

Evaluation of Free/Open Source Software Using OSMM Model

Case Study: WebGIS and Spatial Database

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Abstract

Nowadays, the world of Geospatial Information System is somehow facing to a new paradigm which is the appearance of open source tools as trustable well-formed applications. This pattern, the origin of which goes back to some ten to twenty years ago, is going to strengthen its position by providing more features, attracting more people from GIS community and taking greater market share. This study explores WebGIS Free/Open Source (FOSS) tools, especially UMN MapServer and MapGuide OS, and FOSS spatial databases, mainly PostGIS. It tries to analytically compare different tools available in the field of WebGIS, taking into account various essential parameters. Also, it uses Open Source Maturity Model (OSMM) for a comprehensive evaluation of these tools from different aspects including the product itself, technical support, documentation, integration with other products, and professional services with a unique weighting scheme.

Keywords: GIS, Open source maturity model, FOSS, WebGIS, Spatial Databases.

1. Introduction

The trend of Free/Open Source Software (FOSS) development, especially in the field of Geospatial Information Systems (GIS), has grown rapidly in recent years. Such progress has provided FOSS solutions to different GIS problems. Obviously, the on-going awareness of FOSS tools in GIS community helps with further expansion of these tools to new applications and solving other problems.

Along with this trend towards the application of open source software goes the number of research publications that mentions the use of open source software tools and libraries (see for instance [1]). Furthermore, software and algorithms developed in research projects are increasingly being published under open source licenses (e.g. [2-5]).

Various studies explored this topic. [6] discussed the application of open source software for implementing spatial data infrastructures (SDIs). They conclude that “open-source software provides great potential to make available components for SDI implementations that are affordable by resources poor organisations” and add that “many building blocks for SDIs are already available”. [7],

remarks that “existing [FOSS GIS] products are now entering a phase of rapid refinement and enhancement” while expressing “open source [GIS] software can provide a feature-complete alternative to proprietary software in most system designs.” Also [8] studies geospatial FOSS tools for environmental modelling and management. The authors cover four case studies (workflows) and how FOSS can help to accomplish tasks within these workflows. In their conclusions, they infer that the greatest barriers for an increased use of FOSS in the environmental modelling and management community “seem to be a perceived low importance of geospatial aspect, some technical obstacles, and low visibility.” Recently Steiniger and Bocher ([9]) study current FOSS tools in desktop GIS field while presenting an overview on organisational structures in the open source community. They discuss advantages of FOSS tools for different users expressing like the support of standards and commonly used formats for all users and potential of these tools for furthering the development of a critical perspective on GIS for university researchers. Finally, from university perspective, they outline that “FOSS preserves the researcher from “re-inventing the wheel” and “FOSS products intrinsically have the ‘best’ available documentation, i.e. one can study the source code to understand how things are done”. Regarding 8 studied software, they conclude that most projects were started by companies with commercial background or evolved from research projects and “that most of the projects have a slightly different application and platform focus”.

Here, in this article we are going to study FOSS GIS tools available in the web mapping and spatial database environment. This study begins by what FOSS means, what WebGIS and spatial database are and how users understand FOSS world. Next, it presents evaluation method, shortly called OSMM, describing different aspects of this method and various parameters and functions used in studying of WebGIS tools. The paper continues with a brief introduction of each software. Section 4, the heart of paper, analyzes selected web mapping software, resulting in a table which compares them together. Then, OSMM is applied to UMN MapServer, MapGuide OS and PostGIS and the results of analysis is discussed in following sections.

1.1 Free/Open Source Software

Free Software Foundation presents following definition for Free software: "Free software is a matter of the users' freedom to run, copy, distribute, study, change and improve the software. More precisely, it refers to four kinds of freedom for the users of the software:

- The freedom to run the program, for any purpose (freedom 0).
- The freedom to study how the program works, and adapt it to the users' needs (freedom 1). Access to the source code is a precondition for this.
- The freedom to redistribute copies so users can help the neighboring users (freedom 2).
- The freedom to improve the program, and release users' improvements to the public, so that the whole community benefits from it (freedom 3). Access to the source code is a precondition for this." [10]

The term "Open Source" is used by some people with more or less the same meaning, as "Free Software". Some wrap this up to Free/Open Source Software or shortly FOSS. It is worth mentioning that just contrary to what some people assume, FOSS doesn't mean that the software are not commercial. That's because Free/Open Source doesn't mean at no charge. FOSS tools can be easily considered as commercial products too.

