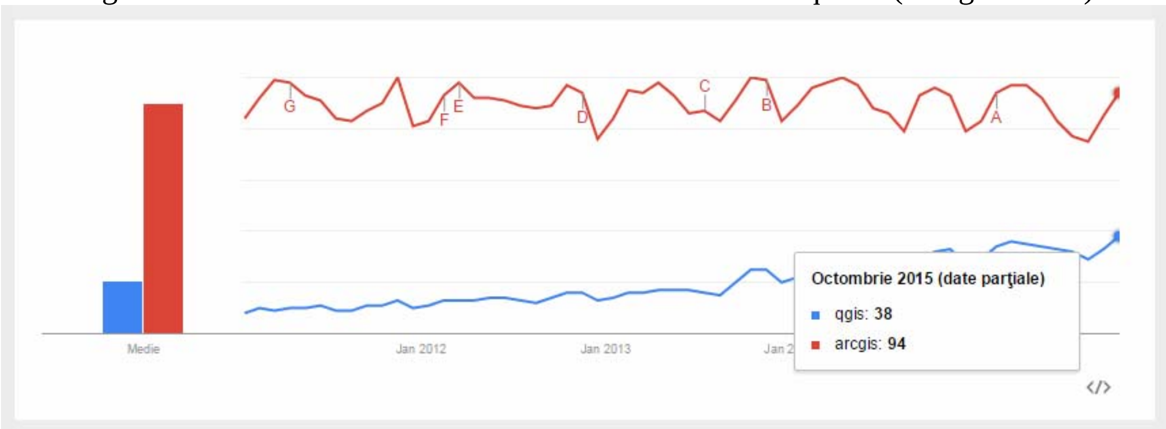

Figure 7 – Comparison between QGIS and ArcGIS searches between January 2011 and October 2015

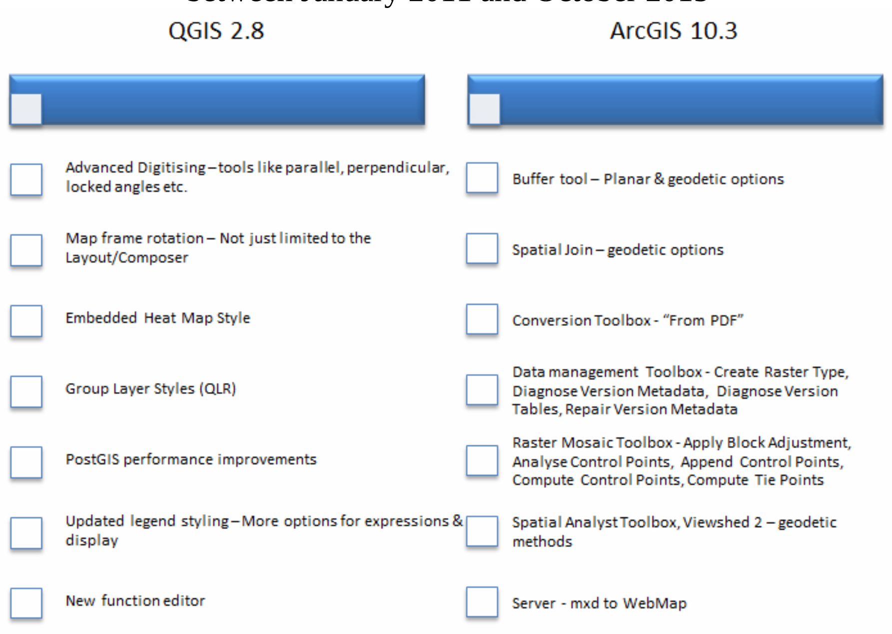

Figure 8 – New integrated features

The model is built upon the continuum of land rights because it is describing land interests, covering basic information related to components of land administration, like party related data; data on RRRs and the basic administrative units where RRRs apply to; data on spatial units and on surveying and topology/geometry. All the components of the data sets are represented using UML packages and class diagrams. (figure 9)

Another important issue is 3D Cadastre. According to 3D Cadastres direction of the FIG Working group, in Romania has to consider where, when, and how to apply 3D Cadastre. It must be designed in the nearest future a generic solution, from legal, organizational and technical viewpoints. Apartments or condominiums are the most frequent type of 3D objects to which RRRs are attached, and it could be argued that these are managed quite well even without a 3D Cadastre. (Felus, 2014) There are occurring more and more complicated cases where the condominium needs to be connected to a 3D volume (above or below the earth surface) from an adjoining parcel. This is nowadays often solved in a suboptimal way (e.g. a lease, but not appropriate to describe the proprietary relationships and rights), and a 3D Cadastre solution would be better to apply in this situation. (Herban, 2012)

Especially it is important the dynamic component of land, setting the requirements for spatio-temporal models for dynamic modelling, like the following:

