Open Source Software: The use of open source GIS software and its impact on organizations

Author

Mahmoud Refaat Nasr

Student ID Number: M00033608
mahrnasr@gmail.com

Supervisor

Carlisle George, PhD

June 2007

Middlesex University

School of Computing Science

A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Business Information Technology

Acknowledgements

I still remember my first orientation session in June 2005 when I had just started my Master program. Back then it all seemed like a long journey and the thesis I am presenting now seemed so distant. Now that I have finished my thesis and my master program, I can't help but look back on all the classes I attended, the wonderful people I met, and the knowledge I have gained. When I look back on all this, I have nothing but positive thoughts of the whole experience, and I think what a magnificent and enriching journey this has been.

Now I would like to say a big thank you to all those who helped inspire this research and helped it see the light. I would like to start by thanking my thesis supervisor Dr. Carlisle George whose valuable advice had always kept me on the right track. Also I would like to thank everyone who took the time and effort to participate in the surveys and provide this research with their valuable contributions. Next I would like to thank Richard Stallman whose communication with me provided me with an insight on how sincerely someone can be dedicated to his ideas. Very special thanks go to both my colleague at RITI Dina El Masry and to my friend Naafii Al Barwani for all the time and effort they provided peer reviewing this dissertation and helping me enhance it to the final form it is on now. Last but not least a really big thank you goes to my family for all the support they provided.

Abstract

Open source may be viewed by many as a revolutionary phenomenon that is capable of providing the software industry with an alternative and competitive way of doing business. Research done so far has tackled the history and business aspects of the open source phenomena, and only few have researched its technical aspects.

This thesis explores the reasons behind the poor level of adoption of open source web GIS software, and whether it is due to poor awareness about open source concepts or due to technical deficiencies in the open source tools. The research was done in 2 major phases; the first phase involved conducting surveys to measure the awareness and attitudes towards open source. The surveys examined three categories of people involved in the IT industry, namely: *decision makers*, *software developers*, and *end users*. The measurement of awareness was done by developing an *Awareness Indicator* and a *Sentiment Indicator* for each category. These indicators were developed by the author during the course of the study in order to provide a measurable and descriptive indication of the results. The second phase involved performing a comparative analysis between *MapServer* a leading open source web GIS tool, and three of the leading proprietary web GIS software, namely: ESRI's *ArcIMS*, Intergraph's *GeoMedia WebMap*, and MapInfo's *MapXtreme*.

The results of the research provide an insight on how different categories of people view open source, and demonstrate that lack of awareness about open source concepts and its competencies may be a major reason behind the poor adoption of open source solutions. The results of the comparative analysis also demonstrate that *MapServer* is technically equivalent to its commercial counter parts.

Keywords

Open source; GIS; MapServer

Contents

List of Tables

List of Figures

List of Abbreviations

ACM:	Advanced Computer Machinery
CRM:	Customer Relationship Management
CVS:	Concurrent Versioning System
ERP:	Enterprise Resource planning
FAO:	Food and Agriculture Organization
FLOSS:	Free/Libre Open Source Software
FOSS:	Free Open Source Software
FSF:	Free software Foundation
GIS:	Geographic Information Systems
GML:	Geographic Mark-up Language
GPL:	GNU Public License
IIS:	Internet Information Services
OGC:	Open Geospatial Consortium
OSI:	Open Source Initiative
OSS:	Open Source Software
SDI:	Spatial Data Infrastructure
UMN:	University of Minnesota
WFP:	World Food Program

CHAPTER 1

INTRODUCTION

CHAPTER 1: INTRODUCTION

Many believe that open source software provides benefits to businesses equivalent to those provided by commercial software products; these benefits include a very low cost of ownership, more frequent updates to the software and its functionality, and the ability to extensively customize the software to meet the needs of the business. Open source software is being supported and promoted by many organizations; such organizations include academic bodies, software developers, and other communities dedicated to open source software and open standards development such as the open source initiative (OSI) and the open geospatial consortium (OGC). These organizations are trying to increase the awareness of businesses and the public to benefits that can be obtained from open source software; they aim to promote it by engaging in activities such as conducting research and sponsoring open source communities.

Even though open source software is capable of providing various benefits to both consumers and businesses, many have kept their distance from it. Reasons for that include fear of security vulnerabilities, the thought that open source software comes with no dependable technical support, concerns regarding reliability and stability issues, and other concerns that have not been examined thoroughly before taking the decision of not implementing open source software.

When we take a look at open source GIS software we can see that it is very popular between academics, and is supported by non-profit organizations such as the FAO or the UN, which indicates that they are technically adequate for their projects. However, open source GIS software is not adopted by many companies and businesses.

This research project investigates why the use of open source GIS tools is not very common among commercial businesses. The project will present a comparative analysis between the specifications and functionality provided by some of the leading commercial GIS software, and one of the most used open source web GIS software (*MapServer*). The results of the above comparisons should clarify the major differences between commercial and open source GIS software, if any, as well as address the various concerns of organizations that are considering using open source GIS software.

1.1 Research Objective

- To review of current writings on open source and more specifically GIS software.
- To examine the awareness and feelings of end users, decision makers, and software developers regarding open source concepts.
- To examine which technical criteria of the software are considered when selecting a web GIS tool.
- Perform a comparative analysis between commercial GIS packages and a leading open source web GIS package.

1.2 Research Questions

- Why there is a poor adoption of open source GIS tools in mainstream enterprises?
- What are the concerns of developers and organizations regarding open source software?
- Are there technical deficiencies in open source GIS tools that discourage developers and users from widely adopting them?

1.3 Research Framework

Three investigations will be performed in order to fulfil the purpose of the project. The first 2 investigations will be primarily conducted through online surveys. Only the third and final investigation will be performed by comparing technical features of open source software with equivalent commercial products. These investigations are outlined below.

1. The first investigation will gauge how informed people are regarding the open source concepts. The conclusions derived from this investigation will help shed light on how open source is regarded as well as answer the research questions regarding the reasons behind the majority of commercial software projects not considering open source as a competitive alternative.

2. The second investigation will examine the selection criteria of web GIS software. This will be done by studying how commercial GIS companies market their products to potential customers, here the websites and online brochures of web GIS products for the 3 major GIS software providers in the world will be examined; namely ESRI, Intergraph, and MapInfo. The products that will be examined are ESRI's *ArcIMS*, Intergraph's *GeoMedia WebMap*, and MapInfo's *MapXtreme*.

3. The Third and final investigation will provide a comparative analysis between one open source web GIS software (*MapServer*) and its commercial counterparts to see if there are technical deficiencies in open source web GIS software.

The population of the surveys will be comprised of IT professionals deal or who have dealt with web GIS in one of 3 ways; Decision makers, Users, and Developers. The surveys will be hosted and conducted online.

1.4 Thesis Report Structure

Table 1.1: Thesis Structure

Chapter Name	Description
Chapter 1: Introduction	An introduction to the project, the research questions and the research methodology
Chapter 2: Background and Literature Review	Provides background information on the topic of open source and GIS, and examines the literature on the topic
Chapter 3: Research Methodology	Details the methodology that will be applied to achieve the research objectives
Chapter 4: Data Collection and Analysis of Findings	Description of how the research was conducted, the data processing tasks, and the findings of the conducted surveys and research
Chapter 5: Conclusion and Recommendations	Presents the final conclusion of the research along with future recommendations for the industry as well as researches in the same domain
Chapter 6: Research limitations and Self Evaluation	Criticism of my performance during the duration of the research, as well as criticizing the limitations that faced the project.

CHAPTER 2

BACKGROUND AND LITERATURE REVIEW

CHAPTER 2: BACKGROUND AND LITERATURE REVIEW

2.1 Introduction

In the late 1990's and after loosing substantial market share to Microsoft's Internet Explorer, Netscape decided to take a revolutionary path to try to regain some of its lost market share, and deny Microsoft a monopoly over the web browser market. They decided to take the yet to be known *Open Source* path. In January 23rd 1998 Netscape decided to provide both its web browser and its source code free of charge to the public domain. Strongly adopted by the developer community, Netscape's *Open Source* project came to be the "Mozilla" project. The Mozilla project attracted many developers to improve and innovate on product suite they considered to be very promising. Mozilla products were freely available to users all over the world through the project's website. By the early 2000's the Mozilla browsers have gained so much popularity among mainstream users that it posed a major challenge to Microsoft's Internet Explorer. People liked Mozilla products (of which the Firefox web browser is the most famous) because it was faster and substantially more secure than Microsoft's Internet Explorer, it was less prone to exposing their identity related information to malicious attackers, and finally because it offered new useful features to users (such as tabbed browsing, and interface customization). (*Compiled from various sources*)

Additionally a brief look at the field of Geographical Information Systems (GIS) shows a recent inclination towards encouraging open source software development. These preferences can be seen in many of the projects being tendered both by government bodies and many of the grant projects funded by the European Union or the United Nations in developed as well as developing nations. The preference towards open source tools in the official tender documents of these projects ranges from implicit inclination towards open source and free licensing schemes, to the extent of explicitly requiring open source licensing schemes such GPL. A good example for this is the project initiated by the WFP and the FAO to create an open source GIS network called the *GeoNetwork* <http://www.fao.org/geonetwork>.

2.2 Background

In recent years we have been hearing people and companies speaking about alternative options to Microsoft's operating system *Windows*. And we heard of different alternatives such as open source Linux, UNIX, and Mac OS, and in this operating system arena open source options such as Linux and other alternative options are slowly gaining popularity <http://marketshare.hitslink.com>. Examiners of other areas would also notice the popularity of open source software. For example *Apache*, the free open source web server is used by more than 70% of internet sites <http://news.netcraft.com/archives/web_server_survey.html>. In another domain many home users, corporations, and even government bodies such as the French assembly (that will replace *Microsoft Windows* and *Microsoft Office* with *Linux* as the operating system of choice for all their desktops, and *Open Office* as their office productivity suite <http://www.pcadvisor.co.uk/news/index.cfm?newsid=7687>) are replacing proprietary closed source and costly office products (such as Microsoft *Office* or IBM *Lotus*) with *Open Office*, a free and open source office productivity suite sponsored by Sun Microsystems. In the database field various alternatives are being considered to replace huge proprietary database engines such as *Oracle*, *Sybase* or Microsoft *SQL Server*, individuals and businesses are looking for alternatives from the open source field such as *MySQL*, *MaxDB*, and *PostgreSQL*. Finally in the field of GIS, users and developers from all disciplines have been trying to replace commercial proprietary software such as *ArcGIS*, *GeoMedia*, and *MapInfo*, with open source tools such as *GRASS*, *MapTools*, *MapBuilder*, and *GeoTools*.

Before Netscape's initiative in 1998 the term *open source* did not really exist, rather there was the term *free software* which was promoted by the Free Software Foundation (FSF) that was founded by Richard Stallman. The FSF was dedicated to promoting the right of users to use, study, copy, modify, and redistribute computer programs. The FSF was established in 1985 and had the objective of promoting freedom of using software as any party may wish. However, the FSF never put specific guidelines that if followed would make the software "free", and the term "free" does not appeal to businesses in general, after all there is no such thing as a free lunch. The FSF had started by attempting to develop a free operating system, they named it the GNU operating system that later evolved to Linux. The major

contribution recognized to the FSF was the GNU Public license or the *GPL*, as a software license, the GPL was cleverly designed to ensure that no form of restriction can ever be placed on software derived from GPL licensed products (See Appendix 3).

In 1998 the Open Source Initiative (OSI) was founded in order to promote the standards of free software to the business community. The Open Source Initiative (OSI), which is a non-profit organization dedicated to promoting the open source values and providing software with the open source compliance certification. The first thing that needed clear definition was the term *open source* itself. According to the OSI, for any software to be considered open source, it has to fulfill all of the ten following terms of distribution <http://opensource.org>:

1. It must ensure **free distribution** of the software and must not impose any restrictions on any party to give away or sell the software.

2. The software must include the **source code** with it.

3. The license must allow modification and **derived works;** meaning that if someone modifies the original software he should be able to redistribute his new work under the same conditions.

4. The license must ensure the **integrity of the author's code** by restricting the distribution of source code in modified forms only if the author will be releasing patch files with the source code. If the author will not be releasing patches for his source code, then the source code may be freely distributed.

5. The license shall have **no discrimination against any persons or groups** and countries for that matter.

6. It should hold **no discrimination against any fields of Endeavour** (such as genetic engineering or nuclear energy).

7. The rights attached to the program **must apply to all entities that the program is distributed to**.

8. The license must **not be specific to product**.

9. The license **must not restrict other software**. For example the license can not force all other software distributed on the same medium to comply with the open source requirements.

10. The license **must be technology neutral**, and should not be inclined to any individual technology or interface style.

With regards to the development life cycle of open source software is usually referred to as *bazaar* mode development, as opposed to conventional *cathedral* mode development where development of the software is limited between selected groups of developers and follows a predefined procedure such as the waterfall model (as with proprietary software development).

Eric S. Raymond (2001), co-founder of the Open Source Initiative, describes the *bazaar development* mode as one where the software is exposed by its owner/creator to a large population of developers who are all welcome to add code, debug, scrutinize the existing code, and in some cases where the owner of the project looses interest in it, someone else in the community may take over the project. Projects like the world famous Linux operating system was developed in bazaar mode, where the project was made available by its owner *Linus Trovalds* to a world wide developer population where everyone was able to constructively contribute to the project in different ways. It is worth noting that Linux originally evolved over the years by a population of mostly part time developers.

2.3 Overview of the Open Source Business

Open source software is developed by volunteers who are usually not paid, most open source licenses make sure that no money is being made from selling the code, and most open source products offer free support for their products. So *how is money made in the open source business? How do companies survive by providing free software and services? What really keeps them going? Does anyone actually make money from open source?* The short answer is YES, and here are some examples.

RedHat (which provides the RedHat distribution of Linux and other services related to open source software) made $105.8 million in total revenue in the last quarter of 2006 <http://www.redhat.com/about/news/prarchive/2006>. Another successful example is Sun Microsystems, which has always been a major contributor to the open source community and provides many open source products (such as the Java platform which has been released under GPL license in November 2006 <http://www.sun.com/2006-1113/feature/story.jsp>, Open office, and Net Beans) and services has made $3.189 billion in the first quarter of the fiscal year 2007 (ending October 1 2006 as reported on their website), of course it should be mentioned that Sun Microsystems has a large pool of products that include hardware and consulting services in addition to the open source technologies. Autodesk is another for-profit company that made $1.523 billion in net revenue in the fiscal year 2006 (Autodesk annual report fiscal year 2006). Autodesk recently started offering open source geospatial products such as open source Map Builder.

It has been observed that open source oriented companies make money selling support to OSS products, developing business specific add-ons for OSS tools, and selling accessory products such as books, manuals, and training material (such as O'Reily and associates)

One might think that because open source software is provided for free and along with its source code, then there is no need to attach a license to it. Therefore it may come as a surprise to learn that there are more than 30 license formats approved by the OSI. These licenses all cover the 10 terms of open source licensing but differ in other

aspects. However some licenses are more restrictive than others when it comes to enforcing open source values; for example the GNU Public License (GPL) was designed to ensure that any software resulting from an originally GPL licensed software should be GPL licensed, while research style licenses such as MIT and BSD do not introduce such enforcement, therefore making it easier for commercial software development companies to sell the open source originating code they develop.

2.4 Literature review

In an effort to investigate the previous literature addressing the research questions, various literatures have been researched ranging from the Journals and papers available on the ACM digital library, First Monday which is a peer reviewed online Journal, published papers and theses available on MIT's Free/Open source research community, in addition to research reports conducted by independent companies such as Forrester.

Various papers from different conferences that focus on open source software have also been reviewed. There were two conferences that specially produced material that was of great value to this research. The first was the Free and Open Source Software for GeoInformatics (FOSS4G) conference that focuses on the latest research and activities of open source GIS software and their use in different business domains. The second was the ACM's Workshop on Open Source Software Engineering (WOSSE) which deals in various topics related to the open source business and the technical aspects of developing open source software.

It has been found that most of the available literature discusses research done to address the first two research questions regarding the reasons for poor adoption of open source software and the concerns regarding open source alternatives, but only very few of the research studies examined addressed the fourth research question regarding the technical competency of open source GIS software by performing a comparative analysis between proprietary GIS software and open source GIS software.

In the following, the research questions are discussed in light of the relevant literature that resulted from previous research.

2.4.1 Motivations for adoption of open source GIS tools in mainstream businesses

One of the first reasons that come to mind when one thinks what would motivate business to adopt FOSS would be the substantial reduction in license cost of software applications. While researching literature written on the topic it was noticed that businesses involved in open source could be classified into two categories. The first category is profit oriented software development companies (mostly Independent Software Vendors) that develop software based on open source tools. The second category is companies who act as end users to software developed using open source tools.

With an aim to examine the incentives of the first category of businesses (software companies) Rossi and Bonaccorsi (2005) conducted a survey on 146 Italian firms providing open source solutions. Rossi and Bonaccorsi concluded that such firms are motivated by both extrinsic and intrinsic incentives. Extrinsic motivations are presented in reduced license costs, supplying software related services, reducing the cost of testing by relying on the open source community, and making use of the large pool of qualified open source developers, therefore reducing the cost of hiring developers in many cases. Intrinsic motivations are mostly related to conforming to the values of the open source community and code sharing. Rossi and Bonaccorsi found that only 18.5% of the companies surveyed actually conformed to the open source community standards and values while trying to make profit. The rest were either inconsistent in their behaviour towards open source standards or used open source tools in an opportunistic manner to make the most benefit they could from that model without contributing back to the open source community.