Open source software present different license types usually with the goal of encouraging users to extent this trend more and more. Among the most commonly used ones are GPL, LGPL, BSD and MIT licenses.

Also it is useful to note that using FOSS has following advantages :

- Security
- Retain Control
- Quality
- Cost
- Standards
- Flexibility
- Support

1.2 WebGIS and Spatial Database

WebGIS or Web Mapping is the process of designing, implementing, generating and delivering maps on the World Wide Web [11] while concerning about analysis, and processing of project specific geodata as well as their exploratory aspects [11]. There are different types of web maps as listed below [11]:

- Static web maps
- Dynamically created web maps
- Distributed web maps

- Animated web maps
- Real-time web maps
- Personalized web maps
- Open, reusable web maps
- Interactive web maps
- Analytic web maps
- Collaborative web maps

Spatial database is a type of database which works with spatial data. In reality, present spatial databases have been created by adding some capabilities to the existing databases. These capabilities are [12]:

- Spatial data type
- Spatial indexing
- Spatial operators
- Spatial application routines

Fig. 1 demonstrates hierarchy of spatial objects as defined in OGC Simple Features for SQL (SFS) standard and implemented by most spatial databases.

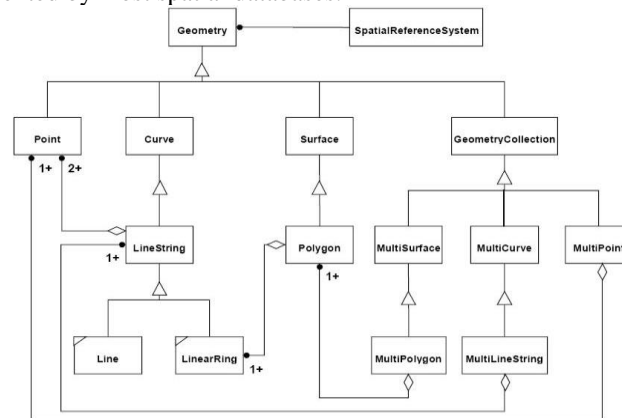


Figure 1. Geometry class hierarchy [13]

1.3 Users and FOSS

According to [14] users facing FOSS products can be divided into two main groups: early adapters and pragmatists. Early adapters are comfortable with using "unfinished" products, whereas pragmatists prefer to wait for the "whole"—or mature—product. Early adapters seek a competitive advantage through technology. However, this strategy comes with a price: a willingness to live with the providers of new technologies. On the other hand, Pragmatists want efficient and cost-effective products. Pragmatists expect technology to support the company's existing strategy, so they wait for a technology to become proven and then begin to implement it quickly. Considering these different users, it is concluded that

Changing from an early-stage company to a mature company is crossing the chasm for free/open source trend [14].

Based on needs of each group of users, a mechanism for maturity assessment of FOSS products called OSMM has been presented [14]. Moreover, one can distinguish three different purpose of using FOSS including: experimentation, pilot, and production. Hence, minimum scores, coming out of OSMM, for different users and their purposes is recommended as s Table 1 displays these minimum scores.

Table 1. Recommended minimum OSMM scores out of 100 [14]

Purpose of Use	Type of User	
	Early Adopter	Pragmatist
Experimentation	25	40
Pilot	40	60
Production	60	70

2. Evaluation Method

This paper applies OSMM model to the most significant WebGIS software in GIS field to measure their maturity. It provides a good indicator of their usage in different applications. Moreover, an analytical comparison of WebGIS tools is given based on the main functions which any WebGIS software should offer. These functions together with their descriptions are listed in Table 2.

2.1 OSMM

According to [14] and [15], Open Source Maturity Model (OSMM) is a mechanism for evaluating open source products helping professionals choosing the most suitable one.