- Dealing with data (storage and retrieval of large-scale datasets, integrating data from external sources, representation of space, cells as evolving entities
- Extensibility of models (algorithms should be independent of data structures, different models have different rules (Markov chain, regression), working with modellers, cognitively meaningful interfaces (language and data-flow), suitable visualization enviroments

For an appropriate GIS library there are two main requirements:

- Modularity (division into independent components, database, algorithms) and changes in one component do not affect the others
- Extensibility (library can be extended without modifying the existing code, algorithms to be independent from the data model, changes in data model should affect only the database)

Using ESRI technology were developped applications based on LADM. (figure 10)

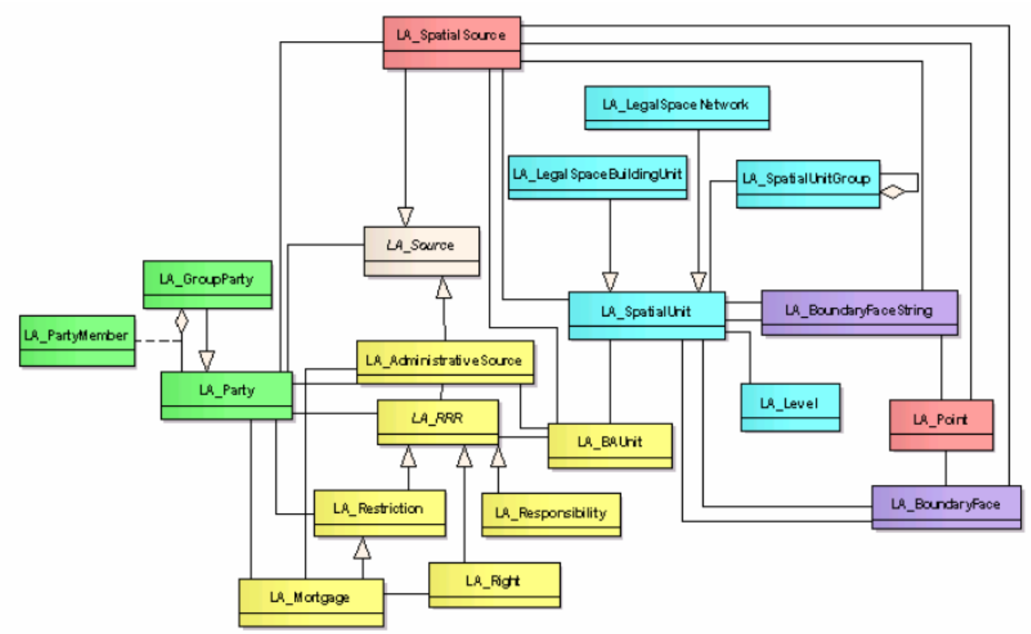

Figure 9 – The LADM Classes (ISO 19152)

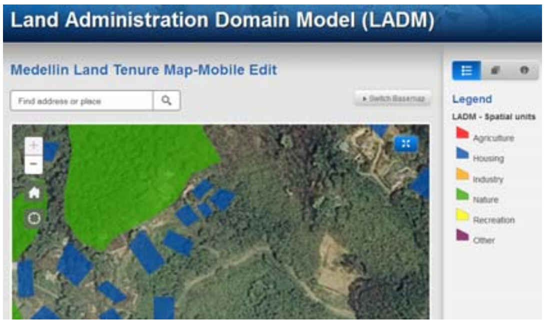

Figure 10 – Online Application using ESRI Technology

There are developped applications based on open source technology, like SOLA. (Solutions for Open Land Administration). (figure 11) SOLA is only one successfully system amongst many possible open source solutions for land administration and cadastre requirements, because there were implemented land administration systems based on open source by various organisations. An open source software is being used by Ireland's Property Registration Authority, the state organisation responsible for all land and property registration transactions. This authority is using a web application called "Landdirect", based on OSS GeoServer for publishing spatial data retrieved from the integrated title registration information system database. Landdirect displays maps which show land registry boundaries over a background map or orthophoto supplied by the Ordnance Survey of Ireland, allowing the user find some details about the property. (Zein, 2015)

In SOLA development process had been applied two constraints: first is that open source software to be used in the implementation and the second constraint is that the system should be portable to a wide range of major hardware and operating system platforms.

The result was an architecture based on a modular generic core making the software open to customization according to the needs of land and cadastre authorities or agencies in different countries. SOLA's database design is based on the Land Administration Model (LADM) as laid down in ISO 19152.