In another relevant study that aimed to examine how firms do business in the open source model, Bonaccorsi and Rossi (2003) found that many software development companies make use of the robustness provided by the open source development model in order to make financial benefits while providing the least possible contribution to the OSS community that will make them accepted as members in the community. Most of the companies that were studied made use of the open source

licensing schemes by adapting the OSS and redistributing it under a licensing scheme that is most appropriate to them and enables them to generate profit.

In a Forrester report (2005) aiming to study how firms should work with the OSS ecosystem, Michael Goulde interviewed more than 30 software development and user companies. Goulde found that almost all software development companies such as JBoss, Novell, MySQL, and RedHat generate revenue either by providing support services to open source software, developing customized add-ons to accommodate specific customer requirements, or by even by providing software under dual license, or more restrictive license strategies.

The findings of the above research prove that there is money to be made when developing software using open source tools. Yet the motivations of the companies adopting the open source model vary according to their commitment to the open source standards.

A research performed by Michael Goulde (2005) is to investigate the different business models in the open source scene are summarized in table 2.1 presented in the following page. The research examined how different companies involved in open source attempt to generate revenue. This table show that many successful, world famous companies such IBM and Novell take part in open source software development and actually benefit from it.

Table 2.1 The categories and business models of major players in Open Source

Player Category	Revenue Model	Key Features	Example Players
Open Source Communities	**Donations**: Activities of community are funded by donations from outside the community as well as implicit donations made by community participants	**Meritocracy**: Developers are given more responsibilities by peers within the project based on the quality, quantity, and consistency of their participation	▪ GNU Project ▪ Spring ▪ Groovy ▪ Drools ▪ Tigris.org
Open Source Foundations	**Memberships and donations**: Activities of foundation funded by membership fees as well as implicit donations made by participants.	**Project management Communities**: A management structure that provides project strategy and guidance without relying on individuals. Ultimate goal of meritocracy system is to be named to the project management committee.	▪ Apache software Foundation ▪ Eclipse Foundation ▪ Mozilla Foundation ▪ Perl Foundation ▪ Python Software Foundation ▪ Jabber Software Foundation
Open Source Consortia	**Memberships and donations**: Revenue model similar to foundations but different governance	**Customer Focus**: Focus on customer scenario requirements for the open source technology and on evolving the open source technology to address those scenarios.	▪ Open Source Development Lab ▪ ObjectWeb Consortium ▪ Sendmail Consortium ▪ The Open Group
Commercial Open Source Software Supplier	**Support services and licenses**: Service and support subscriptions or open source products add-on products, licenses for add-on products, software license under dual-license technologies.	**Dual Licensing**: Gives customers choice of open source license of a more commercially oriented license. Source code still available, but customers have a choice of surrendering certain freedoms and obligations for support, features, or other value.	▪ JBOSS ▪ MySQL ▪ RedHat ▪ SugarCRM
Strategic ISVs	**Support services and licenses**: Revenue model similar to commercial open source software supplier, but greater reliance on revenue from proprietary products	**SW donation and patent assignment**: Surrendering proprietary IP assets to advance open source projects for longer-term, more strategic gains	▪ Novell ▪ IBM Software Group ▪ Salesforce.com

Source: Goulde, 2005, p.7

Now when we come to take a look on GIS software, we will notice a trend in the previous years by GIS software vendors towards open standards; by open standards we are referring to publicly available specifications that are published, widely used within an industry, and consensus based. This trend became of great importance to GIS users and clients after suffering for years from having different proprietary software packages with proprietary data formats that limit the chances of data exchange with other entities. Therefore there was a need to go towards interoperability between data and applications. According to the OGC website, the Open Geospatial Consortium (OGC) was formed in 1994 to address the GIS community needs for better integration and interoperability among others. The open standards provided by the OGC are not tied to any specific vendor and can be used by

anybody. Yet it is worth mentioning here that the roots of the OGC originate from the free open source GRASS project that started in the 1980s (Christl 2006).

Previous efforts have been made to justify the adoption of open source GIS software in businesses and governments. For example a study conducted in 2001 by Raghavan et al to assess the feasibility of building a spatial data infrastructure (SDI[i]) using open source GIS tools concluded that there are tools available in the open source domain that can provide the required technology to build an SDI (Raghavan et al 2001). Yet the study documented some of the troubles that faced the implementation, such as data interoperability problems, and full compliance with industry standards. However a brief look at any of the current open source GIS software will indicate that open source GIS software has matured a lot since the findings of this study to address usability and interoperability issues.

[i] A Spatial Data Infrastructure is a framework of spatial data, metadata, and tools that are interconnected to make use of spatial data in an efficient and flexible way (wikipedia.org). SDI's offer organizations a unique chance to make use of the spatial data available in each department and reduce data redundancy. In an SDI metadata is managed centrally by it owner department.

2.4.2 Development Methodology for open source software

(Raymond 2001) Discusses how open source software is usually developed using bazaar mode where the code is openly available on the open source community for reuse, testing, criticism, and collaboration. Figure 2.1 illustrates Raymond's view on how open source projects start and that is by addressing a developer's "itch". There are several portals that host open source projects and enable management, communication, versioning, bug control, and documentation sharing between members of the projects. The two most known of such portals are sourceforge.net <www.sourceforge.net> and freshmeat.net <www.freshmeat.net>.

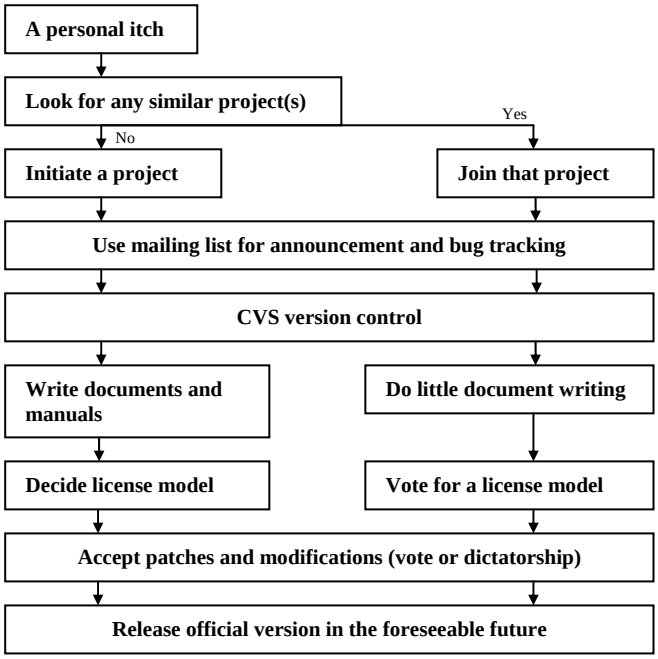


Figure 2.1: Open Source software development life cycle

Source: Al Khatib, 2006, p.29

In an attempt to investigate patterns of software development for open source projects, Stewart et al (2005) selected project samples from the online OS repository sourceforge.net <www.sourceforge.net>. The study found that most of the OS software developed in bazaar mode enabled by sourceforge.net improved in quality (measured by stability, functionality, and reduced number of bug reports) as well as in the overall number of lines of code during the lifetime of the given project. A second

finding by the same research concluded that not all collaborators used sourceforge.net in the same way. Some used it to contribute to the project code and features, others used it to report bugs in a certain release, others requested support, while another group published the features they wish to see in upcoming versions or releases. Finally the study concluded that this diverse behaviour contributes to the robustness that characterizes the open source development model by enabling a larger communication channel between the users and the developers.

In another attempt to characterize the OSS development process, Capiluppi et al (2002) conducted a study on a sample of 400 projects from the open source portal freshmeat.net <www.freshmeat.net>. An interesting finding of this study was that some projects start out as bazaar mode project, and then later, when a certain business decides to incorporate these projects in their products, the businesses then form an internal closed community that requires no support from the general OS community. Such closed communities build their own support teams and develop their own patches. Capiluppi's findings support the case that the bazaar model used in OS development is actually productive and robust. Capiluppi's research findings also demonstrate a very good case of how businesses can use on OS software for their benefit.

Another study that aimed to study the benefit of OS software to commercial industries found that businesses benefit from the OS model due to the large number of users involved in the testing process of OS software. The benefit returned on businesses is not simply due to the quantity of testers, but due to the quality of users and testers as well. Most of the users that do the testing are drawn to the project by interest and background knowledge in the domain of the project (Gurbani et al 2005). When we contrast this to the conventional proprietary software development life cycles, we will find that the tester population for proprietary software is usually less in number, and usually less in quality because they either come from in-house testing departments, or from volunteers.

The research studies discussed show that the bazaar mode of development brings the users (who voluntarily act as testers) and the developers closer, therefore helping

produce more usable software that provides functionality that is of value to the users (because the users initially requested it).

2.4.3 Are there deficiencies in open source GIS that discourage its usage?

OS GIS software started in the 1982 with the GRASS (Geographic Resources Analysis Support System) project that was started by the US army as a tool for land planning and environmental management for the military. Of course it had not yet named open source back then. GRASS became very popular in the open source community and among academics and it is still evolving as a very successful open source GIS tool until present time. Most of the OS GIS software makes use of the already available OS infrastructure presented such as Operating Systems (different distributions of Linux), Web Servers (such as Apache), and Databases (such as MySql and PostGres). When the OGC started publishing standards for geospatial data interoperability and application standards, it has become easier for the open source community to incorporate the open standards of the OGC and even participate in the development of the standards.

The OGC's success can be seen by the level of adoption to its standards in the OS community. For example the *SF (Simple Feature access) for SQL* standard which defines an interface for transparent access of geographic data, has been adopted by OS data bases such as *MySql* (that - according to the mysql.com website - started by implementing a subset of the specification), and PostGIS (that is fully compliant with the OGC specification) as well as by proprietary ones such as *Oracle*, and IBM *DB2* as stated on the OGC website. The adoption of the OGC's SF SQL standard (among other OGC standards) by the Database community made it easier to store geographic data in the Database as tables holding geographic attributes rather than as flat files . The large adoption of such an openly available specification between Database providers has driven proprietary GIS software providers such as ESRI and Intergraph to move towards providing support for storage of geographic data in open formats that can be accessed by all software packages that comply with OGC standards instead of having to store their data in a proprietarily encrypted format that can only be opened by their software.

One of the few studies that were conducted to compare OS and proprietary GIS applications compared between the OS *Map server* tool which is a tool for publishing geographic data on the web that was developed in the University of Minnesota, and the proprietary tools *MapXtreme* by Map Info Corporation, and *ArcIMS* by Esri Inc. (Horanont et al, 2002). During the course of their research Horanont et al observed that unlike the proprietary tools considered, Map server has no prototype wizard that would help users create a web enabled mapping website without having to write code. Wizards usually provide a very handy tool for users who want to create very basic applications without having to write code; this observation raises the issue of usability in OS GIS software as compared to proprietary software.

Another observation that is very interesting in Horanont's research was that in order to publish geographic data on the internet using proprietary software some form of data conversion and processing needed to be performed on separate desktop packages in order to prepare the data for online publishing. The data conversion process was not required for OS *Map Server* because it uses the OGR library that can natively access a wide variety of data formats. This finding surely provides a positive point for the interoperability features of OS tools such as Map Server. A summary of the findings of this study is presented in table 2.2.

In another study to investigate the available open source web based GIS tools, Lee and Lee (2006) concluded that the open source tools they investigated were quite mature but are unlikely to replace the commercial products especially for map creation and production. The reason mentioned for this was that commercial products have very advanced features for the map creation process that are still un-matched by similar open source tools. The author agrees with the findings of this research having personally tried a few OS desktop GIS map production tools, and found them to be challenging from a usability perspective.

The findings of the above research studies are encouraging to both software companies who wish to work with open source software, and end users (businesses) who wish to implement open source software in their business. The findings demonstrate the robustness with which open source software is developing as well as how open it is when it comes to interoperability and standards.

Further research is yet required to investigate the technical competencies of open source GIS software, and find the reasons behind the relatively low level of adoption to open source GIS software.

Table 2.2: Web Mapping tools and features

Supported features	Map Extreme	Arc View IMS	MapServer
Map label	Y	Y	Y
Layer control	Y	Y	Y
Zoom scale	Y	Y	Y
Index map	Y	Y	Y
Thematic map	Y	Y	Y
Query tools	Y	Y	Y
Dynamic lettering	Y	Y	Y
Spatial analysis supported	Y	Y	Y
geo-coding	Y	Y	Y
Database	JDBC	ODBC (ArcView)	ODBC
XML protocol	Y	N	Y
Browser supported	Netscape or Internet Explorer versions 4.x or greater.	Netscape or Internet Explorer versions 3.x or greater.	Netscape or Internet Explorer versions 4.x or greater.
Raster/Vector Display Supported	Y/Y	Y/N	Y/Y
Programming language	Java	Avenue/Java	any CGI
Technical level	Java Servlet/Applet skill	Basic Html/Avenue	Basic Html/CGI
Prototype Builder Wizard	Y	Y	N
Plug-in/Other software required	Tomcat/other servlet container	ArcView 3.x Program on Server	N

Source: Horanont et al, 2002, gisdevelopment.net

2.5 Conclusion

The above researches and studies we came across in this chapter gave a brief background on the development of open source as a concept, as well as demonstrate the different business models involved in open source. They also showed us that many companies run successful businesses based on open source licensing. Additionally the researches provided us with a comparison between an open source web GIS tool and its proprietary counter parts that showed that open source products provided similar functionality to its proprietary counter parts.

The researches we came across in this chapter will help this research by helping to set the scope and direction for the questions of the surveys that will be conducted. The questions in the surveys will be refined using the conclusions and findings of these studies. Also some of the findings regarding the GIS software require updating because the comparative analysis performed by Horanont et al (2002) discussed an ESRI proprietary web programming language called *Avenue* that was used by ESRI before the release of the new family of products which uses conventional web development languages such as Java and .NET. The research that will be performed will shed light on the technical capabilities of the latest releases of both open source and commercial GIS software.

CHAPTER 3

RESEARCH METHODOLOGY

CHAPTER 3: RESEARCH METHODOLOGY

3.1 Introduction:

The purpose of this chapter is to explain and clarify the research path that this thesis will take.

3.2 Research Questions:

The research will attempt to answer the following research questions:

- Why there is a poor adoption of open source GIS tools in mainstream enterprises?
- What are the concerns of developers and organizations regarding open source software?
- Are there technical deficiencies in open source GIS tools that discourage developers and users from widely using them?

3.3 Purpose of the research:

The purpose of this project is to investigate why the use of open source GIS tools is not very common among commercial businesses. The project will present a comparison between the specifications and functionality provided by some of the leading commercial GIS software, and some of the commonly used open source GIS software. The results of the above comparisons should clarify the major differences between commercial and open source GIS software, as well as the economic and technical impacts on organizations that are considering using open source GIS software. The purpose of the research is outlined in the following points below:

- To investigate the reasons why open source GIS software are not commonly used in businesses.
- To demonstrate how requirements for developing a web based GIS application are gathered, as well as the selection criteria for a certain software tool.
- To conduct a thorough comparison between commercial and open source GIS software packages and tools.
- Analyze the differences between commercial and open source GIS software.

3.4 Research Framework

Three investigations will be performed in order to fulfil the purpose of the project. The investigations will be primarily conducted through online surveys. Only the final investigation will be performed by comparing technical features of open source software with equivalent commercial products. The details of each investigation will be explained in section 3.5. Figure 3.1 outlines the path of the investigations that will be performed during the course of this research.

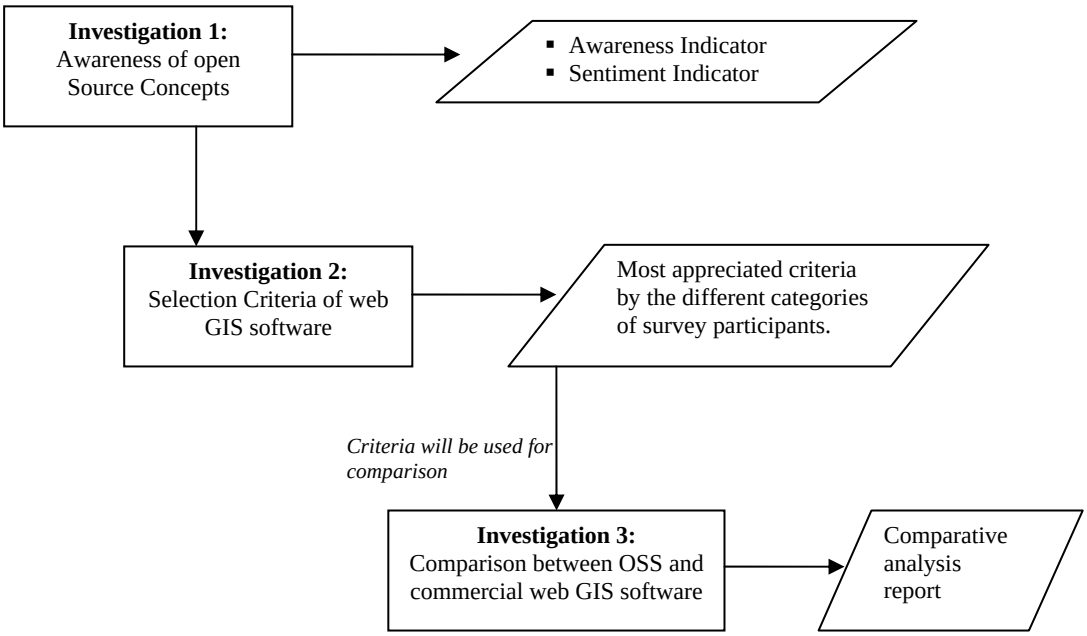


Figure 3.1: Research Path

3.4.1 Population

The population of the surveys will be comprised of IT professionals who deal or who have dealt with web GIS in one of 3 ways; Decision makers, Users, and Developers. The surveys will be hosted and conducted online. Participants will be sent a link to the surveys' URL, and they will answer the survey online. The surveys will be hosted using the free online service of the website <www.createsurvey.com> which offers the possibility of hosting surveys for the duration of one month per user free of

charge. The website also provides basic descriptive statistics for the completed surveys. The estimated number of participants in each category will be as per the following table:

Table 3.1: Estimated Survey Populations

Category	Description	Estimated number of participants
Decision Makers	Composed of officials and managers in positions that entitle them to take the final decision on which software should be used	5
Users	End users of web GIS applications	25
Developers	Software developers of web GIS applications	15

The estimated numbers for the users and developers category are expected to increase, since participants will be encouraged to circulate the survey to their colleagues.