This model defines four steps in analyzing any software's maturity, as described below:

- Assessing each element of maturity individually and assigning a score,
- Defining a weighting method to preceding elements based on requirements,
- Calculating total maturity score for the product,
- Assessing each element and scoring their maturity on scale of 1 to10.

The elements of this model along with applicable indicators and their associated weights are summarized in Table 3.

Table 2. Significant Functions of a WebGIS

Name		Description
Zoom	Click	zoom in/out by clicking on the map
	By Box	zoom in/out by drawing a rectangle on the map showing zoom extent
	MouseWheel	zoom in/out by moving mouse wheel
	Keyboard	zoom in/out via keyboard
	Zoombar	zoom in/out via provided bar in different levels
Pan	Click	put clicked point at center of view
	Dbl Click	pan through double click. Puts double clicked point at center of view. (usually, when click is reserved for another operation)
	On edge	pan via controls provided in sides of map
	Keyboard	pan via keyboard
	With OverviewMap	pan through using overview map
Selection	Drag	pan by dragging with mouse
	By Point	select a point representing clicked feature or a set of features with regarding a tolerance
	By Rectangle	select one or more features via drawing a rectangle showing selection extent
	By Polygon	select one or more features via drawing a polygon showing selection extent
OverviewMap		a fixed map in smaller size which, for e.g., shows displayed extent at the time of zoom in
Layer Tree		tree structures of layers for turning on/off
Legend		legend
Scale bar		scale bar
Distance		measuring distance
Area		measuring area
Volume		measuring volume
Buffer		buffer analysis
Draw features		draw features (usually based on WFS-T standard)
Edit features		edit features (usually based on WFS-T standard)
Print		print map in different formats like PDF
Theme change		change styling and symbology
Tiling		tiling option
AJAX		AJAX support

Table 3. Details of OSMM Model Including Elements, Indicators and Weights

Element		Indicators	Weight
Product	Functionality	Using product descriptions, Referencing standards, Querying the developers, Querying the user community	4
	Product Longevity	Version number, Life span, Total number of downloads	
	Product Quality	Source code examination, Quality assurance efforts (software tests) evaluation, Assessment of activity level of the product,	
	Product Team	Size of project team, Skills and experience of team members	

Technical supports	Community Support	Number of mailing list, Number of mailing list members, Traffic on mailing list, Quality of postings, Responsiveness of postings	2
	Paid Support	Number of Supports, Distribution of supports, Quality of contracts	
Documentation		Developer-created docs, Web postings, Commercially published documentation	1
Training		Web-based mini-tutorials, Developer-created tutorials, Commercial tutorials, Classroom delivered by development team, Classroom delivered by commercial entity	1
Integration with other products		Operating systems, Web Servers, Standards, DB integration, Applications built on top of it, Other integrations or helpful applications	1.5
Professional Services		Number of Professional Services	0.5
Total		-	10

3. Selected GIS Software

3.1 UMN Mapserver

UMN MapServer is originally developed by University of Minnesota, NASA and Minnesota department of Natural Resources which is now hosted by the TerraSIP project. UMN MapServer can be used in two modes: as a CGI application and as an API called MapScript which is programmable by various programming languages. The heart of MapServer in CGI mode is the Mapfile concept wherein the application configuration is specified. Moreover, a HTML template file is used to format outputs based on MapServer specific CGI variables [16]. During its life cycle, some important applications like CartoWeb, KaMap, p.mapper and Chameleon have been developed beside it. These applications add some more functionality such as AJAX support, authentication, and some GIS features to the MapServer. Some other applications like MapStorer, which works along with MapServer, are helpful in building WebGIS applications which are more comfortable for example in providing nice GUI to create Mapfiles.

3.2 MapGuide OS

In spring 2004 Autodesk released an open version of its WebGIS software, i.e., MapGuide OS, to open source community which is now managed by its project steering committee. MapGuide OS works in three-tier architecture mode as displayed in Fig. 2. MapGuide OS offers seven services through MapGuide Server components which are Site Service, Resource Service, Drawing Service, Feature Service, Mapping Service, Rendering Service, and Tile

Service. MapGuide Studio which is a commercial product can be used to configure maps and layers, however, MapGuide Web Studio, a lighter version of the commercial counterpart, is shipped with open source version.