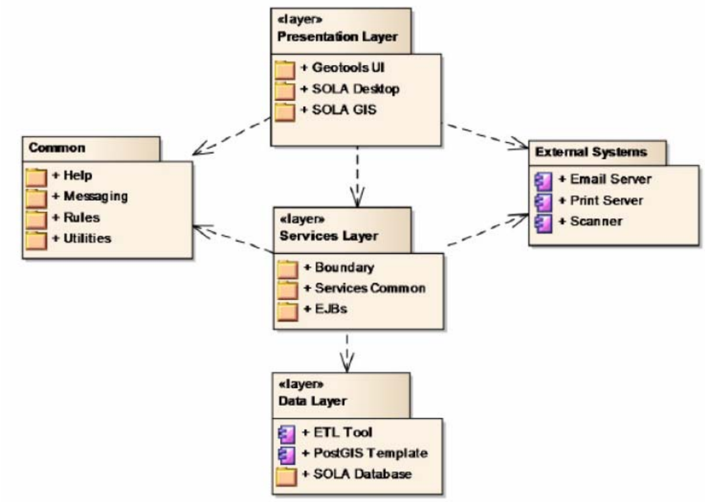

Figure 11 - SOLA package overview (SOLA Software Architecture Document, 2011)

According to http://www.flossola.org/, SOLA software is composed by six modular parts. Registry module is a software for land administration agencies in the purpose to require a secure, robust and transparent tenure registration solution. It is providing an integrated registration and cadastral functions, case management and a LADM compliant database.

Systematic Registration is a module created to support specific activities in cases in which tenure information is collected for the first time. As reports, this module is creating public display listings and maps, generates title certificates and can transfer data to district or national land offices enabling centralized control and maintenance of tenure records. State Land is a module that is assisting both national and local governments to manage land and property that is owned, occupied or controlled by the state. This controlled management is starting with acquisition and is finishing with disposal. Open Tenure is a mobile application which is working on Andriod and iOS devices, facilitating the recording of tenure rights by a community. Community Server is a web based portal dedicated to record and manage the tenure rights collected by a community. This module is integrated with the Open Tenure mobile solution but can be used independently. Web Admin is a web based administration console with the purpose to provide a single administrative port for all SOLA modules that are used by an organisation.

Auxiliary had been also developed some special modules like the following: Mass Valuation (for general property taxation purposes using mass appraisal techniques); Public (a web based portal for various searches of the general public); Addressing (standardized street naming and property number allocation); Forest tenure; Fisheries tenure; Pastoral tenure.

In the generic core has being included all essential functionalities of a land administration system, having adapted application programming interfaces (APIs) and extension mechanisms in the purpose to customize SOLA for specific countries as for example Ghana, Samoa and Nepal.

5. OS GIS in Education

Because of these successfully open source solutions, academia in particular can not ignore them, especially as their use brings some advantages in the educational process. There are a variety of online educational content on site http://www.osgeo.org/educational_content.

Many universities in the world (eg http://www.lunduniversity.lu.se/lubas/i-uoh-lu-GISN04, http://smconservation.gmu.edu/programs/graduate-and-professional/professional-training-courses/essentials-of-open-source-gis/) already included in their curriculum the open source GIS courses, besides those in which are included the proprietary GIS solutions.

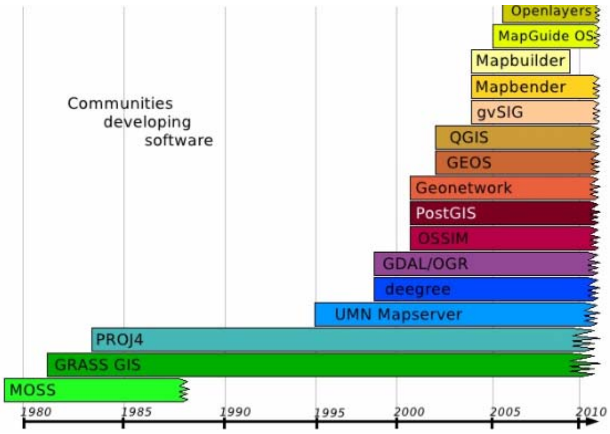

Figure 12 – Increasing Use of GIS OSS (Neteler, 2009)

In the purpose of training in GIS are approved both open source and proprietary software products. The proprietary solutions are used especially because represent main software and their knowledge can be an advantage in employment. The open source solutions are especially studied because of the costs and of the possibility to modify and freely distribute GIS applications. (Badea, 2014) The main reasons for training using open source products are:

- The teachers want to start teaching GIS faster than those schools can allocate financial resources to purchase proprietary software;
- The students want to install and use the GIS softare on personal computers at home and use it for a longer period than a trial solution;
- The teachers want to highlight certain specific GIS features.

6. Conclusions

The main idea is that the open source solutions are gaining importance in GIS academic educational environment as well as in the land administration systems, being used in less or more advanced countries.

Practically, it can be observed that the main functions of land administration systems can be developed through collaboration and improved by an interested community.

The collaborative development will significantly reduce the total cost of ownership of a land administration system, being a cost efficient land administration software solution that could ensure an appropriate property management.

Having this global situation, the academic staff already included open source subjects in the curricula, adapting the level of open source GIS knowledge to the actual situation.

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