3.4.2 Ethical Issues:

Information about individual participants and their demographic data will not be disclosed in the research. User information that is collected using these surveys will be treated with confidentiality.

3.5 Investigations and Data Processing

All surveys involved in the investigations will include a few questions that will help provide statistics related to the demographics of the population participating in the surveys.

Such questions will relate to the experience of the individual, the size of the organization, and the role of the individual in the organization.

Investigation1: Awareness of the open source concepts

This first investigation will gauge how informed and aware people are regarding the open source concepts. The conclusions derived from this investigation will help shed light on how open source is regarded as well as answer the research questions regarding the reasons behind the majority of commercial software projects not considering open source as a competitive alternative. This investigation will include a survey (see Appendix 1), which will focus basically on how the different categories of the population (decision makers, users, and developers) regard the open source concepts.

The survey will include three sets of questions:

1. Close ended *yes/ no/ don't know* questions that will test people's awareness of the standards set by the OSI for open source software. The "Don't Know" option was added after testing the survey on a small sample of participants.

2. Close ended *yes/ no/ don't know* questions that will asses how people feel about open source software in general.

3. Multiple choice and open ended questions to explore which open source software people are actually familiar with, the reasons that may motivate people to use OS software, and previous experiences with OS software.

Data Processing:

Before concluding any results from the survey, the answered surveys will be first cleaned and coded to match the scaling system mentioned below. *MiniTab* statistical software will be used[ii] for the statistical analysis of the survey. Further details on the data cleaning and coding process will be discussed in the following chapter.

1. The questions that measure people's awareness of the open source standards will be used to develop an *Awareness Indicator*. All answers that agree with

[ii] An evaluation version of the software was used for the statistical analysis tasks in this research.

the OSI specifications will be counted as a +ve value, while those that disagree will be counted as a –ve value. The higher the awareness Indicator, the more aware that person is of open source specifications.

2. The second group of questions that measures how people feel about open source will be used to develop a *Sentiment Indicator*. Answers with positive sentiment towards open source concepts will be counted as a +ve value, while those with a negative sentiment will be counted as a –ve value. The higher the sentiment Indicator, the more positive that person feels about open source software.

3. The multiple choice and open ended questions will be used to provide detailed descriptions of the participants' attitudes towards the open source concepts.

The above mentioned indicators were developed because the author thought it would be more descriptive to develop the *Awareness Indicator* and the *Sentiment Indicator* in the form of aggregated indicators instead of providing statistics about each individual question. Such statistics are detailed in Appendix 2.

Investigation 2: Selection criteria of open source GIS software.

This second investigation will study how commercial GIS companies market their products to potential customers. This will be done by examining the websites and online brochures of the web GIS products for the 3 major GIS software providers in the world; namely ESRI, Intergraph, and MapInfo. The products that will be examined are ESRI's *ArcIMS*, Intergraph's *GeoMedia WebMap*, and MapInfo's *MapXtreme*. The brochures and websites of each product will be examined to see the main points of strength that each vendor believes differentiates them from the others. The author is assuming that each of these commercial companies has done its market research and believes that the points of strength the software that the company is highlighting is of importance to prospective customers. After examining the points of strength for each software, the author will design a survey (see Appendix 1) to examine how a population of GIS users, developers, and decision makers regard the features that are marketed by commercial software companies. The results of the

survey will also point out what features are actually considered by users when they have to select a web GIS software to implement one of their projects.

Survey 2 will be composed of a group of questions divided as follows:

1. A set of close ended *yes/ no/ don't know* questions to aggregate the population's familiarity with the topic. The "Don't Know" option was added after testing the survey on a small sample of participants.

2. A set of scaled questions that examine the inclination of participants towards specific features in web GIS software, the answers will be scaled using a likert scale.

3. A set of multiple choices and open ended questions to explore the actual features that users in each population use, or would like to use in their applications.

Data Processing:

Before reaching any conclusions from the results of the answered surveys, the answers will be cleaned and coded in an appropriate way to enable the answers to be scored accordingly. *MiniTab* statistical software will be used for the statistical analysis of the survey. Further details on the data cleaning and coding process will be discussed in the following chapter.

1. The close ended questions will be used to provide a group of descriptive statistics on the participants' general familiarity with GIS technology.

2. The likert scaled questions will be used to provide a score for each selection criteria addressed by the questions, the criteria with the highest score will be used investigation 3.

3. The multiple choice and open ended questions will be used to provide comprehensive descriptions of the participants' GIS usage patterns.

Investigation 3: Comparative Analysis between OS and commercial web GIS software

This final investigation will use features considered in the second investigation regarding the selection criteria of web GIS software. The features will be used as points of comparison between the 3 major commercial web GIS products and one of the leading and most commonly used open source web GIS software (UMN *MapServer*). The outcome of this comparative analysis will be important because it will address the concerns of decision makers and developers regarding the technical adequacy of OS web GIS software in comparison to commercial and proprietary ones.

CHAPTER 4

DATA COLLECTION AND ANALYSIS OF FINDINGS

CHAPTER 4: DATA COLLECTION AND ANALYSIS OF FINDINGS

4.1 Introduction

An invitation to participate in the surveys has been sent by email to the survey population with the URL for the online surveys that was hosted on the online survey service provided by <www.createsurvey.com>. The survey population was selected from a group of IT professionals who currently deal with or have dealt with web GIS software in one of 3 ways; as Decision makers, as Users, and as Developers.

Participants were able to take part in the survey and provide their input using the internet. The website which was used to host the survey <www.createsurvey.com> provided basic descriptive statistics on the posted responses (such as the number of respondents, and the percentage for each answer), as well as provide the responses in several forms of formatted excel sheets. This was very helpful because it reduced the effort required for data entry and data preparation. This chapter explains the data collected for each of the three investigations, the data cleaning and preparation processes, and an analysis of the findings.

4.2 Investigation1: Awareness of Open Source Concepts

This survey was answered by 43 of the initially intended 45 individuals. A few users were confused about how to classify themselves in the 3 major categories of decision makers, end users, and software developers. A few users used the "other" option for their role in the organization, and provided a description of what they do. The description of what the participants do was later examined and each such participant was assigned one of the 3 initial categories; for example those who mentioned that their jobs were an *IT Consultant* were assigned to the *decision maker* category because they are involved in the decision making process of software selection. Most of the participants (39.53 %) workolved tlves ine part tm

It was interesting to find that Java was the most used open source tools used by 34 (79%) of the survey participants followed by Firefox used by 29 (67%) of the survey participants followed by Linux used by 28 (65%) of the survey participants.

Regarding the roles of the participants in the organizations, they were as follows:

- 8 (18.6%) of the participants were decision makers.
- 13 (30.4%) of the participants were end users.
- 22 (66%) of the participants were software developers.

Additionally the core questions of this first survey included two sets of close ended true or false questions. The first set of 7 questions aimed at measuring the *awareness* of the survey participants about the major concepts of open source as set by the open source initiative (OSI); of course the OSI specifications in the questions have been rephrased to be easily comprehended by the general participants. The second set of 6 questions aimed at measuring the *sentiment* of the participants regarding open source software, and how they feel about it in general. The questions were designed to eventually develop two indicators regarding open source concepts; an *Awareness Indicator*, and a *Sentiment Indicator*. The author thought it would be more descriptive to provide theses indicators in the form of aggregated indicators instead of providing statistics for each individual question.

4.2.1 The Awareness Indicator

This Indicator represents a measure of the *level of awareness* the participants have about open source concepts. As mentioned earlier, the survey consisted of two groups of questions; the first group of questions was used for the calculation of the *Awareness Indicator*.

The questions concerned with the awareness of open source concepts were based on the criteria set by the OSI (Open Source Initiative) that were mentioned in the literature review (Chapter 2). The wording of the OSI criteria has been simplified in the questions to be easily understandable by the participants. The entire survey can be found in Appendix 1. The questions involved in the calculation of the *Awareness Indicator* were questions number: 11, 13, 14, 16, 17, 18, and 19.

These questions had one of three alternatives for an answer:

- True
- False
- Don't Know

To calculate the *Awareness Indicator*, the responses first had to be coded. Each response received a score depending on whether the response matches the OSI criteria in question or not. So if the response agrees with the OSI criteria related to a specific question, the response gets a +1 point. If the response contradicts the OSI criteria related to the specific question, the response gets a –1 point. All questions answered by *"Don't know"* get zero points. Because as mentioned earlier the wording of each question was different from the exact wording of the OSI, and was intended to be comprehendible by the participants, not all questions with a *"True"* response get a +1 point, and not all questions with a *"False"* response get a -1 point. The coding was performed according to the following table:

Table 4.1: Question Scores for Awareness Indicator

Question Number	True	False	Don't Know
11, 14, 16, 18, 19	+1	-1	0
13, 17	-1	+1	0

The value of the *Awareness Indicator* is dependant on the number of questions involved in the evaluation which is 7 questions. Therefore the *Awareness Indicator* can be ranging anywhere between +7 for participants who are fully aware about Open Source concepts, and -7 for participants who are absolutely not aware about any of the open source concepts.

The coded results were then loaded into *Minitab 15* statistical software which offers various statistical analysis tools that are not available in conventional spread sheet software such as Microsoft Excel and Open Office Calc (which is the open source equivalent of Microsoft Excel). *Minitab* was selected over other statistical software such as SPSS due to its ease of use and the availability of online tutorials having lots of examples on how to perform specific analyses. *Minitab* was used to calculate the

Awareness Indicator for each response. *Minitab* was then used to plot the histogram, individual plots, and calculating the average *Awareness Indicator* for each group of users. As per the graphs below it can be seen that the Software Developer category had the highest average *Awareness Indicator* of 2, while the End User category has the lowest average *Awareness Indicator* of .7692.

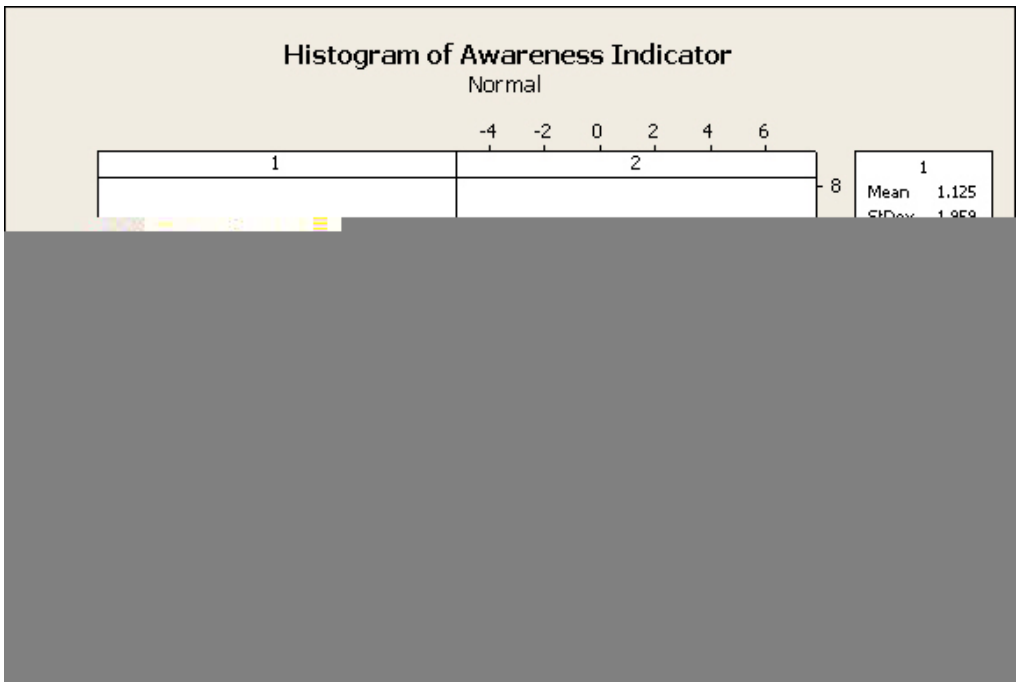


Figure 4.1: Histogram Distribution of Awareness Indicator

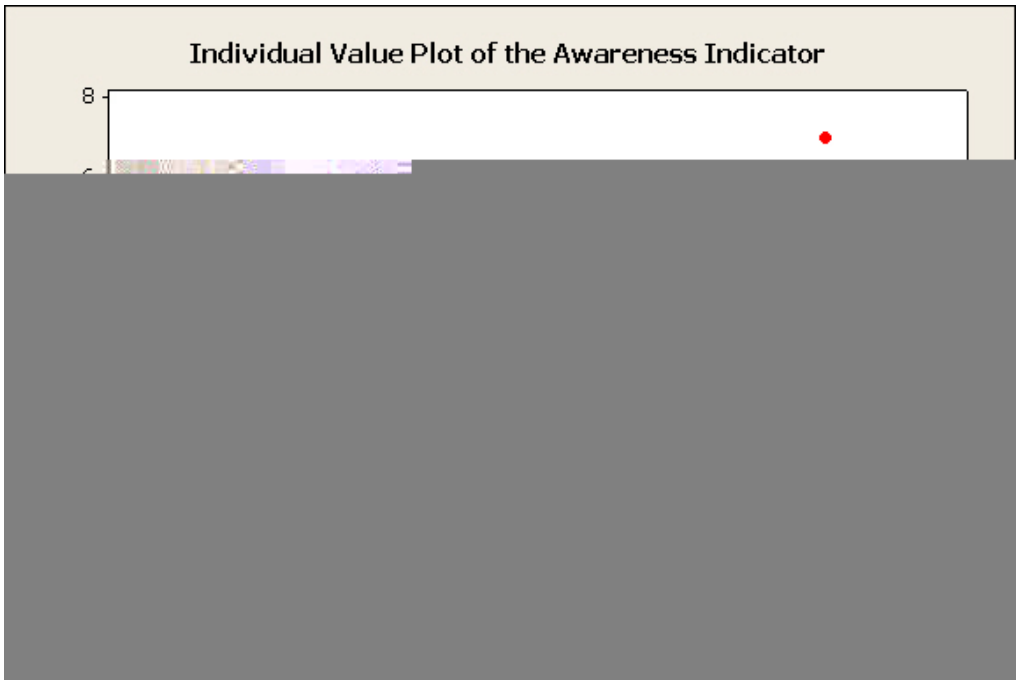


Figure 4.2: Individual value plot of Awareness Indicator

4.2.3 Sentiment Indicator

This Indicator attempts to measure how people *feel* about open source software by assessing whether or not people have positive opinions about open source software. The questions involved in the evaluation of this Indicator were the second group of questions in survey 1. These were a set of 6 questions that could have one of 3 possible answer; *True*, *False*, and *Don't Know*. The following are an example of such opinion measuring questions:

- I believe that open source software is usually full of bugs and is unstable.
- I think that open source software is developed by amateur developers who don't have a regular fulltime day job.
- Developers working on open source projects are not paid.

Of course agreeing with statements such as the above implies a negative sentiment about open source. Each of the 6 questions involved posed a single point of view about open source software, and the survey participants were required to state whether they think this statement was true or not. The entire survey can be found in Appendix 1. The questions involved in the calculation of the *Sentiment Indicator* are questions number: 8, 9, 10, 15, 20, and 21.

To calculate the *Sentiment Indicator*, the responses were first coded. Each response received a score according to whether the response was positive regarding open source software. So for example for the question *"I believe that open source software is usually full of bugs and is unstable"*; a *True* response will result -1 points, while a *False* response will result in a +1 points, and a *Don't Know* would result in 0 points. The coding was done according to the following table:

Table 4.2: Question Scores for Sentiment Indicator

Question Numbers	True	False	Don't Know
21	+1	-1	0
8, 9, 10, 15, 20	-1	+1	0

The value of the *Sentiment Indicator* is dependant on the number of questions involved in the evaluation which is 6 questions. Therefore the *Sentiment Indicator* can range anywhere between +6 for participants who feel very positive and enthusiastic about open source software, and -6 for participants who feel very negative about open source software, and will therefore be discouraged to use it.

Minitab was used to calculate the *Sentiment Indicator* for each response. *Minitab* was then used to plot the histogram, individual plots, and calculating the average *Sentiment Indicator* for each group of users, and as per the graphs below it can be seen that the Software Developer category also has the highest average *Sentiment Indicator* of 3.136, while the Decision Maker category has the lowest average *Sentiment Indicator* of 1.75.