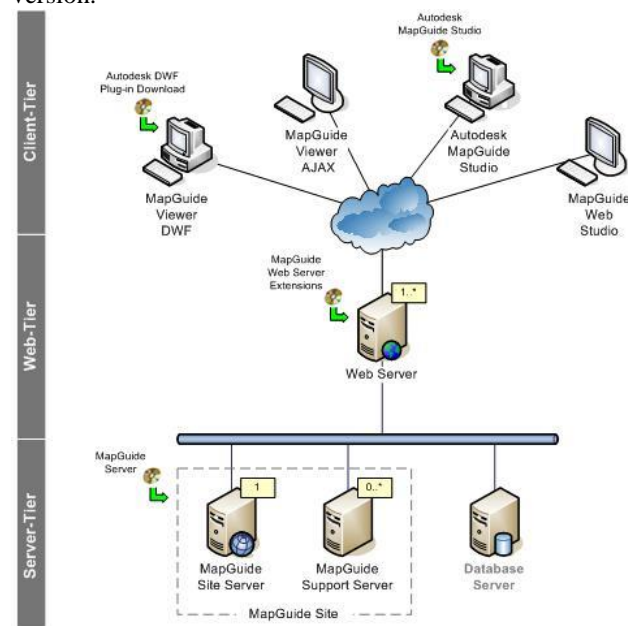


Figure 2. Architecture of MapGuide OS

3.3 PostGIS

PostGIS is a spatial add-on for PostgreSQL which itself is a famous open source object-relational database. It has been developed and supported by Refractions Research Inc. and first released in March 2001 under GNU GPL license. Evolving with time it gained a good compliance with OGC SFS specifications but started to move from OGC specifications to ISO SQL/MM standard as of version 1.2 in late 2006.

In general, its features as stated in the report of Refractions Research Inc. include [17]:

- Proper spatial objects (point, line, polygon, multipoint, multiline, multipolygon, geometrycollection)
- Spatial indexing (R-tree with GiST*)
- Simple analytical functions (area, length, distance)
- Spatial predicates
- Spatial operators
- Coordinate system metadata
- Coordinate re-projection support (via Proj4)
- Data import and export tools

3.4 MySQL

MySQL is the most famous open source relational database management system now. Written in C/C++, it can be used almost by all operating systems. It has started to develop spatial capabilities like spatial types and functions as of version 4.1 in 2003. MySQL used to be maintained by MySQL AB, a Swedish company which is now a subsidiary of Sun Microsystems.

Geometry types provided by MySQL completely conform to OGC SFS, but just a subset of its functions is implemented. MySQL supports spatial indexing which utilizes R-Trees with quadratic splitting algorithm. Applying spatial indexes in spatial functions is a matter that optimizer decides on it; however, it is possible to prevent MySQL from using it. MySQL does not support two metadata tables standardized in OGC SFS specification.

4. Software Evaluation

4.1 Analytical Comparison of WebGIS Software

According to factors specified in Table 2, as the most essential properties of a WebGIS, available software in this field have been analyzed and compared with each other. For a better understanding, final results is summarized and arranged in Table 4.

4.2 Applying OSMM to UMN Mapserver and MapGuide OS

For applying OSMM model to these two software various internet resources including their mailing list, documentation and development team are used. Beside MapGuide OS, this paper evaluates MapServer in addition to four other applications which have been built on top of it, i.e., CartoWeb, KaMap, p.mapper and Chameleon. Investigation of each element follows (Table6-a, b, c, d and e).

Table 5. Functionality Analysis

	MapGuide OS	UMN MapServer
Browser	Internet Explorer, Firefox, Safari	IE, Firefox, Opera, Netscape, Safari
Viewer	1. AJAX Viewer (pure DHTML no plug-in required) 2. Vector-based DWF Viewer (requires an ActiveX Control)	No extra plug-in needed. Just to use JavaScript in client-side
Development Environment	PHP 5.2.1, .NET Framework 2.0, Java™ JDK 5.0 and the Tomcat Servlet engine version 5.5.12	PHP, Python, Perl, Ruby, Java, and C#
Data Access (Read/Write)	1. ESRI Shapefile, SDF, ArcSDE, MySQL, Oracle Spatial/Locator, ODBC GDAL (Raster file formats) (Read-only) OGR (Vector file formats) (All through FDO API) 2.DWF for CAD-based data access 3. OGC WMS and WFS via FDO(Read-only)	1. TIFF/GeoTIFF, EPPL7, and many other raster formats via GDAL (R/W) 2. ESRI shapfiles, PostGIS, ESRI ArcSDE, Oracle Spatial, MySQL and many other vector formats via OGR (R/W) 3. WMS (client/server), non-transactional WFS (client/server), WMC, WCS, Filter Encoding, SLD, GML, SOS
Projection System	Through Proj.4 Library	Through Proj.4 Library
Overview Map	No	Yes
Pan	Yes In panzoom bar	Yes by click Additional applications Dbl click: kamap Pan on edge: cartoweb, chameleon With keyboard: p.mapper, kamap With overviewmap: kamap, p.mapper, cartoweb With drag: kamap, cartoweb
Zoom	Yes panzoom bar, zoom box	Yes by click Zoom level setting, zoom bar additional applications : zoom box: cartoweb, chameleon, KaMap, p.mapper by mouse wheel: p.mapper with keyboard: p.mapper, kamap
Layer Overview	Yes	Yes Complex Layer Tree by CartoWeb
Scale Bar	Yes	Yes
Legend	Yes	Yes
Select by point, rectangle, polygon	By point, rectangle	By point, rectangle:
Spatial Query	Yes	Yes with result querymap
Attribute Query (various forms)	Yes with spatial filter Tooltip Attribute Query	Yes with result querymap, with Join external tables
Labeling	Yes	Yes
Basic Queries (Distance, Area, Volume)	Distance,	Distance:p.mapper, CartoWeb Area: p.mapper, CartoWeb
Advanced features	Buffer Analysis, Print, Theme change (color change)	Print Draw Features: CartoWeb Edit Features: CartoWeb
Tiling	Yes	Yes
Ajax	Yes (just in Ajax viewer)	KaMap, CartoWeb

Table 4. Analvtical Comparison of FOSS WebGIS software

		UMN MapServer	KaMap	p.mapper	Chameleon	MapGuide OS	GeoServer	MapBuilder	Mapbender	OpenLayers
Zoom	Click	√	√	√	√	-	√	√	√	-
	By Box	-	-	√	√	√	√	√	√	√
	MouseWheel	-	√	√	-	-	-	-	-	√
	Keyboard	-	√	√	-	-	-	-	-	√
	Zoombar	-	-	√	√	√	-	√	-	√
Pan	Click	√	√	-	-	√	√	-	-	-
	DbI Click	-	√	-	-	-	-	-	-	√
	On edge	-	-	√	√	-	-	-	√	-
	Keyboard	-	-	√	-	-	-	-	-	√
	With OverviewMap	-	√	-	√	-	-	-	√	√
	Drag	-	√	-	√	√	-	√	√	√
Selection	By Point	√	-	√	√	√	√	√	√	√
	By Rectangle	√	-	√	-	√	√	-	-	√
	By Polygon	-	-	-	-	-	-	-	-	-
OverviewMap		√	√	√	√	-	-	-	√	√
Layer Tree		√	√	√	√	√	-	√	√	√
Legend		√	√	√	√	√	-	-	√	-
Scale bar		√	√	√	√	√	-	√	√	√
Distance		-	-	√	√	√	-	-	-	√
Area		-	-	-	-	-	-	-	-	-
Volume		-	-	-	-	-	-	-	-	-
Buffer		-	-	-	-	√	-	-	-	-
Draw features		√	-	-	-	-	√	√	√	√
Edit features		√	-	-	-	-	√	√	√	√
Print		√	√	√	√	√	√	-	√	-
Theme change		√	-	-	-	√	√	-	-	√
Tiling		√	√	√	√	√	-	-	-	√
AJAX		-	√	-	-	√	-	√	-	√