Figure 4.3: Histogram of Sentiment Indicator

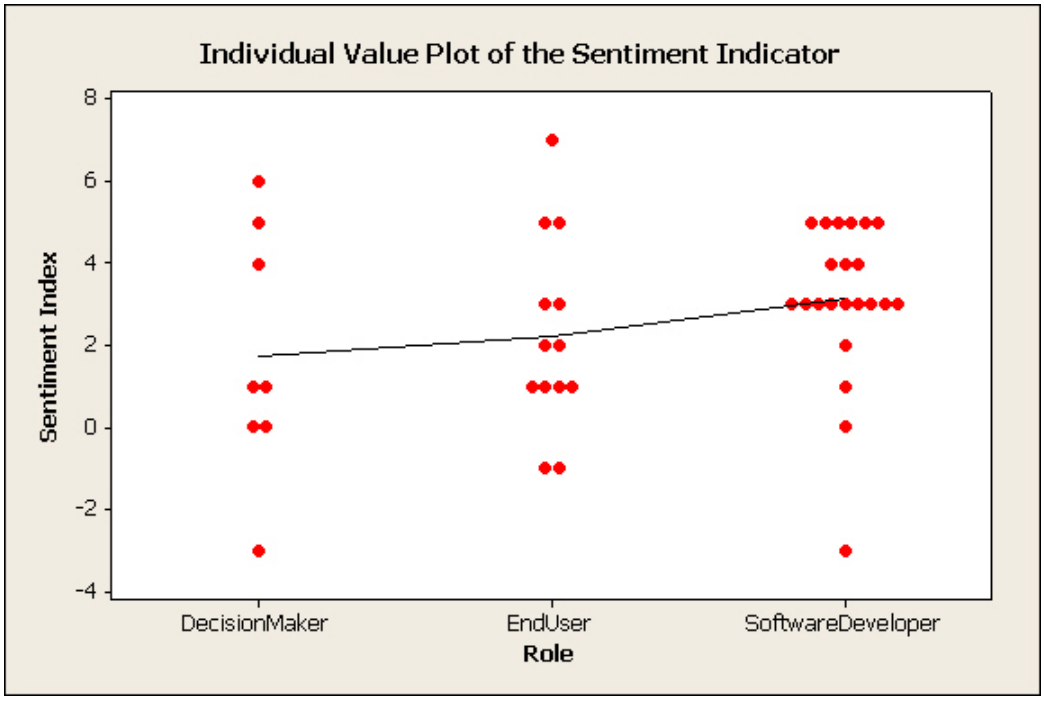


Figure 4.4: Individual value plot of Sentiment Indicator

4.2.4 Further insight on findings:

It was clear from the survey that software developers were the most aware and most likely to use open source software in their projects. This is probably due to the fact that software developers actively follow up the advances in the different technologies and are therefore more familiar with the capabilities of such technologies. Also software developers generally tend to have an exploratory nature therefore they are willing to try new technologies before judging on the feasibility of these technologies, after all Linux was developed by a community of enthusiastic software developers.

The survey contained a question regarding what may motivate the participants to use open source, the number one reason selected by participants was *the freedom to install the software on an unlimited number of computers* selected by 35 (81.4%) of the survey participants, followed by both *the free license charge* and *the flexibility to modify the source code* selected by 31 (72%) of the survey participants. The interesting thing about these findings is that they prove that the lack of license fees may prove to be a very strong motivation for the use of open source.

In the open ended questions that asked participants to discuss their opinion on open source software, a few participants of the "User" category mentioned that they had tried downloading and using open source software such as Linux and Open Office but they faced usability difficulties and switched back to the software they ordinarily use. This is of course typical to the cautious nature of users who usually prefer to stay with the software they are accustomed to using.

Summary of findings Investigation 1:

Table 4.3: Summary of Awareness and Sentiment Indicators for participant categories

Participant Category	Awareness Indicator	Sentiment Indicator
Decision makers	1.125	1.75
End Users	0.769	2.231
Software Developers	2	3.136

- Software developers were found to be the most aware and most likely to use open source software in their projects.

- *"freedom to install the software on an unlimited number of computers"* is considered the number 1 potential motive for using OS software followed by "*free license charge*" and "*flexibility to modify the source code*"

- A few participants of the *user* category mentioned challenges they faced with OS software with regards to usability.

4.3 Investigation 2: Selection Criteria for web based GIS software

The survey for this investigation focused on studying the criteria that are considered when selecting web GIS software to develop a web based mapping application. Before designing the questions in this survey, the major features of some of the major commercial web GIS software tools were examined. The products that were examined were ESRI's *ArcIMS*, Intergraph's *GeoMedia WebMap*, and MapInfo's *MapXtreme*. The brochures and websites of each product were thoroughly examined to see the main points of strength that each software vendor highlighted and believed they differentiate them from the competitors. The author is assuming that each of these commercial companies has done its market research and believes that the points of strength for the software that the company is highlighting are of importance to their customers. The following are the features that were found to be strongly stressed by the commercial software vendors:

1. The ability of the software to be integrated within the company's information systems such as ERP and CRM.
2. The pricing scheme of the software license; whether the license is per number of users, or otherwise.
3. Whether the software has extreme hardware requirements or if it works on normally available hardware configurations.
4. How easy it is to install the software. Some software requires very complicated installation procedures while others come with installers that facilitate the process.
5. How stable the software is in terms of uptime and downtime.
6. The diversity of both attribute and spatial data sources that the software can use.
7. Compliance with technology standards such as those set forth by the open geospatial consortium (OGC) which is an international non-profit organization committed to developing standards for geospatial and location based services.
8. Response time to online user queries and whether the response performance is reduced as the number of users increases.
9. The diversity of spatial analysis capabilities provided by the software.

10. Support for different internet clients such as Internet Explorer, Firefox, and Safari.
11. Whether the software supports being installed on different web server platforms such as IIS, Apache, etc.
12. Whether the software provides a template or a wizard to help jump start the development of online web applications by reducing the code required to be written by the developers.
13. Two of the software vendors (ESRI, and MapInfo) highlighted the fact that their products support development using more than one development language such as JSP, and the .NET languages.
14. Whether the software requires the installation of additional plug-ins on the end user's side.
15. Support for creating and consuming web services.
16. Availability of free geospatial data with the software.
17. The availability and quality of the accompanying documentation that addresses different skill levels, and has lots of coding examples.
18. The market share of the software.

This survey was answered by 38 respondents out of the initial estimated 45. A few participants declined filling the survey because they thought they didn't have adequate GIS knowledge to answer the survey. Even though they were assured that only their opinion as users would be considered regardless of their experience, they still didn't feel comfortable about participating. The role of the participants in this survey was found to be as follows:

- 7 (18.4%) of the participants were Decision Makers
- 10 (26.3%) of the participants were End Users
- 21 (55.3%) of the participants were Software Developers

The questions concerned with the selection criteria included various questions covering the different features mentioned above, the questions were scaled on a likert scale with the 5 options ranging between *strongly disagree*, and *strongly agree*. Responses then received scores according to the following table:

Table 4.4 Question scoring for Likert scale questions in survey 2

Response	Score
Strongly Disagree	1
Disagree	2
No Opinion	3
Agree	4
Strongly Agree	5

The sum of response scores for each question was calculated in order to be able to identify which features were considered important by the participants. After that the responses were split up according to the roles of the participants in order to see what each group of participants regarded as important features. All these operations were performed on *Open Office Calc* which is the open source equivalent of *Microsoft Excel*. After the sum was calculated for each selection criteria, the sum was aggregated for each of the three major participant groups in order to be able to assess which selection criteria are important to each group of participants (decision makers, software developers, and end users).

The figure below (Figure 4.5) shows the score that each of the selection criteria received from the total population of the survey. As it can be seen the criteria that scored most is *whether the software supports a variety of web browsers on the client side or not*, while the criteria that scored least was *the market share of the software*.

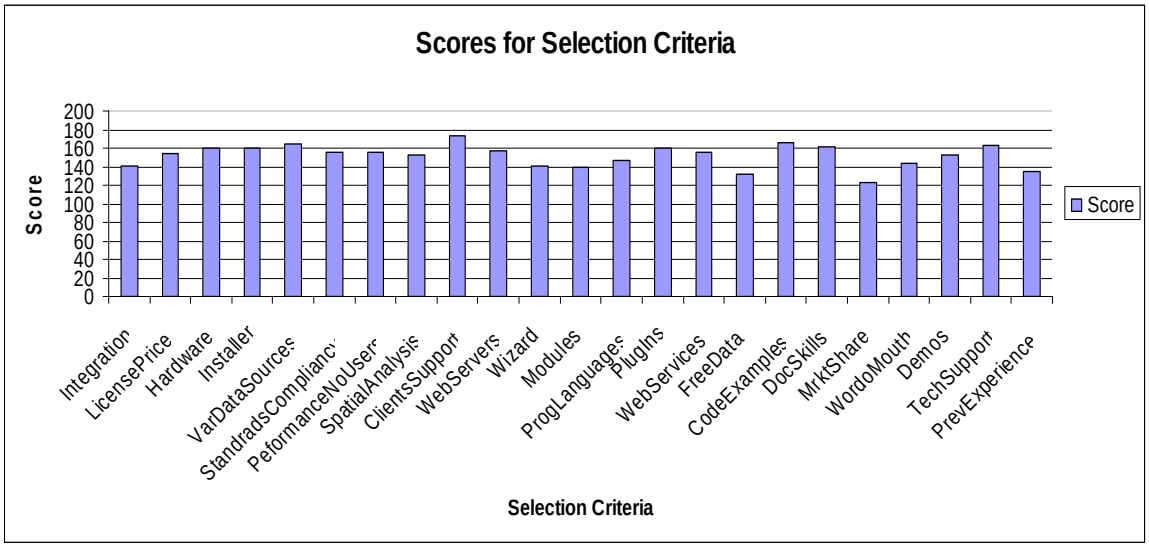


Fig. 4.5: Scores for selection criteria of Web GIS software

The results were further aggregated according to the user groups participating in the survey (please refer to Appendix 2 for detailed results). For **Decision Makers**, the top 5 criteria were:

1. Support for a variety of web clients.
2. License pricing.
3. Ease of software installation.
4. The availability of numerous code examples in the documentation.
5. Whether the performance remains high as the number of users increases.

While the criteria that received the lowest scores for that participant category included:

1. The market share of the software.
2. Whether the software comes with free data or not.
3. The variety of programming languages that can be used to develop applications using that software.
4. Other users' opinions or words of mouth.

For **Software Developers,** the top 5 criteria were:

1. Support for a variety of web clients.
2. The availability of numerous code examples in the documentation.

3. The ability of the software to connect to and display various data sources and perform analysis on them.
4. The availability of documentation that addresses different skill levels.
5. Compliancy of the software with technology standards.

While the criteria that received the lowest scores for that participant category included:

1. The market share of the software.
2. The availability of free data accompanying the software.
3. The previous experience of the software vendor.
4. Other users' opinions or words of mouth.
5. The availability of a wizard that helps in developing web mapping applications, therefore reducing the amount of code required to be written.

For **End Users,** the top 5 criteria were:

1. The availability of technical support.
2. The presence of an installer.
3. Support for a variety of web clients.
4. That the software has no extreme hardware requirements.
5.

- 31 (81.58%) of the survey participants chose both spatial queries, and buffer zones.
- 28 (73.68%) of the survey participants chose routing analysis, best/least distance path between 2 points on a route.
- 26 (68.42%) of the survey participants chose aggregation and summarization of features.

As for the spatial analysis features that were actually used by visitors and users of web mapping sites, participants' responses were as follows:

- 26 (68.42%) of the survey participants chose thematic maps and colour coded maps.
- 21 (55.26%) of the survey participants chose spatial queries.
- 20 (52.63%) of the survey participants chose routing analysis, best/least distance path between 2 points on a route.

Users were also offered the chance to mention other spatial analysis features which they wanted to see on web mapping sites. Only 5 users added features to the already existing list, and they mentioned the following:

- 3D analysis such as line of sight analysis, and 3D terrain visualization.
- Step by step directions on how to reach a certain address (this can also be achieved using routing analysis).
- Editing or modifying map data online; this refers to the ability to modify the geometries of map features online.

4.3.1 Further insight on findings

The above statistics show that users usually have very high expectations regarding the spatial analysis they want to see, when in fact the analyses they use actually use when they visit web mapping sites is just a fraction of what is actually offered. It is interesting however that the availability of a wizard to help users rapidly develop online mapping sites received a low score from all 3 categories of the survey population. This could be justified by the fact that online mapping sites have varying degrees of complexity with regards to the functional requirements.

Some of the survey participants who showed experience in GIS projects implementation were asked some follow-up questions regarding the software development practices in web mapping projects they were involved in. Only 6 of the participants in the original survey were chosen to participate in this follow up, and agreed to take part. The following open ended questions were provided to the users through direct email:

1. *Have the projects you participated in gone through a "pre-tendering" phase where the functional requirements are carefully studied? Or did you think they simply included all the latest features without carefully examining the actual purpose of that project?*

   Users responded that the projects they participated in go through a stage where functional requirements of the application are carefully studied, where the requirements are actually compared to the functionality provided by the different software proposed for the project.

2. *When you start a web mapping project, are the functional requirements always ready by the client/consultant? Or do you work with together to develop the functional requirements?*

   Responses indicated that the projects they participated in go through a stage where the functional requirements are investigated and clarified by the customer.

3. *Do the functional requirements of the application shift as the project progresses or do they remain the same?*

   Almost all respondents indicated that the functional requirements tend to shift or "mature" as the project progresses. One of the participants justified this by the client becoming more aware of the full capabilities of the software and therefore asks for more functionality to use the software to its full potential. While another participant mentioned that the functional and analytical

requirements are changed by the client as per the availability of data required for the project as well as the change of project schedule.

4. *Has it ever happened that the functional requirements of the required application were exceeding the capability of the software provided for the project?*

   Only one respondent answered that mentioned that this has happened in a project that he participated in. He justified this by the fact that the project started with an inclination towards specific software, instead of choosing the software based on the project requirements.

Summary of finding for Investigation 2:

Table 4.5: Top 5 features for all user categories

ID	Feature	Score
1	I would prefer to use GIS web software that would easily integrate with my organization's ERP or CRM.	141
2	The license price of the GIS tool is a very important factor for me when selecting a GIS tool.	154
3	I would prefer a GIS tool that does not have extreme hardware requirements; one that can run on my existing hardware.	160
4	I prefer software that comes with an installer than one that requires compiling and lots of manual setting up.	160
5	I prefer software that enables me to display and analyze data from a variety of data sources on my website.	165

- Users usually have very high expectations regarding the spatial analysis they want to see.

- Even in projects that undergo a *needs analysis phase*, the functional requirements tend to change or "mature" as the project progresses.

- Most of the software used in web mapping projects proves to provide sufficient features for the project needs.

4.4 Investigation 3: Comparison between Open Source and Commercial web GIS software

The previous investigation showed the features that different categories of the survey participants considered important. This investigation will consider the selection criteria mentioned in the previous investigation, and compare which features are present in the open source web mapping software (*Map Server*) with those available in commercial web mapping software (*ArcIMS, GeoMedia WebMap, and MapXtreme*). The website for each of the above mentioned products were used to come to the findings of this investigation.

1. **Support for different web browsers:**
    a. **Map Server:** Browser independent.
    b. **ArcIMS:** Browser independent.
    c. **GeoMedia WebMap:** Browser Independent.
    d. **MapXtreme:** IE and certain versions of Netscape

2. **Availability of code examples in the documentation:**
    a. **Map Server:** Yes
    b. **ArcIMS:** Yes
    c. **GeoMedia WebMap:** Yes
    d. **MapXtreme:** Yes

3. **Ability to connect to, display, and perform analysis on data from various data sources:**
    a. **Map Server:**
        i. Raster[iii]: TIFF/GeoTIFF, EPPL7, MrSID, IMG, Jpeg, and OGC web coverage server among many other formats through the GDAL library.
        ii. Vector[iv]: ESRI shape files, PostGIS, ESRI ArcSDE, Oracle Spatial, MySQL and many others through its OGR library.

[iii] Raster data type consists of rows and columns of cells where in each cell is stored a single value, Raster data types usually refer to *image* style data.

b. ArcIMS:

i. Raster: TIFF/GeoTIFF, EPPL7, MrSID, IMG, Jpeg, among other formats. (OGC web coverage is not supported)

ii. Vector: ESRI shape files, ESRI ArcSDE, ArcInfo Coverages, CAD files, Commercial RDMS engines among other formats.

c. GeoMedia WebMap:

i. Raster: TIFF/GeoTIFF, MrSID, Intergraph Raster files, JPG

ii. Vector: ESRI Shape files, ArcInfo Coverages, MapInfpo tables, CAD files, Oracle spatial, and MS SQL among other formats.

d. MapXtreme:

i. Raster: BMP, JPG, TIFF/GeoTIFF, BIL, SID, PNG, IMG, PSD and ECW files

ii. Vector: ESRI shape files, MapInfo Tables, OGC GML, Commercial RDMS engines among other formats

4. Technical support:

a. Map Server: Technical support is basically provided free of charge through online user communities, online documentation and tutorials, and developer communities. Commercial technical support which provides a professional service level is also provided through some companies such as DM solutions.

b. ArcIMS: A free of charge knowledge base is available online for users to review solutions to previous problems solved by the technical support team. Users can also log a problem, however in this case responses are not guaranteed to be punctual. Another form of subscription support is also available and guarantees prompt support. Product updates and patches are also available on the website free of charge.

c. GeoMedia WebMap: A free of charge knowledge base is available on the support website, and is searchable by any visitor to the website.

[iv] Vector data type uses geometries such as points, lines (series of point coordinates), or polygons, also called areas (shapes bounded by lines), to represent objects

Logging a problem is only possible for customers paying annual maintenance fees.

   d. **MapXtreme:** A free of charge knowledge bas is available online, and is searchable by the general visitors of the website. A free discussion area is also provided for the users where they can exchange information and experience. As with the other commercial software providers, professional support is provided to paying customers.