Table 6. Results of Applying OSM model on MapGuide OS and UMN MapServer

a. Longevity Assessment			
Item		MapGuide OS	UMN MapServer
Life span		November 2005	1994 (officially 1997)
Version number (current stable)		2.0	5.0.2
Total number of downloads		23000 in first year	Not available
b. Product Team Assessment			
Size of Project team		33	29 (13 from MapServer site)
Average rate of activity (based on the number of commits of top 10 contributor during last year)		497	235
c. Support Options Assessment			
Community Support	Number of mailing lists	3	4 (11 including chameleon, kamap, p.mapper, cartoweb)
	Number of mailing members	506	Not available
	Traffic on the mailing list	488 post/month	450 post/month

	Quality of postings	Very good	Very Good
	Number of support	16 (including 1 individual support)	92 (including 32 individual support)
Paid Support	Distribution of support (number of countries)	10	25
	Quality of contract	Not available	7x24 support: 12 (out of 16) Email support: 16 Forum or message board support: 11 Onsite support: 15 Phone support: 16 Remote support: 16
d. Documentation Assessment			
Developer-created doc		Good developer guide Good installation reference Complete web API and viewer API ref.	Very Good HowTo's and References
Web postings		Not so much, just a few Some presentations in FOSS4G conferences	Various number of PDF different kinds of exercise materials presented in FOSS4G conferences
Commercially published doc		0	Appeared in 3 books 1 is devoted completely to it
e. Product Integration Assessment			
Operating system		Linux: Red Hat Enterprise ES 4.0 and Fedora Core 6 Windows: Microsoft Windows Server 2003 and Microsoft Windows 2000	Linux, Windows, Mac OS X, Solaris, and Unix, BSD
Web Server		Apache HTTP Server, Microsoft IIS 5.0 & 6.0	Apache HTTP Server, IIS, Tomcat (for Java Mapscript)
Standards		WMS (Read-only) WFS (Read-only)	WMS (client/server), non-transactional WFS (client/server), WMC, WCS, Filter Encoding, SLD, GML, SOS
DB integration		ArcSDE, MySQL, Oracle Spatial/Locator, ODBC	Good support of PostGIS, Oracle Spatial, PostgreSQL, SQLite, Informix DataBlade, ESRI Personal GeoDatabase, ESRI ArcSDE, MySQL, SQL Server
Applications built on top of it		DMSG Fusion	KaMap, p.mapper, Chameleon, CartoWeb dbox, Fusion, Fist, Geomoose
Other integrations or helpful applications		Autocad Map, Maestro, Autodesk MapGuide Studio, Google Maps	GRASS, R, QGIS, gvSIG, MapStorer
f. Training Options Assessment			
Web-based mini-tutorials		Few found in Autodesk site	Few found
Developer-created tutorials		Good samples for different programming languages. Some tutorials	Good tutorials listed in its site Good samples and examples Good Demos
Commercial tutorials		Some offered	Not available
Classroom delivered by development team		Yes	No
Classroom delivered by commercial entity		Yes just few	Yes just few
g. Professional Services Assessment			
Number of Professional Services		6 (including 1 individual)	92 including 32 individual support (from OSGeo)