5. **The documentation addresses different skills of developers:**
   a. **Map Server:** Yes
   b. **ArcIMS:** Yes
   c. **GeoMedia WebMap:** Yes
   d. **MapXtreme:** Yes

6. **The server software does not require extreme hardware requirements:**
   a. **Map Server:** Can be installed on most common personal computers.
   b. **ArcIMS:** Has a hardware requirement for each server software application, but all requirements are easy to fulfil.
   c. **GeoMedia WebMap:** No information was available on the product web page.
   d. **MapXtreme:** Can be installed on most common personal computers.

7. **The server software comes with an installer and does not require compilation:**
   a. **Map Server:** A compilable version as well as a couple of installer versions is available for windows operating systems.
   b. **ArcIMS:** Yes, comes with an installer.
   c. **GeoMedia WebMap:** Yes, comes with an installer.
   d. **MapXtreme:** Yes, comes with an installer.

8. **The software does not require users of the website to install additional plug-ins:**
   a. **Map Server:** No additional plug-ins are required.
   b. **ArcIMS:** No additional plug-ins are required

c. **GeoMedia WebMap:** Different plug-ins (active-x control or java applet) are provided with the software for vector rendering depending on the design and architecture of the website.

d. MapXtreme: No additional plug-ins are required

9. The software can be installed on a variety of web servers:

a. Map Server: Apache, IIS, any HTTP web server.

b. ArcIMS: There is a separate release for Apache, IIS, Oracle application server, sun java system, web logic, Websphere.

c. GeoMedia WebMap: IIS Only

d. MapXtreme: The website states that it is compatible with all popular web servers, but does not state which.

10. The performance of the software remains high even as the number of users increases:

No information was available on the software websites regarding this aspect of the softwares investigated.

11. The software is compliant with technology standards:

a. Map Server: Compliant with OGC standards (WMS (client/server), non-transactional WFS (client/server), WMC, WCS, Filter Encoding, SLD, GML, SOS)

b. ArcIMS: Compliant with OGC specifications (WMS, WFS)

c. GeoMedia WebMap: Compliant with OGC standards (SFS, WFS, WMS)

d. MapXtreme: OGC WMS

12. The software supports providing and consuming web services:

a. Map Server: Yes

b. ArcIMS: Yes

c. GeoMedia WebMap: Yes

d. MapXtreme: Yes

13. Spatial Analysis:

a. **Map Server:** Most of the spatial analysis is performed using the libraries for raster and vector analysis including thematic maps[v], spatial queries[vi], image rendering, and text annotation.
b. **ArcIMS:** Thematic Maps, Image rendering, Spatial and attribute Queries, Data Extraction, Address and Coordinate Geocoding[vii], find address, buffer zones, text annotation
c. **GeoMedia WebMap:** Thematic maps, Spatial and attribute queries, Address and Coordinate Geocoding, Aggregation, Analytical merge, functional attributes, table joins, find address, buffer zones measure length and angle, text annotation
d. **MapXtreme:** Gradient fills, pie charts, buffer zones, thematic maps, advanced text labelling, spatial and attribute analysis

14. Programming languages:

a. **Map Server:** PHP, Python, Perl, Ruby, Java, and C#
b. **ArcIMS:** JSP, ASP, .NET, Cold Fusion
c. **GeoMedia WebMap:** .NET, JavaScript
d. **MapXtreme:** .NET, HAHTsite, ASP, XML and Oracle OCI

[v] Thematic maps provide a colour coded representation of the features displayed in the map; the colours represent distinct attributes or range of attributes of the features.
[vi] Spatial queries help answer questions with a spatial dimension, such as what is the closest hotel to a certain lake.
[vii] Geocoding refers to the presentation of textual coordinate or street address data as a graphical representation on a map.

4.4.1 Summary of comparison

Table 4.6: Summary of Comparison

	Feature	MapServer	ArcIMS	GeoMedia WebMap	MapXtreme
1	Support for different web browsers	Yes	Yes	Yes	Internet Explorer and specific versions of Netscape
2	Code examples in the documentation	Yes	Yes	Yes	Yes
3	Connects to various data sources	A variety of Raster and vector data sources	A variety of Raster and vector data sources	A variety of Raster and vector data sources	A variety of Raster and vector data sources
4	Technical support	Free online support from online communities & Commercial support through service companies	Interactive free online knowledge base and user forums & commercial support services	Static knowledge base & commercial support services	Static free online knowledge base and user forums & commercial support services
5	The documentation addresses different skills of developers	Yes	Yes	Yes	Yes
6	The server software does not require extreme hardware requirements	Can be installed on most PC configurations	HW requirements depends on server technology	No information was available on the product website	Can be installed on most PC configurations
7	The server software comes with an installer and does not require compilation	Yes in addition to compilable versions	Yes	Yes	Yes

	Feature	MapServer	ArcIMS	GeoMedia WebMap	MapXtreme
8	The software does not require users of the website to install additional plug-ins	No Plugins are required on user side	No Plugins are required on user side	Active-X and Java applets required and are supplied by the server	No Plug-ins are required on user side
9	The software can be installed on a variety of web servers	Yes	Yes	Only Microsoft IIS	Yes
10	The performance of the software remains high even as the number of users increases	No information was available on the product website	No information was available on the product website	No information was available on the product website	No information was available on the product website
11	The software is compliant with technology standards	OGC Standards	OGC Standards	OGC Standards	OGC Standards
12	The software supports providing and consuming web services	Yes	Yes	Yes	Yes
13	Spatial Analysis	Yes	Yes	Yes	Yes
14	Programming languages	PHP, Python, Perl, Ruby, Java, and C#	JSP, ASP, .NET, Cold Fusion	.NET, JavaScript	.NET, HAHTsite, ASP, XML and Oracle OCI

4.4.2 Further insight on findings

The previous comparison shows that the open source alternative (*MapServer*) for commercial web GIS software is very competitive and almost equivalent to commercial web GIS software products. In fact the open source mapping GIS software *MapServer* is compliant with more OGC specifications than most of the commercial alternatives used in the comparison. Even in spatial analysis features and data connectivity features *MapServer* proves to be competitive. For example *MapServer* offers users with the possibility to use proprietary data sources such as shape files and Oracle as well as open source data sources such as PostGIS. However *MapServer* may still challenge users when it comes to installation and setting up, which the author has personally experienced when trying to install the Microsoft Windows version of *MapServer* that comes with an installer. There were many compatibility issues, missing DLL file references, registry keys and environment variables which I had to do by myself after referring to many online *MapServer* support communities.

Comparing the findings of this comparison with the one performed by Horanont et al, 2002 that was mentioned in the literature review (Chapter 2), we will find that even the older version of the commercial software that were considered for comparison (such as ArcIMS) have moved away from proprietary development languages such as *Avenue* and are supporting development using a variety of common and open development languages.

Summary of findings for Investigation 3:

- MapServer is a very competitive software and almost equivalent to its proprietary rivals.
- MapServer is in close contact with the industry and is compliant with numerous open standards.
- Installation of MapServer on Windows remains a challenge as compared to the proprietary products.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

Open source software provides many benefits to businesses compared to commercial software products; these benefits include a very low cost of ownership, more frequent updates to the software and its functionality, and the ability to extensively customize the software to meet the needs of the business. Many organizations are supporting and promoting the use of open source software; such organizations include academic bodies, software developers, and other communities dedicated to open source software development such as the open source initiative (OSI) and the open geospatial consortium (OGC). These organizations are trying to increase the awareness of businesses and the public to benefits that can be obtained from open source software; they aim to promote it by engaging in activities such as conducting research and sponsoring open source communities.

Even though open source software is capable of providing many benefits to both consumers and businesses, many have kept their distance from it. Reasons for that include fear of security vulnerabilities, the thought that open source software comes with no technical support at all, fear of reliability and stability issues, and many other reasons that have not been examined thoroughly before taking the decision of not implementing open source software.

The purpose of this project was to investigate why the use of open source GIS tools is not very common among commercial businesses. The author assumed that the reasons for poor adoption could be one of three things;

1. Lack of awareness of what open source is.
2. Negative sentiment about open source products.
3. And the possibility that open source web mapping products provided inferior functionality to its commercial rivals.

Therefore two surveys were conducted; the **first survey** with a focus to measure the survey participants' awareness about open source concepts by developing an *Awareness Indicator* and a *Sentiment Indicator*, the **second survey** focused on studying the criteria which users consider when selecting an open source GIS web mapping tool. Finally a **comparison was conducted** between a selected open source web mapping tool (MapServer) and three of the commercially leading web mapping tools namely ArcIMS, GeoMedia WebMap and MapXtreme.

The purpose of this chapter is to provide a conclusion of the research findings as well as to see how these findings attempt to answer the research questions.

5.2 Summary of Findings

5.2.1 Investigation1: Awareness of Open Source Concepts

This survey aimed at measuring an *Awareness Indicator* to see the extent that participants are aware of open source concepts, and a *Sentiment Indicator* to see how people feel about the open source model. The participants of the survey were categorized into three distinct categories; Software developers, End users, and Decision makers. The Software Developer category were found to have the highest average *Awareness Indicator* of 2, while the End User category has the lowest average *Awareness Indicator* of .7692. Decision makers had an average *Awareness Indicator* of 1.125. As for the *Sentiment Indicator* the Software Developer category also has the highest average *Sentiment Indicator* of 3.136, while the Decision Maker category had the lowest average *Sentiment Indicator* of 1.75.

Table 5.1: Summary of Awareness and Sentiment Indicators for participant categories

Participant Category	Awareness Indicator	Sentiment Indicator
Decision makers	1.125	1.75
End Users	0.769	2.231
Software Developers	2	3.136

It can be seen that the scores of the decision makers in both tests were low. They were not fully aware of open source concepts and they had a very negative image of the open source model. And since decision makers are usually the ones who decide the direction of technology in a company or a project, the poor level of adoption of open source web mapping products could be justified.

5.2.2 Investigation 2: Selection Criteria for web based GIS software

This survey attempted to study the criteria that were considered when selecting web GIS software to develop a web based mapping application. Before designing the questions in this survey, the major features of the three major commercial web GIS software tools were examined.

For **Decision Makers**, the top 5 criteria were:

1. Support for a variety of web clients.
2. License pricing.
3. Ease of software installation.
4. The availability of numerous code examples in the documentation.
5. Whether the performance remains high as the number of users increases.

For **Software Developers,** the top 5 criteria were:

1. Support for a variety of web clients.
2. The availability of numerous code examples in the documentation.
3. The ability of the software to connect to and display various data sources and perform analysis on them.
4. The availability of documentation that addresses different skill levels.
5. Compliancy of the software with technology standards.

For **End Users,** the top 5 criteria were:

1. The availability of technical support.
2. The presence of an installer.
3. Support for a variety of web clients.

4. That the software has no extreme hardware requirements.
5. Not requiring the users to install additional plug-ins.

5.2.3 Investigation 3: Comparative Analysis between Open Source and Commercial web GIS software

The previous investigation showed the features that different categories of the survey participants considered important. This investigation considered the selection criteria mentioned in the previous investigation, and compared which features were present in the open source web mapping software (*MapServer*) with those available in commercial web mapping software (*ArcIMS, GeoMedia WebMap, and MapXtreme*).

The comparison proved that the open source alternative (*MapServer*) for commercial web GIS software is very competitive and almost equivalent to commercial web GIS software products. In fact the open source mapping GIS software *MapServer* is compliant with more OGC specifications than most of the commercial alternatives used in the comparison. Even in spatial analysis features and data connectivity features *MapServer* proves to be competitive. For example *MapServer* (unlike the other commercial products considered in the comparison) offers users with the possibility to use proprietary data sources such as shape files and Oracle as well as open source data sources such as PostGIS. However *MapServer* may still challenge users when it comes to installation and setting up, which had been personally experienced by the author when trying to install the Microsoft Windows version of *MapServer* that comes with an installer. Many compatibility issues had been faced, missing DLL file references, registry keys and environment variables which had to be entered manually after referring to many online *MapServer* support communities.

5.3 Conclusion

This thesis started with a purpose to answer the following research questions:

- Why there is a poor adoption of open source GIS tools in mainstream enterprises?

- What are the concerns of developers and organizations regarding open source software?
- Are there technical deficiencies in open source GIS tools that discourage developers and users from widely using them?

This author started the thesis with an assumption that open source web GIS software is very competitive to its commercial rivals, but the problem was with people's attitudes towards it. The author came to the following conclusions:

1. The results regarding the Awareness Indicator prove that decision makers have relatively low awareness regarding what the open source concepts are all about. Additionally the *Sentiment Indicator* results also prove that decision makers seem to have a negative image about open source software development. They seem to think they would not receive technical support, that it's developed by amateur developers, they also don't see the cash return they would expect in the proprietary software model which mostly comes from proprietary licensing. With decision makers having the final say on which technology to use in which projects, the above findings seem to justify why there is a poor adoption of open source GIS tools in mainstream businesses, and the concerns of organizations to open source software.

    - *Decision makers are currently not fully aware of how open source works; they also have a negative image about it and are therefore unlikely to support using it.*

2. The comparison performed between *MapServer* and the 3 leading proprietary web mapping products proved that *MapServer* was equivalent in features to the proprietary products considered, and was even compliant with more standards than the proprietary products. *MapServer* also provided developers with options to use more data sources. Therefore on the technical side *MapServer* proved to be very competitive to its proprietary rivals. These findings may answer whether there are technical

deficiencies that may discourage developers and users from widely using them.

- *MapServer, the open source web GIS software, provides almost the same features as proprietary ones.*

- *The open source web GIS software considered (MapServer) is compliant with more industry standards than most of its proprietary counterparts.*

- *Commercial products are moving away from proprietary development languages and preferring common open languages.*

The author also wanted to study the software developers' motivations to choose open source software over proprietary ones; however the surveys and the responses received for the surveys as well as the software comparison did not indicate whether or not and why developers may be inclined to prefer working with proprietary software over open source ones.

5.4 Recommendations

It appeared from the findings of the research that decision makers; the people who may influence the use of open source GIS tools in many projects, are not fully aware of the open source business model, and are not aware of the full capabilities that open source software can provide. Therefore the author would like to recommend that greater exposure of open source concepts and features be made for decision makers to match the scope they may be most interested in (which is business and generating revenue). For example orientation seminars, exhibitions, and marketing campaigns demonstrating the benefits of open source software to organizations could be performed by for profit companies providing open source services such as training and support.

5.5 Suggestions for Future Research

Further research can be performed to extend and enhance the work done in this thesis. For example a software project could be developed using *MapServer* and one or more of the proprietary products, and numerous comparisons could be performed to highlight the differences in development speed, complexity, and development patterns for both types of products. Also it would be interesting to study the response of commercial software companies to the advancement of its open source rivals.

CHAPTER 6

RESEARCH LIMITATIONS AND SELF EVALUATION

CHAPTER 6: RESEARCH LIMITATIONS AND SELF EVALUATION

Since this is my very first research project, I have to admit that it has been a very enriching experience that taught me a great deal on how to conduct a research and how to manage the data collected to derive the relevant conclusions. Now, and after completing the research and writing my dissertation, I have this fulfilling sense of accomplishment. In this chapter I will discuss my experience throughout the duration of this research and the lessons I learnt from this journey.

6.1 Research limitations:

This research faced a few limitations described below:

- The survey questions were very broad and included lots of details that were not used to draw any conclusion. This may have been one of the reasons that the number of participants in the surveys was below the expected population. However, such questions were used to ensure the diversity of the population.

- The participants in both surveys could be considered very diverse and relatively low in number. I think that the population should have been more focused.

- A very interesting point which would have added a richer perspective to the results was that I didn't personally participate in the development of an open source web GIS applications to be able to provide a more concise comparison. The author already has in-depth knowledge in developing such applications using proprietary products, and comparing that with the development of an equivalent application using an open source product would have proved very useful to this research. However the time allocated for the project was not sufficient to conduct the surveys, analyze their results and still perform a comparison in development patterns. This may well be an item for future research.

6.2 Research Strengths:

- I believe that this research has discussed interesting points regarding open source GIS software that were not investigated in depth in previous research and may help further advances in open source GIS software research and how it is marketed.

- This research has provided an updated comparative analysis between major commercial web GIS software and *MapServer*.

- The research may help provide a starting point for further research on the reasons that motivate or shape the decisions to use open source in implementing GIS projects.

- Even though this is my first academic research project, I am satisfied with the quality of work I have done in this project, and the quality of the final report I have written.

6.3 Self Evaluation:

At the beginning of the project and while setting the initial project plan I overestimated the time allocated for the research, and therefore I had originally set to do a lot more work than what could be actually done in the project duration. For example I had initially set to develop a web mapping application in addition to the conducted surveys in order to be able to perform a concise comparison between the development process using an open source web mapping GIS tool and the proprietary ones which I have experience implementing from my professional experience.

Additionally, I had not foreseen many of the delays that faced the progress of the research project; the following is a list of the delays faced at each of the project phases:

- Spending more than the originally planned time for the literature review, basically this was because the search for academic writings on the subject of open source software and open source GIS software was a lengthy process.

- Time spent in collecting and analyzing in depth material on the various research techniques, deciding on an exact framework for the research path and finally learning how to conduct surveys and analyze their data.

- I had not allocated enough time in the plan for modifications and/or re-writing of any of the thesis sections.

- Both surveys were more on the lengthy side, which may be one of the reasons the number of participants didn't increase as expected.

6.4 Lessons Learnt:

- This project has taught me the value of time management and planning ahead.

- Being the first academic research to conduct, it has been a very enriching experience to me that taught me a great deal about how to conduct a research project and ensure integrity of the results.

- I have re-acquired my love for reading through the course of this project, a love which I hope remains with me in the future.

APPENDIX 1

CONDUCTED SURVEYS

Appendix 1: Conducted Surveys

Survey 1: Awareness of Open Source Concepts

1. * How many years of experience do you have in IT?

- 1-3
- 3-5
- 5-7
- 7+

2. * How many years of experience do you have in GIS?

- None
- 1-3
- 3-5
- 5-7
- 7+

3. * What is the total number of employees in your organization?

- 1-25
- 26-50
- 51-100
- 100+

4. What is the name of your organization? (Optional)

5. * Your organization can be best described as

- Software vendor/developer
- Public sector
- Private sector
- Other, please specify

6. * What is your role in the organization?

- Decision Maker
- End User
- Software Developer
- Other, please specify

7. * Does your organization use or develop open source software?

- Yes, we use open source software.

☐ Yes, we develop open source software.
☐ No.

8. * I think that open source software is developed by amateur developers who don't have a regular fulltime day job.
○ True
○ False
○ Don't Know

9. * I believe that open source software is usually full of bugs and is unstable
○ True
○ False
○ Don't Know

10. * If I use open source software I will not be receiving any technical support or warranty on the software
○ True
○ False
○ Don't Know

11. * The term "Open source" indicates that the software is provided free of charge.
○ True
○ False
○ Don't Know

12. * Please mark from the following list all software/tools that you may have used before, or plan on using in the future:
☐ Linux (any distribution)
☐ Open Office
☐ Notepad++
☐ GRASS
☐ MapServer
☐ QGIS
☐ Open Layers
☐ PHP
☐ Java
☐ Apache
☐ MySQL
☐ Firefox
☐ PostGres SQL

PostGIS

Other, please specify

13. * There is only one type of open source license. (I.e. all open source licenses are alike)

True

False

Don't Know

14. * Open source software licenses pose no limitations to how you can use or distribute the software

True

False

Don't Know

15. * Developers working on open source projects are not paid

True

False

Don't Know

16. * When contributing software to the open source community, the source code has to be provided.

True

False

Don't Know

17. * If you create open source software, you can state in the open source license that you create any restrictions on who is entitled to use it (e.g. by restricting people from certain countries).

True

False

Don't Know

18. * If you developed software derived from an open source one, then you can copyright the derived software and distribute it under a proprietary style licenses.

True

False

Don't Know

19. * Open source software can be freely distributed to any party.

True

False

Don't Know

20. * Free software provided by Microsoft (such as Internet Explorer), Apple (such as I-tunes), and Yahoo! (such as the Yahoo Messenger) are considered open source software.

- True
- False
- Don't Know

21. * All software that complies with the specifications of "The Open Source Initiative" is very likely to comply with industry standards as well (such as W3C, ISO, and OGC).

- True
- False
- Don't Know

22. * If I decide to use an Open Source product, I will be encouraged to do so for the following reasons (select all that apply):

- I will not have to pay a license fee
- Freedom to install on unlimited number of computers
- Flexibility to modify the source code to accommodate the application to my organization’s needs
- I don’t have to pay support and maintenance fees
- Developers in my organization gain in-depth experience in the application.
- I will be able to make use from the online support of the open source community.
- Open source software provides better features than an equivalent proprietary.
- I will be able to resell the application I develop using open source tools and make money.
- Open source software complies with industry standards more than proprietary ones.
- Other, please specify

23. If you use or have used open source software and would like to share your experience, please mention which software it was and write your comments in the following area.

24. Please enter your name and email (each on a separate line) if you agree to be contacted for clarifications. (Optional)

25. Finally, if you have anything you would like to add regarding Open Source concepts, or about this survey, please do so in the following area: (Optional)

Survey 2: Selection Criteria of Web GIS software

1. * How many years of experience do you have in IT?

- 1-3
- 3-5
- 5-7
- 7+

2. * How many years of experience in do you have in GIS?

- None
- 1-3
- 3-5
- 5-7
- 7+

3. * What is the total number of employees in your organization?

- 1-25
- 26-50
- 51-100
- 100+

4. What is the name of your organization? (Optional)

5. * Your organization can be best described as

- Software vendor/developer
- Public sector
- Private sector
- Other, please specify

6. * What is your role in the organization?

- Decision Maker
- End User
- Software Developer
- Other, please specify

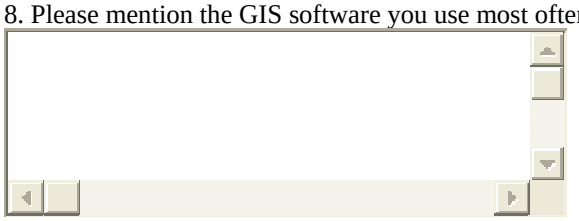
7. * Does your organization use or develop open source software?

- Yes, we use open source software.

Yes, we develop open source software.

No.

8. Please mention the GIS software you use most often, and the reason(s) you prefer it



9. * Have you used any web GIS products in the past 6 months?

Yes

No

10. * Which of the following web mapping services have you used:

Google Maps or Google Earth

Yahoo! Maps

Microsoft Virtual Earth

None

Other, please specify

11. * Were you ever involved in developing, or selecting a tool for developing a web GIS product?

Yes, I was involved in developing

Yes, I was involved in selecting

No

12. * Are you aware of the open Geospatial Consortium?

Yes

No

13. * I would prefer to use a GIS web software that would easily integrate with my organization's ERP or CRM.

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

14. * The license price of the GIS tool is a very important factor for me when selecting a GIS tool.

Strongly disagree

Disagree

No Opinion
Agree
Strongly Agree

15. * I would prefer a GIS tool that does not have extreme hardware requirements; one that can run on my existing hardware.

Strongly disagree
Disagree
No Opinion
Agree
Strongly Agree

16. * I prefer software that comes with an installer than one that requires compiling and lots of manual setting up.

Strongly disagree
Disagree
No Opinion
Agree
Strongly Agree

17. * I prefer a software that enables me to display and analyze data from a variety of data sources on my website

Strongly disagree
Disagree
No Opinion
Agree
Strongly Agree

18. * I would prefer a software that is compliant with technology standards such as those developed by the OGC (GML, WMS, WFS, SFS).

Strongly disagree
Disagree
No Opinion
Agree
Strongly Agree

19. * I expect the software performance to remain high even as the number users accessing my site increases.

Strongly disagree
Disagree
No Opinion

Agree

Strongly Agree

20. * I prefer a software that, by default (without additional add-ons), provides the possibility of performing a wide range spatial analysis to the users (spatial queries, buffer zoning, Geocoding, routing, linear referencing).

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

21. * I am more likely to select a software that supports different web browsers (e.g. Internet Explorer, Firefox, Safari) than a software that is limited to only one browser.

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

22. * I prefer a software that can be installed on a variety of web servers (e.g. IIS, Apache, Zeus, Oracle HTTP server)

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

23. * I would prefer to work with a software that comes with a wizard that helps me rapidly develop a web mapping application without having to write much code.

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

24. I would prefer a GIS tool that is composed of modules (a specific module for each seperate set of functions)

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

25. * The software I will choose must support development using a variety of development languages (e.g. ASP .NET, JSP, Java, PHP).

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

26. * I prefer a software that does not require users of my website to install any additional plugins.

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

27. * I prefer a software that supports providing and consuming Web services.

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

28. * I would prefer a software that comes with free geospatial data.

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

29. * I would prefer a software that comes with numerous coding examples in the documentation.

Strongly disagree

Disagree

No Opinion

Agree

Strongly Agree

30. * I would prefer a software with documentation that addresses different levels of development skills.

Disagree

No Opinion

Agree

Strongly Agree

36. * I would like the web GIS software to provide the following analysis capabilities to the users of my websites:

Spatial Queries (overlapping features, containing features)

Buffer zoning (search within a distance)

Geocoding (as in address geocoding)

Routing analysis (to know the best path between 2 points on a map)

Linear referencing

Aggregation and summarization of geospatial information

Thematic or Colour coded maps

Other, please specify

37. * I have used/found the following analysis features in web based GIS websites that I have visited.

Spatial Queries (overlapping features, containing features)

Buffer zoning (search within a distance)

Address Geocoding

Feature Geocoding

Routing analysis (to know the best path between 2 points on a map)

Linear referencing

Aggregation and summarization of geospatial information

Thematic or Colour coded maps

Other, please specify

38. * I use the following formats as common geospatial data sources

File formats (e.g. GML, shape files, attributed DGN files)

Commercial Database engines (e.g. Oracle, IBM DB2, and MS SQL)

Open Source Database engines (e.g. PostGIS, MySQL)

Other, please specify

39. * Do you attempt to access data from different sources simultaneously (such as shape files and oracle spatial data) for your application?

Yes

No

40. * Do you attempt to use web GIS software to modify spatial data online (e.g. add or edit geographic features)?

Yes

No

41. * Which of the following GIS web mapping tools have you recently used:

UMN MapServer

Arc Ims

MapXtreme

GeoMedia WebMap

Autodesk Mapguide

Bentley Geo Web Publisher

Map Layers

Google Maps API

Yahoo! Maps API

Microsoft Virtual earth API

Other, please specify

42. * Which of the following GIS web tools are you aware of

UMN MapServer

Arc Ims

MapXtreme

GeoMedia WebMap

Autodesk Mapguide

Bentley Geo Web Publisher

Map Layers

Google Maps API

Yahoo! Maps API

Microsoft Virtual earth API

43. Please provide your name and email (each on a separate line) if you are willing to be contacted for clarifications. (Optional)

44. Finally, if you have anything you would like to add regarding the selection criteria of web GIS tools, or about this survey, please do so in the following area: (Optional)

APPENDIX 2

SURVEY RESULTS

Appendix 2: Survey Results

Survey 1: Awareness of Open Source Concepts

The following statistics were provided by the survey website www.createsurvey.com

		No. of Responses	%
1	**How many years of experience do you have in IT?**		
	1-3	15	34.88%
	3-5	4	9.30%
	5-7	5	11.63%
	7+	19	44.19%
2	**How many years of experience do you have in GIS?**		
	None	15	34.88%
	1-3	12	27.91%
	3-5	6	13.95%
	5-7	1	2.33%
	7+	9	20.93%
3	**What is the total number of employees in your organization?**		
	1-25	17	39.53%
	26-50	4	9.30%
	51-100	4	9.30%
	100+	18	41.86%
4	**What is the name of your organization? (Optional)**		
5	**Your organization can be best described as**		
	Software vendor/developer	16	37.21%
	Public sector	6	13.95%
	Private sector	17	39.53%
	Other, please specify	4	9.30%
6	**What is your role in the organization?**		
	Decision Maker	7	16.28%
	End User	3	6.98%
	Software Developer	18	41.86%
	Other, please specify	15	34.88%
7	**Does your organization use or develop open source software?**		
	Yes, we use open source software.	23	53.49%
	Yes, we develop open source software.	9	20.93%
	No.	18	41.86%

		No. of Responses	%
8	**I think that open source software is developed by amateur developers who don't have a regular fulltime day job.**		
	TRUE	1	2.33%
	FALSE	37	86.05%
	Don't Know	5	11.63%
9	**I believe that open source software is usually full of bugs and is unstable**		
	TRUE	4	9.30%
	FALSE	33	76.74%
	Don't Know	6	13.95%
10	**If I use open source software I will not be receiving any technical support or warranty on the software**		
	TRUE	15	34.88%
	FALSE	20	46.51%
	Don't Know	8	18.60%
11	**The term "Open source" indicates that the software is provided free of charge.**		
	TRUE	20	46.51%
	FALSE	21	48.84%
	Don't Know	2	4.65%
12	**Please mark from the following list all software/tools that you may have used before, or plan on using in the future:**		
	Linux (any distribution)	28	65.12%
	Open Office	23	53.49%
	Notepad++	18	41.86%
	GRASS	9	20.93%
	MapServer	17	39.53%
	QGIS	13	30.23%
	Open Layers	2	4.65%
	PHP	25	58.14%
	Java	34	79.07%
	Apache	27	62.79%
	MySQL	28	65.12%
	Firefox	29	67.44%
	PostGres SQL	18	41.86%
	PostGIS	14	32.56%
	Other, please specify	4	9.30%
	Other: *Eclipse, Net beans, GCC, Mapwindow, GDAL, OGR, Tex, Ocr-a-font, Electric_schoolbell, The gimp, NASM, Gimp, Kdevelop, MapGuide Open Source*		
13	**There is only one type of open source license. (i.e. all open source licenses are alike)**		
	TRUE	8	18.60%
	FALSE	26	60.47%
	Don't Know	9	20.93%

		No. of Responses	%
14	**Open source software licenses pose no limitations to how you can use or distribute the software**		
	TRUE	17	39.53%
	FALSE	24	55.81%
	Don't Know	2	4.65%
15	**Developers working on open source projects are not paid**		
	TRUE	1	2.33%
	FALSE	34	79.07%
	Don't Know	8	18.60%
16	**When contributing software to the open source community, the source code has to be provided.**		
	TRUE	34	79.07%
	FALSE	3	6.98%
	Don't Know	6	13.95%
17	**If you create open source software, you can state in the open source license that you create any restrictions on who is entitled to use it (e.g. by restricting people from certain countries).**		
	TRUE	9	20.93%
	FALSE	24	55.81%
	Don't Know	10	23.26%
18	**If you developed software derived from an open source one, then you can copyright the derived software and distribute it under a proprietary style licenses.**		
	TRUE	11	25.58%
	FALSE	23	53.49%
	Don't Know	9	20.93%
19	**Open source software can be freely distributed to any party.**		
	TRUE	36	83.72%
	FALSE	5	11.63%
	Don't Know	2	4.65%
20	**Free software provided by Microsoft (such as Internet Explorer), Apple (such as I-tunes), and Yahoo! (such as the Yahoo Messenger) are considered open source software.**		
	TRUE	0	0.00%
	FALSE	41	95.35%
	Don't Know	2	4.65%
21	**All software that complies with the specifications of "The Open Source Initiative" is very likely to comply with industry standards as well (such as W3C, ISO, and OGC).**		
	TRUE	22	51.16%
	FALSE	11	25.58%
	Don't Know	10	23.26%

		No. of Responses	%
22	**If I decide to use an Open Source product, I will be encouraged to do so for the following reasons (select all that apply):**		
	I will not have to pay a license fee	31	72.09%
	Freedom to install on unlimited number of computers	35	81.40%
	Flexibility to modify the source code to accommodate the application to my organization's needs	31	72.09%
	I don't have to pay support and maintenance fees	16	37.21%
	Developers in my organization gain in-depth experience in the application.	21	48.84%
	I will be able to make use from the online support of the open source community.	27	62.79%
	Open source software provides better features than an equivalent proprietary.	7	16.28%
	I will be able to resell the application I develop using open source tools and make money.	18	41.86%
	Open source software complies with industry standards more than proprietary ones.	8	18.60%
	Other, please specify	1	2.33%
	Other: *I will be independent of market directions*		
23	**If you use or have used an open source software and would like to share your experience, please mention which software it was and write your comments in the following area.**		
	PostGres & PostGIS: - The security of the user to use the portgres database, it don't take any domain user it takes a local user with low privileges (i.e. don't allow administrators to use the database) - When using the command line to use the pgsql command, u have to log on as the local user who was given in the setup process of the PostGres.		
	Only used Firefox and it's great.		
	Map Server powerful in displaying maps on web rather than other commercial softwares as it is more flexible and easier to use also with more functionality than others		
	I have attempted to use PostgreSQL and PostGIS but found them unwieldy and difficult to manage. I have also used geoda and crimestat and found them to be fantastic pieces of software with features not found in ESRI or MapInfo.		
	I have used Firefox and I liked it more than IE because it was faster, had more features, and provided me with more security features		
24	**Please enter your name and email (each on a separate line) if you agree to be contacted for clarifications. (Optional)**		

		No. of Responses	%
25	**Finally, if you have anything you would like to add regarding Open Source concepts, or about this survey, please do so in the following area: (Optional)**		
	The issue is liability. If the software causes a problem or was compiled from proprietary software, then who is liable for the problem. The author of the software that delivers the final software not the original software developer of the open source.		
	In the 1950s and early 1960s, open source was the norm. After IBM started selling software it became proprietary. I hope the pendulum swings back, and most software is again open source, or ""free""/libre. The answer to #18 depends on the particular license used by the original software. BSD or public domain = True, GPL = false.		
	Open Source is a very good option for people looking for better OS than Microsoft's; however the only withdrew is not have the sufficient marketing or the service at least in Egypt.		