Table 7. PostGIS Extension to OGC SFS Functions

Category	Function
Management Functions	DropGeometryTable, UpdateGeometrySRID
Operators	Operators for comparison of bounding boxes of geometries and also to test if two geometries are the same.
Measurement Functions	ST_area2d, ST_distance_spheroid, ST_length2d, length3d, ST_length_spheroid, ST_length3d_spheroid, ST_distance, ST_max_distance, ST_perimeter2d, ST_perimeter3d, ST_azimuth
Geometry Outputs	ST_AsBinary, ST_AsEWKT, ST_AsEWKB, ST_AsHEXEWKB, ST_AsSVG, ST_AsGML, ST_AsKML
Geometry Constructors	ST_GeomFromEWKT, ST_GeomFromEWKB, ST_MakePoint, ST_MakePointM, ST_MakeBox2D, ST_MakeBox3D, ST_MakeLine, ST_LineFromMultiPoint, ST_MakePolygon, ST_BuildArea, ST_Polygonize, ST_Collect, ST_Dump, ST_DumpRings
Geometry Editors	ST_AddBBOX, ST_DropBBOX, ST_AddPoint, ST_RemovePoint, ST_SetPoint, ST_Force_collection, ST_Force_2d, ST_Force_3dz, ST_Force_3d, ST_Force_3dm, ST_Force_4d, ST_Multi, ST_Transform, ST_Affine (2D and 3D Affine), ST_Translate, ST_Scale, ST_RotateZ, ST_RotateX, ST_RotateY, ST_TransScale, ST_Reverse, ST_ForceRHR (for Right-Hand-Rule), ST_Simplify, ST_SnapToGrid, ST_Segmentize, ST_LineMerge
Linear Referencing	ST_line_interpolate_point, ST_line_substring, ST_line_locate_point, ST_locate_along_measure, ST_locate_between_measures
Miscellaneous	ST_Summary, ST_box2d, ST_box3d, ST_extent (maximum extent of geometry features), ST_zmflag, ST_HasBBOX, ST_ndims, ST_nrings, ST_npoints, ST_isvalid, ST_expand, ST_estimated_extent, ST_find_srid, ST_mem_size (amount of space geometry takes in memory), ST_point_inside_circle, ST_xmin, ST_xmax, ST_Accum
SQL-MM Functions	Besides functions that are similar to OGC SFS: ST_CoordDim, ST_IsValid, ST_OrderingEquals, ST_Perimeter, ST_Transform, ST_WKBToSQL, ST_WKTToSQL
ArcSDE Functions	ST_EnvelopesIntersect, ST_Is3d, ST_IsMeasured, ST_LocateAlong, ST_LocateBetween, ST_M, ST_Z

Due to existence of a commercial counterpart for MapGuide OS, assessment on training can be used too. For UMN MapServer, there are not so many training options. Usually, companies who support the software can offer a training course as well. Commercial classrooms and trainings usually can be requested from the dealers and supporter companies. Information provided here shows just available scheduled classrooms and training courses. Table 6-f summarizes the result of this assessment.

For examining the following element just one indicator, i.e. Service Provider of OSGeo (OSGeo, 2012), is used. Table 6-g shows the result of this assessment.

4.3 Applying OSMM to PostGIS

As noted before, PostGIS is in compliance with geometry class hierarchy defined by OGC and its functions, predicates and operators. Additionally, more functions and operators are provided which can be used in SELECT statements as Table 7 lists them.

Furthermore, pgRouting plug-in is developed separately for routing tasks. Also, support of complete topology and raster formats via GDAL is in progress. PostGIS alongside with WKT and WKB formats of OGC, prepare EWKT and EWKB (ISO/IEC, 1999), as specified by ISO SQL/MM, to manage 3dz, 3dm and 4d coordinates [17].

In the following have been presented results of applying OSMM to PostGIS (Table 8- a, b, c, d, e, f and g).

Table 8. Results of applying OSMM model to PostGIS

a. Analysis of Longevity		
Item	Result	
Life span	31 May 2001	
Version number (current stable)	1.3.3	
Total number of Downloads	800 download per day of source code	
b. Project Team Assessment		
Size of Project team	4 main developer + 12 more developers listed in [18]	
Average rate of activity (based on the number of commits of top 5 contributor during last year)	97	
c. Support Options Assessment		
Community Support	Number of mailing lists	3
	Number of mailing list members	Not available
	Traffic on the mailing list	418 post/month
	Quality of postings	Very good
Paid Support	Number of support	82 (including 32 individuals)
	Distribution of support (number of countries)	24
	Quality of contract	Not available
d. Documentation Assessment		