Survey 2: Selection Criteria of web GIS software

The following statistics were provided by the survey website www.createsurvey.com

		No. of Responses	%
1	**How many years of experience do you have in IT?**		
	1-3	13	34.21%
	3-5	4	10.53%
	5-7	7	18.42%
	7+	14	36.84%
2	**How many years of experience in do you have in GIS?**		
	None	6	15.79%
	1-3	15	39.47%
	3-5	4	10.53%
	5-7	5	13.16%
	7+	8	21.05%
3	**What is the total number of employees in your organization?**		
	1-25	19	50.00%
	26-50	3	7.89%
	51-100	7	18.42%
	100+	9	23.68%
4	**What is the name of your organization? (Optional)**		
5	**Your organization can be best described as**		
	Software vendor/developer	11	28.95%
	Public sector	5	13.16%
	Private sector	16	42.11%
	Other, please specify	6	15.79%
6	**What is your role in the organization?**		
	Decision Maker	5	13.16%
	End User	3	7.89%
	Software Developer	17	44.74%
	Other, please specify	13	34.21%
7	**Does your organization use or develop open source software?**		
	Yes, we use open source software.	22	57.89%
	Yes, we develop open source software.	9	23.68%
	No.	15	39.47%
8	**Please mention the GIS software you use most often, and the reason(s) you prefer it**		
	Google Earth/Maps, GDAL, OGR, Mapwindow, MapServer		
	GeoMedia Pro , Arc GIS		

		No. of Responses	%
	ESRI desktop & web mapping - good integration throughout product range Autodesk MapGuide web mapping		
	GeoMedia Pro, GeoMedia Web Map --> This is the GIS software that we are using in MOG. ArcGIS --> To use some functionality that does not exist in GeoMedia. AutoCAD Map, Map 3D --> To use some functionality that does not exist in GeoMedia. Also because the AutoCAD is a powerful drawing software. Autodesk Map Guide --> Just for training and trying		
	1-QGIS:simple gis viewer allows me to access PostGIS database and import shape files into PostGIS database as well also using grass tools through it, allows me to export map server files which helps in GIS web application 2-Udig:allows me access web feature server to draw layers as features 3-grass:still trying to make some basic functions using it is so powerful as I see but need some learning		
	GeoMedia Professional GeoMedia WebMap GeoMedia Publisher Open Source		
	Intergraph & Esri products, the reason of choosing it depends mostly on the client requirements, data, end product etc..		
9	**Have you used any web GIS products in the past 6 months?**		
	Yes	30	78.95%
	No	8	21.05%
10	**Which of the following web mapping services have you used:**		
	Google Maps or Google Earth	37	97.37%
	Yahoo! Maps	12	31.58%
	Microsoft Virtual Earth	9	23.68%
	None	1	2.63%
	Other, please specify	10	26.32%
11	**Were you ever involved in developing, or selecting a tool for developing a web GIS product?**		
	Yes, I was involved in developing	19	50.00%
	Yes, I was involved in selecting	6	15.79%
	No	13	34.21%
12	**Are you aware of the open GeoSpatial Consortium?**		
	Yes	27	71.05%
	No	11	28.95%
13	**I would prefer to use a GIS web software that would easily integrate with my organization's ERP or CRM.**		
	Strongly disagree	0	0.00%
	Disagree	2	5.26%
	No Opinion	15	39.47%
	Agree	13	34.21%
	Strongly Agree	8	21.05%

		No. of Responses	%
14	**The license price of the GIS tool is a very important factor for me when selecting a GIS tool.**		
	Strongly disagree	1	2.63%
	Disagree	1	2.63%
	No Opinion	5	13.16%
	Agree	19	50.00%
	Strongly Agree	12	31.58%
15	**I would prefer a GIS tool that does not have extreme hardware requirements; one that can run on my existing hardware.**		
	Strongly disagree	0	0.00%
	Disagree	1	2.63%
	No Opinion	6	15.79%
	Agree	15	39.47%
	Strongly Agree	16	42.11%
16	**I prefer software that comes with an installer than one that requires compiling and lots of manual setting up.**		
	Strongly disagree	0	0.00%
	Disagree	4	10.53%
	No Opinion	2	5.26%
	Agree	14	36.84%
	Strongly Agree	18	47.37%
17	**I prefer a software that enables me to display and analyze data from a variety of data sources on my website**		
	Strongly disagree	1	2.63%
	Disagree	0	0.00%
	No Opinion	4	10.53%
	Agree	13	34.21%
	Strongly Agree	20	52.63%
18	**I would prefer a software that is compliant with technology standards such as those developed by the OGC (GML, WMS, WFS, SFS).**		
	Strongly disagree	0	0.00%
	Disagree	1	2.63%
	No Opinion	9	23.68%
	Agree	14	36.84%
	Strongly Agree	14	36.84%
19	**I expect the software performance to remain high even as the number users accessing my site increases.**		
	Strongly disagree	0	0.00%
	Disagree	5	13.16%
	No Opinion	3	7.89%
	Agree	14	36.84%
	Strongly Agree	16	42.11%

		No. of Responses	%
20	**I prefer a software that, by default (without additional add-ons), provides the possibility of performing a wide range spatial analysis to the users (spatial queries, buffer zoning, geocoding, routing, linear referencing).**		
	Strongly disagree	1	2.63%
	Disagree	1	2.63%
	No Opinion	5	13.16%
	Agree	20	52.63%
	Strongly Agree	11	28.95%
21	**I am more likely to select a software that supports different web browsers (e.g. Internet Explorer, Firefox, Safari) than a software that is limited to only one browser.**		
	Strongly disagree	0	0.00%
	Disagree	1	2.63%
	No Opinion	2	5.26%
	Agree	9	23.68%
	Strongly Agree	26	68.42%
22	**I prefer a software that can be installed on a variety of web servers (e.g. IIS, Apache, Zeus, Oracle HTTP server)**		
	Strongly disagree	0	0.00%
	Disagree	4	10.53%
	No Opinion	5	13.16%
	Agree	11	28.95%
	Strongly Agree	18	47.37%
23	**I would prefer to work with a software that comes with a wizard that helps me rapidly develop a web mapping application without having to write much code.**		
	Strongly disagree	1	2.63%
	Disagree	7	18.42%
	No Opinion	4	10.53%
	Agree	16	42.11%
	Strongly Agree	10	26.32%
24	**I would prefer a GIS tool that is composed of modules (a specific module for each separate set of functions)**		
	Strongly disagree	1	2.63%
	Disagree	4	10.53%
	No Opinion	8	21.05%
	Agree	18	47.37%
	Strongly Agree	7	18.42%

		No. of Responses	%
25	**The software I will choose must support development using a variety of development languages (e.g. ASP .NET, JSP, Java, PHP).**		
	Strongly disagree	0	0.00%
	Disagree	4	10.53%
	No Opinion	6	15.79%
	Agree	20	52.63%
	Strongly Agree	8	21.05%
26	**I prefer a software that does not require users of my website to install any additional plugins.**		
	Strongly disagree	0	0.00%
	Disagree	2	5.26%
	No Opinion	5	13.16%
	Agree	14	36.84%
	Strongly Agree	17	44.74%
27	**I prefer a software that supports providing and consuming Web services.**		
	Strongly disagree	0	0.00%
	Disagree	0	0.00%
	No Opinion	8	21.05%
	Agree	19	50.00%
	Strongly Agree	11	28.95%
28	**I would prefer a software that comes with free geospatial data.**		
	Strongly disagree	0	0.00%
	Disagree	4	10.53%
	No Opinion	15	39.47%
	Agree	16	42.11%
	Strongly Agree	3	7.89%
29	**I would prefer a software that comes with numerous coding examples in the documentation.**		
	Strongly disagree	0	0.00%
	Disagree	0	0.00%
	No Opinion	5	13.16%
	Agree	14	36.84%
	Strongly Agree	19	50.00%
30	**I would prefer a software with documentation that addresses different levels of development skills.**		
	Strongly disagree	0	0.00%
	Disagree	2	5.26%
	No Opinion	2	5.26%
	Agree	19	50.00%
	Strongly Agree	15	39.47%

		No. of Responses	%
31	**The market share that a software has in my market will help me decide which software to choose.**		
	Strongly disagree	2	5.26%
	Disagree	9	23.68%
	No Opinion	9	23.68%
	Agree	14	36.84%
	Strongly Agree	4	10.53%
32	**I would consider other users' opinions or word of mouth when choosing a software.**		
	Strongly disagree	0	0.00%
	Disagree	4	10.53%
	No Opinion	5	13.16%
	Agree	25	65.79%
	Strongly Agree	4	10.53%
33	**I will probably ask the software vendor/developer to demonstrate to me issues such as stability and the effect of the number of users on response time.**		
	Strongly disagree	0	0.00%
	Disagree	1	2.63%
	No Opinion	5	13.16%
	Agree	24	63.16%
	Strongly Agree	8	21.05%
34	**The presence of technical support is an important factor in my selection of a software.**		
	Strongly disagree	0	0.00%
	Disagree	2	5.26%
	No Opinion	3	7.89%
	Agree	15	39.47%
	Strongly Agree	18	47.37%
35	**I expect the software vendor/developer to have a proven implementation/development track in sites organizations similar to mine.**		
	Strongly disagree	0	0.00%
	Disagree	5	13.16%
	No Opinion	9	23.68%
	Agree	22	57.89%
	Strongly Agree	2	5.26%
36	**I would like the web GIS software to provide the following analysis capabilities to the users of my websites:**		
	Spatial Queries (overlapping features, containing features)	31	81.58%
	Buffer zoning (search within a distance)	31	81.58%
	Geocoding (as in address geocoding)	24	63.16%
	Routing analysis (to know the best path between 2 points on a map)	28	73.68%
	Linear referencing	14	36.84%
	Aggregation and summarization of geospatial information	26	68.42%
	Thematic or Colour coded maps	33	86.84%

		No. of Responses	%
	Other, please specify	6	15.79%
	3D Line of Sight		
	step by step how to reach and important land marks that I'll meet to tell me I'm on the right way		
	finding object or feature		
	Adding and editing the geospatial data		
37	**I have used/found the following analysis features in web based GIS websites that I have visited.**		
	Spatial Queries (overlapping features, containing features)	21	55.26%
	Buffer zoning (search within a distance)	17	44.74%
	Address Geocoding	12	31.58%
	Feature Geocoding	6	15.79%
	Routing analysis (to know the best path between 2 points on a map)	20	52.63%
	Linear referencing	3	7.89%
	Aggregation and summarization of geospatial information	11	28.95%
	Thematic or Colour coded maps	26	68.42%
	Other, please specify	4	10.53%
	Adding and editing the geospatial data		
	finding features, adding land marks, turn on and off layers, printing functionality, changing projection		
38	**I use the following formats as common geospatial data sources**		
	File formats (e.g. GML, shape files, attributed DGN files)	28	73.68%
	Commercial Database engines (e.g. Oracle, IBM DB2, MS SQL)	21	55.26%
	Open Source Database engines (e.g. PostGIS, MySQL)	17	44.74%
	Other, please specify	5	13.16%
	SQLite		
	SQL files, CVS files		
	WFS, WMS		
39	**Do you attempt to access data from different sources simultaneously (such as shape files and oracle spatial data) for your application?**		
	Yes	29	76.32%
	No	9	23.68%
40	**Do you attempt to use web GIS software to modify spatial data online (e.g. add or edit geographic features)?**		
	Yes	16	42.11%
	No	22	57.89%
41	**Which of the following GIS web mapping tools have you recently used:**		
	UMN MapServer	15	39.47%
	Arc Ims	11	28.95%
	MapXtreme	0	0.00%
	GeoMedia WebMap	12	31.58%

	No. of Responses	%
Autodesk Mapguide	5	13.16%
Bentley Geo Web Publisher	0	0.00%
Map Layers	1	2.63%
Google Maps API	19	50.00%
Yahoo! Maps API	3	7.89%
Microsoft Virtual earth API	3	7.89%
Other, please specify	5	13.16%
OpenLayers, Geoserver		
chameleon, gmap		

42 Which of the following GIS web tools are you aware of

UMN MapServer	18	47.37%
Arc Ims	22	57.89%
MapXtreme	7	18.42%
GeoMedia WebMap	20	52.63%
Autodesk Mapguide	14	36.84%
Bentley Geo Web Publisher	3	7.89%
Map Layers	3	7.89%
Google Maps API	27	71.05%
Yahoo! Maps API	12	31.58%
Microsoft Virtual earth API	14	36.84%

43 Please provide your name and email (each on a separate line) if you are willing to be contacted for clarifications. (Optional)

44 Finally, if you have anything you would like to add regarding the selection criteria of web GIS tools, or about this survey, please do so in the following area: (Optional)

If you don't pay for your software, then you should do something to give back to the ""Open Source community"". I don't like paying for Windows software (especially GIS software, because it sucks), and I prefer to give back to the community. This comment doesn't really fall in-line with the survey; that said...Linux rules (assuming you can't afford an Apple; which I can't).

I look at the presence of user mailing lists or forum, as they can prove to be very helpful!

This is a great idea! I wonder if you could send me the results. My mail is above. Thnx! Ivana.

Good Luck

Survey 2: Selection Criteria of web GIS software (Compiled Results)

The statistics in the following tables were compiled by the author

Statistics for all user categories		
ID	**Feature**	**Score**
1	I would prefer to use GIS web software that would easily integrate with my organization's ERP or CRM.	141
2	The license price of the GIS tool is a very important factor for me when selecting a GIS tool.	154
3	I would prefer a GIS tool that does not have extreme hardware requirements; one that can run on my existing hardware.	160
4	I prefer software that comes with an installer than one that requires compiling and lots of manual setting up.	160
5	I prefer software that enables me to display and analyze data from a variety of data sources on my website.	165
6	I would prefer software that is compliant with technology standards such as those developed by the OGC (GML, WMS, WFS, SFS).	155
7	I expect the software performance to remain high even as the number users accessing my site increases.	155
8	I prefer a software that, by default (without additional add-ons), provides the possibility of performing a wide range spatial analysis to the users (spatial queries, buffer zoning, geocoding, routing, linear referencing).	153
9	I am more likely to select software that supports different web browsers (e.g. Internet Explorer, Firefox, Safari) than software that is limited to only one browser.	174
10	I prefer a software that can be installed on a variety of web servers (e.g. IIS, Apache, Zeus, Oracle HTTP server)	157
11	I would prefer to work with software that comes with a wizard that helps me rapidly develop a web mapping application without having to write much code.	141
ID	**Feature**	**Score**

12	I would prefer a GIS tool that is composed of modules (a specific module for each separate set of functions)	140
13	The software I will choose must support development using a variety of development languages (e.g. ASP .NET, JSP, Java, PHP).	146
14	I prefer a software that does not require users of my website to install any additional plug-ins.	160
15	I prefer a software that supports providing and consuming Web services.	155
16	I would prefer software that comes with free geospatial data.	132
17	I would prefer software that comes with numerous coding examples in the documentation.	166
18	I would prefer software with documentation that addresses different levels of development skills.	161
19	The market share that software has in my market will help me decide which software to choose.	123
20	I would consider other users' opinions or word of mouth when choosing software.	143
21	I will probably ask the software vendor/developer to demonstrate to me issues such as stability and the effect of the number of users on response time.	153
22	The presence of technical support is an important factor in my selection of software.	163
23	I expect the software vendor/developer to have a proven implementation/development track in sites organizations similar to mine.	135

ClientsSupport	174
CodeExamples	166
VarDataSources	165
TechSupport	163
DocSkills	161
Hardware	160
Installer	160
PlugIns	160

ıser Categories

Score

WebServers	157
PeformanceNoUsers	155
StandradsCompliancy	155
WebServices	155
LicensePrice	154
Demos	153
SpatialAnalysis	153
ProgLanguages	146
WordoMouth	143
Integration	141
Wizard	141
Modules	140
PrevExperience	135
FreeData	132
MrktShare	123

Statistics for Decision Makers		
ID	**Feature**	**Score**
1	I would prefer to use GIS web software that would easily integrate with my organization's ERP or CRM.	27
2	The license price of the GIS tool is a very important factor for me when selecting a GIS tool.	33
3	I would prefer a GIS tool that does not have extreme hardware requirements; one that can run on my existing hardware.	31
4	I prefer software that comes with an installer than one that requires compiling and lots of manual setting up.	32
5	I prefer a software that enables me to display and analyze data from a variety of data sources on my website	29
6	I would prefer software that is compliant with technology standards such as those developed by the OGC (GML, WMS, WFS, and SFS).	30
7	I expect the software performance to remain high even as the number users accessing my site increases.	31
8	I prefer a software that, by default (without additional add-ons), provides the possibility of performing a wide range spatial analysis to the users (spatial queries, buffer zoning, geocoding, routing, linear referencing).	28
9	I am more likely to select software that supports different web browsers (e.g. Internet Explorer, Firefox, Safari) than software that is limited to only one browser.	34
10	I prefer a software that can be installed on a variety of web servers (e.g. IIS, Apache, Zeus, Oracle HTTP server)	28
11	I would prefer to work with software that comes with a wizard that helps me rapidly develop a web mapping application without having to write much code.	27
12	I would prefer a GIS tool that is composed of modules (a specific module for each separate set of functions)	26
13	The software I will choose must support development using a variety of development languages (e.g. ASP .NET, JSP, Java, PHP).	25
14	I prefer a software that does not require users of my website to install any additional plug-ins.	29

ID	Feature	Score
15	I prefer software that supports providing and consuming Web services.	31
16	I would prefer software that comes with free geospatial data.	21
17	I would prefer software that comes with numerous coding examples in the documentation.	32
18	I would prefer software with documentation that addresses different levels of development skills.	30
19	The market share that software has in my market will help me decide which software to choose.	21
20	I would consider other users' opinions or word of mouth when choosing software.	26
21	I will probably ask the software vendor/developer to demonstrate to me issues such as stability and the effect of the number of users on response time.	27
22	The presence of technical support is an important factor in my selection of software.	30
23	I expect the software vendor/developer to have a proven implementation/development track in sites organizations similar to mine.	22

Sorted Results for Decision Makers	
Criteria	**Score**
ClientsSupport	34
LicensePrice	33
Installer	32
CodeExamples	32
PeformanceNoUsers	31
WebServices	31
Hardware	31
DocSkills	30
StandradsCompliancy	30
TechSupport	30
VarDataSources	29
PlugIns	29
WebServers	28
SpatialAnalysis	28
Wizard	27
Demos	27
Integration	27
Modules	26
WordoMouth	26
ProgLanguages	25
PrevExperience	22
FreeData	21
MrktShare	21