Developer-created doc	Complete guide plus Java API documentation and a nice wiki exists
Web postings	Some found
Commercially published doc	Appeared in 3 books partially
e. Training Assessment	
Web-based minitutorials	Good
Developer-created tutorials	Very good tutorials found plus materials presented at FOSS4G conference
Commercial tutorials	Not available
Classroom delivered by development team	Customizable classrooms offered by Refrations Research Inc.
Classroom delivered by commercial entity	Yes just a few
f. Integration Capabilities Assessment	
Operating system	Linux, Windows, MacOS, UNIX,FreeBSD, Solaris
Drivers and interfaces (mostly from PostgreSQL)	JDBC, ODBC, OLEDB, .Net, Delphi, C++, Tcl, Ruby + a lot more tools for different database tasks
Standards	OGC SFS, WKT, WKB,WKET,WKEB, SQL/MM
Other integrations or helpful applications	UMN MapServer, GRASS, QGIS, uDig, GeoTools, GeoServer, GDAL/OGR, SharpMap, MapWindow, ...
g. Professional Services Assessment	
Number of Professional Services	82 (including 32 individuals)

5. Discussion

Based on information presented in the last section, following scores are given to each element. By applying weights total maturity score, which shows the level of product maturity, is calculated. Table 9 shows the final results.

Table 9. Final Maturity Scores

Element	MapGuide OS	UMN MapServer	PostGIS
Software	6	8.5	8
Support	6	9	8
Documentation	4	8	6
Training	5	6	7
Integration	6	9	9
Professional Services	3	8	8
Total Maturity Score (out of 100)	56	83.5	78.5

Regarding product functionality, UMN Mapserver clearly outweighs MapGuide OS. This is mostly due to longer presence of this software in this area and consequently larger and more organized development team. MapGuide OS has less features, however, it offers more user-friendly interface in comparison to UMN MapServer. This feature makes it a better choice for the beginners. Having Autodesk in background, MapGuide OS could gain a good

support option during its lifetime. Preparing documentations is a vital part of FOSS technology. In this case, UMN MapServer presents more options by offering good start-up materials and also appearing in some books. Although, due to its powerful commercial company in backend, MapGuide has certain training options, MapServer obtains more score due to its more supporters for offering different alternatives.

In Open source world, software are easily integrated with each other. SThis is also the case with UMN MapServer. About MapGuide OS, because Autodesk is backing it up, it has good integration with other Autodesk products. The last factor can be simply compared by looking at number of available professional services for each software.

Having OGC SFS standard in mind, PostGIS provides fundamental components of a spatial database. Beside that, it offers more capabilities for handling, editing and locating spatial data. Regarding routing tasks, an implemented add-on, i.e. pgRouting, has empowered it greatly in this domain. Its long life span emphasizes this point too. As time proceeds, PostGIS has plans to provide full-raster support which leads to a great competitor for Oracle GeoRatser. As one may see clearly, PostGIS presents lots of support options, both as active community and commercial support. PostGIS documentations are admissible while in training area there are more confident alternatives, considering Refraction Research Inc. in the back of product. In addition to good integration capabilities of open source tools, PostGIS have been used by many open source GIS applications ranging from desktop GIS to Web GIS ones. This is mainly the consequence of its applicability as a backend whether as a spatial data repository or also as an analysis tool. Beside developer which provides a full professional services for its product, a big bunch of other choices are in hand, as well.

6. Conclusions

As shown in the previous sections, among the most known free/open source WebGIS tools UMN MapServer and MapGuide OS are more versatile than others, and when comparing these two, UMN MapServer overcomes the MapGuide OS. Also results indicate that UMN MapServer is fully mature open source software compatible with other similar commercial products. In this area there are other tools which can be considered mainly when implementing a powerful WebGIS system. To sum up, high score of UMN MapServer implies that it can be used in a wide range of GIS applications on the web while keeping its compliance with lots of OGC standards and capable of being integrated with other GIS systems.

In the field of spatial databases, FOSS world presents the PostGIS. Having a powerful DBMS in background,

featuring lots of spatial capabilities and being used by many of open source tools, PostGIS is a must in developing most of applications. As this research shows, PostGIS is a fully-grown software to be considered by many users as the main part of GIS applications, specially when dealing with large amount of data that needs fast access and analysis. PostGIS has displayed itself as a strong competitor for commercial counterparts while advancing in some features like 3D functions. MySQL is at the beginning of its spatial road and it sounds that it will be a competitor in this area in the future by providing more spatial features and conforming to standards to a greater degree.

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