Statistics for Software Developers		
ID	**Feature**	**Score**
1	I would prefer to use GIS web software that would easily integrate with my organization's ERP or CRM.	80
2	The license price of the GIS tool is a very important factor for me when selecting a GIS tool.	83
3	I would prefer a GIS tool that does not have extreme hardware requirements; one that can run on my existing hardware.	86
4	I prefer software that comes with an installer than one that requires compiling and lots of manual setting up.	85
5	I prefer a software that enables me to display and analyze data from a variety of data sources on my website	94
6	I would prefer software that is compliant with technology standards such as those developed by the OGC (GML, WMS, WFS, SFS).	91
7	I expect the software performance to remain high even as the number users accessing my site increases.	86
8	I prefer a software that, by default (without additional add-ons), provides the possibility of performing a wide range spatial analysis to the users (spatial queries, buffer zoning, geocoding, routing, linear referencing).	88
9	I am more likely to select software that supports different web browsers (e.g. Internet Explorer, Firefox, Safari) than software that is limited to only one browser.	97
10	I prefer a software that can be installed on a variety of web servers (e.g. IIS, Apache, Zeus, Oracle HTTP server)	89
11	I would prefer to work with software that comes with a wizard that helps me rapidly develop a web mapping application without having to write much code.	78
12	I would prefer a GIS tool that is composed of modules (a specific module for each separate set of functions)	78
13	The software I will choose must support development using a variety of development languages (e.g. ASP .NET, JSP, Java, PHP).	85

ID	Feature	Score
14	I prefer software that does not require users of my website to install any additional plug-ins.	89
15	I prefer software that supports providing and consuming Web services.	87
16	I would prefer software that comes with free geospatial data.	74
17	I would prefer software that comes with numerous coding examples in the documentation.	95
18	I would prefer software with documentation that addresses different levels of development skills.	92
19	The market share that software has in my market will help me decide which software to choose.	65
20	I would consider other users' opinions or word of mouth when choosing software.	77
21	I will probably ask the software vendor/developer to demonstrate to me issues such as stability and the effect of the number of users on response time.	86
22	The presence of technical support is an important factor in my selection of software.	89
23	I expect the software vendor/developer to have a proven implementation/development track in sites organizations similar to mine.	74

Sorted Results for Software Developers	
Criteria	**Score**
ClientsSupport	97
CodeExamples	95
VarDataSources	94
DocSkills	92
StandradsCompliancy	91
PlugIns	89
TechSupport	89
WebServers	89
SpatialAnalysis	88
WebServices	87
PeformanceNoUsers	86
Hardware	86
Demos	86
ProgLanguages	85
Installer	85
LicensePrice	83
Integration	80
Modules	78
Wizard	78
WordoMouth	77
PrevExperience	74
FreeData	74
MrktShare	65

Statistics End Users		
ID	**Feature**	**Score**
1	I would prefer to use GIS web software that would easily integrate with my organization's ERP or CRM.	34
2	The license price of the GIS tool is a very important factor for me when selecting a GIS tool.	38
3	I would prefer a GIS tool that does not have extreme hardware requirements; one that can run on my existing hardware.	43
4	I prefer software that comes with an installer than one that requires compiling and lots of manual setting up.	43
5	I prefer a software that enables me to display and analyze data from a variety of data sources on my website	42
6	I would prefer software that is compliant with technology standards such as those developed by the OGC (GML, WMS, WFS, and SFS).	34
7	I expect the software performance to remain high even as the number users accessing my site increases.	38
8	I prefer a software that, by default (without additional add-ons), provides the possibility of performing a wide range spatial analysis to the users (spatial queries, buffer zoning, geocoding, routing, linear referencing).	37
9	I am more likely to select software that supports different web browsers (e.g. Internet Explorer, Firefox, Safari) than software that is limited to only one browser.	43
10	I prefer a software that can be installed on a variety of web servers (e.g. IIS, Apache, Zeus, Oracle HTTP server)	40
11	I would prefer to work with software that comes with a wizard that helps me rapidly develop a web mapping application without having to write much code.	36
12	I would prefer a GIS tool that is composed of modules (a specific module for each separate set of functions)	36
13	The software I will choose must support development using a variety of development languages (e.g. ASP .NET, JSP, Java, PHP).	36
14	I prefer a software that does not require users of my website to install any additional plug-ins.	42

ID	Feature	Score
15	I prefer software that supports providing and consuming Web services.	37
16	I would prefer software that comes with free geospatial data.	37
17	I would prefer software that comes with numerous coding examples in the documentation.	39
18	I would prefer software with documentation that addresses different levels of development skills.	39
19	The market share that software has in my market will help me decide which software to choose.	37
20	I would consider other users' opinions or word of mouth when choosing software.	40
21	I will probably ask the software vendor/developer to demonstrate to me issues such as stability and the effect of the number of users on response time.	40
22	The presence of technical support is an important factor in my selection of software.	44
23	I expect the software vendor/developer to have a proven implementation/development track in sites organizations similar to mine.	39

Sorted Results for End Users	
Criteria	**Score**
TechSupport	44
Installer	43
ClientsSupport	43
Hardware	43
PlugIns	42
VarDataSources	42
Demos	40
WordoMouth	40
WebServers	40
PrevExperience	39
CodeExamples	39
DocSkills	39
LicensePrice	38
PeformanceNoUsers	38
FreeData	37
SpatialAnalysis	37
MrktShare	37
WebServices	37
ProgLanguages	36
Modules	36

Sorted Results for End Users	
Criteria	**Score**
Wizard	36
StandradsCompliancy	34
Integration	34

APPENDIX 3

GPL LICENSE

Appendix 3: GPL License

The GNU General Public License (GPL) [viii]

As Presented on the Open Source Initiative web site

Version 2, June 1991

Preamble

The licenses for most software are designed to take away your freedom to share and change it. By contrast, the GNU General Public License is intended to guarantee your freedom to share and change free software--to make sure the software is free for all its users. This General Public License applies to most of the Free Software Foundation's software and to any other program whose authors commit to using it. (Some other Free Software Foundation software is covered by the GNU Library General Public License instead.) You can apply it to your programs, too.

When we speak of free software, we are referring to freedom, not price. Our General Public Licenses are designed to make sure that you have the freedom to distribute copies of free software (and charge for this service if you wish), that you receive source code or can get it if you want it, that you can change the software or use pieces of it in new free programs; and that you know you can do these things.

To protect your rights, we need to make restrictions that forbid anyone to deny you these rights or to ask you to surrender the rights.

These restrictions translate to certain responsibilities for you if you distribute copies of the software, or if you modify it. For example, if you distribute copies of such a

[viii] http://www.opensource.org/licenses/gpl-license.php

program, whether gratis or for a fee, you must give the recipients all the rights that you have. You must make sure that they, too, receive or can get the source code. And you must show them these terms so they know their rights.

We protect your rights with two steps: (1) copyright the software, and (2) offer you this license which gives you legal permission to copy, distribute and/or modify the software.

Also, for each author's protection and ours, we want to make certain that everyone understands that there is no warranty for this free software. If the software is modified by someone else and passed on, we want its recipients to know that what they have is not the original, so that any problems introduced by others will not reflect on the original authors' reputations.

Finally, any free program is threatened constantly by software patents. We wish to avoid the danger that redistributors of a free program will individually obtain patent licenses, in effect making the program proprietary. To prevent this, we have made it clear that any patent must be licensed for everyone's free use or not licensed at all.
The precise terms and conditions for copying, distribution and modification follow.

TERMS AND CONDITIONS FOR COPYING, DISTRIBUTION AND MODIFICATION

0. This License applies to any program or other work which contains a notice placed by the copyright holder saying it may be distributed under the terms of this General Public License. The "Program", below, refers to any such program or work, and a "work based on the Program" means either the Program or any derivative work under copyright law: that is to say, a work containing the Program or a portion of it, either verbatim or with modifications and/or translated into another language. (Hereinafter, translation is included without limitation in the term "modification".) Each licensee is addressed as "you". Activities other than copying, distribution and modification are not covered by this License; they are outside its scope. The act of running the Program is not restricted, and the output from the Program is covered only if its contents constitute a work based on the Program (independent of

having been made by running the Program). Whether that is true depends on what the Program does.

1. You may copy and distribute verbatim copies of the Program's source code as you receive it, in any medium, provided that you conspicuously and appropriately publish on each copy an appropriate copyright notice and disclaimer of warranty; keep intact all the notices that refer to this License and to the absence of any warranty; and give any other recipients of the Program a copy of this License along with the Program. You may charge a fee for the physical act of transferring a copy, and you may at your option offer warranty protection in exchange for a fee.

2. You may modify your copy or copies of the Program or any portion of it, thus forming a work based on the Program, and copy and distribute such modifications or work under the terms of Section 1 above, provided that you also meet all of these conditions: a) You must cause the modified files to carry prominent notices stating that you changed the files and the date of any change. b) You must cause any work that you distribute or publish, that in whole or in part contains or is derived from the Program or any part thereof, to be licensed as a whole at no charge to all third parties under the terms of this License. c) If the modified program normally reads commands interactively when run, you must cause it, when started running for such interactive use in the most ordinary way, to print or display an announcement including an appropriate copyright notice and a notice that there is no warranty (or else, saying that you provide a warranty) and that users may redistribute the program under these conditions, and telling the user how to view a copy of this License. (Exception: if the Program itself is interactive but does not normally print such an announcement, your work based on the Program is not required to print an announcement.)

These requirements apply to the modified work as a whole. If identifiable sections of that work are not derived from the Program, and can be reasonably considered independent and separate works in themselves, then this License, and its terms, do not apply to those sections when you distribute them as separate works. But when you distribute the same sections as part of a whole which is a work based on the Program, the distribution of the whole must be on the terms of this License, whose permissions

for other licensees extend to the entire whole, and thus to each and every part regardless of who wrote it. Thus, it is not the intent of this section to claim rights or contest your rights to work written entirely by you; rather, the intent is to exercise the right to control the distribution of derivative or collective works based on the Program. In addition, mere aggregation of another work not based on the Program with the Program (or with a work based on the Program) on a volume of a storage or distribution medium does not bring the other work under the scope of this License.

3. You may copy and distribute the Program (or a work based on it, under Section 2) in object code or executable form under the terms of Sections 1 and 2 above provided that you also do one of the following: a) Accompany it with the complete corresponding machine-readable source code, which must be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or, b) Accompany it with a written offer, valid for at least three years, to give any third party, for a charge no more than your cost of physically performing source distribution, a complete machine-readable copy of the corresponding source code, to be distributed under the terms of Sections 1 and 2 above on a medium customarily used for software interchange; or, c) Accompany it with the information you received as to the offer to distribute corresponding source code. (This alternative is allowed only for noncommercial distribution and only if you received the program in object code or executable form with such an offer, in accord with Subsection b above.)

The source code for a work means the preferred form of the work for making modifications to it. For an executable work, complete source code means all the source code for all modules it contains, plus any associated interface definition files, plus the scripts used to control compilation and installation of the executable. However, as a special exception, the source code distributed need not include anything that is normally distributed (in either source or binary form) with the major components (compiler, kernel, and so on) of the operating system on which the executable runs, unless that component itself accompanies the executable.

If distribution of executable or object code is made by offering access to copy from a designated place, then offering equivalent access to copy the source code from the same place counts as distribution of the source code, even though third parties are not compelled to copy the source along with the object code.

4. You may not copy, modify, sublicense, or distribute the Program except as expressly provided under this License. Any attempt otherwise to copy, modify, sublicense or distribute the Program is void, and will automatically terminate your rights under this License. However, parties who have received copies, or rights, from you under this License will not have their licenses terminated so long as such parties remain in full compliance.

5. You are not required to accept this License, since you have not signed it. However, nothing else grants you permission to modify or distribute the Program or its derivative works. These actions are prohibited by law if you do not accept this License. Therefore, by modifying or distributing the Program (or any work based on the Program), you indicate your acceptance of this License to do so, and all its terms and conditions for copying, distributing or modifying the Program or works based on it.

6. Each time you redistribute the Program (or any work based on the Program), the recipient automatically receives a license from the original licensor to copy, distribute or modify the Program subject to these terms and conditions. You may not impose any further restrictions on the recipients' exercise of the rights granted herein. You are not responsible for enforcing compliance by third parties to this License.

7. If, as a consequence of a court judgment or allegation of patent infringement or for any other reason (not limited to patent issues), conditions are imposed on you (whether by court order, agreement or otherwise) that contradict the conditions of this License, they do not excuse you from the conditions of this License. If you cannot distribute so as to satisfy simultaneously your obligations under this License and any other pertinent obligations, then as a consequence you may not distribute the Program at all. For example, if a patent license would not permit royalty-free redistribution of the Program by all those who receive copies directly or indirectly through you, then the only way you could satisfy both it and this License would be to refrain entirely from distribution of the Program. If any portion of this section is held invalid or unenforceable under any particular circumstance, the balance of the section is intended to apply and the section as a whole is intended to apply in other

circumstances. It is not the purpose of this section to induce you to infringe any patents or other property right claims or to contest validity of any such claims; this section has the sole purpose of protecting the integrity of the free software distribution system, which is implemented by public license practices. Many people have made generous contributions to the wide range of software distributed through that system in reliance on consistent application of that system; it is up to the author/donor to decide if he or she is willing to distribute software through any other system and a licensee cannot impose that choice.
This section is intended to make thoroughly clear what is believed to be a consequence of the rest of this License.

8. If the distribution and/or use of the Program is restricted in certain countries either by patents or by copyrighted interfaces, the original copyright holder who places the Program under this License may add an explicit geographical distribution limitation excluding those countries, so that distribution is permitted only in or among countries not thus excluded. In such case, this License incorporates the limitation as if written in the body of this License.

9. The Free Software Foundation may publish revised and/or new versions of the General Public License from time to time. Such new versions will be similar in spirit to the present version, but may differ in detail to address new problems or concerns.
Each version is given a distinguishing version number. If the Program specifies a version number of this License which applies to it and "any later version", you have the option of following the terms and conditions either of that version or of any later version published by the Free Software Foundation. If the Program does not specify a version number of this License, you may choose any version ever published by the Free Software Foundation.

10. If you wish to incorporate parts of the Program into other free programs whose distribution conditions are different, write to the author to ask for permission. For software which is copyrighted by the Free Software Foundation, write to the Free Software Foundation; we sometimes make exceptions for this. Our decision will be guided by the two goals of preserving the free status of all derivatives of our free software and of promoting the sharing and reuse of software generally.

NO WARRANTY

11. BECAUSE THE PROGRAM IS LICENSED FREE OF CHARGE, THERE IS NO WARRANTY FOR THE PROGRAM, TO THE EXTENT PERMITTED BY APPLICABLE LAW. EXCEPT WHEN OTHERWISE STATED IN WRITING THE COPYRIGHT HOLDERS AND/OR OTHER PARTIES PROVIDE THE PROGRAM "AS IS" WITHOUT WARRANTY OF ANY KIND, EITHER EXPRESSED OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE. THE ENTIRE RISK AS TO THE QUALITY AND PERFORMANCE OF THE PROGRAM IS WITH YOU. SHOULD THE PROGRAM PROVE DEFECTIVE, YOU ASSUME THE COST OF ALL NECESSARY SERVICING, REPAIR OR CORRECTION.

12. IN NO EVENT UNLESS REQUIRED BY APPLICABLE LAW OR AGREED TO IN WRITING WILL ANY COPYRIGHT HOLDER, OR ANY OTHER PARTY WHO MAY MODIFY AND/OR REDISTRIBUTE THE PROGRAM AS PERMITTED ABOVE, BE LIABLE TO YOU FOR DAMAGES, INCLUDING ANY GENERAL, SPECIAL, INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF THE USE OR INABILITY TO USE THE PROGRAM (INCLUDING BUT NOT LIMITED TO LOSS OF DATA OR DATA BEING RENDERED INACCURATE OR LOSSES SUSTAINED BY YOU OR THIRD PARTIES OR A FAILURE OF THE PROGRAM TO OPERATE WITH ANY OTHER PROGRAMS), EVEN IF SUCH HOLDER OR OTHER PARTY HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

END OF TERMS AND CONDITIONS

How to Apply These Terms to Your New Programs

If you develop a new program, and you want it to be of the greatest possible use to the public, the best way to achieve this is to make it free software which everyone can redistribute and change under these terms.
To do so, attach the following notices to the program. It is safest to attach them to the start of each source file to most effectively convey the exclusion of warranty; and each file should have at least the "copyright" line and a pointer to where the full notice is found. One line to give the program's name and a brief idea of what it does.

Copyright (C) <year> <name of author>

This program is free software; you can redistribute it and/or modify it under the terms of the GNU General Public License as published by the Free Software Foundation; either version 2 of the License, or (at your option) any later version.
This program is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the GNU General Public License for more details.
You should have received a copy of the GNU General Public License along with this program; if not, write to the Free Software Foundation, Inc., 59 Temple Place, Suite 330, Boston, MA 02111-1307 USA
Also add information on how to contact you by electronic and paper mail.
If the program is interactive, make it output a short notice like this when it starts in an interactive mode:

Gnomovision version 69, Copyright (C) year name of author
Gnomovision comes with ABSOLUTELY NO WARRANTY; for details type `show w'.

This is free software, and you are welcome to redistribute it under certain conditions; type `show c' for details.

The hypothetical commands `show w' and `show c' should show the appropriate parts of the General Public License. Of course, the commands you use may be called

something other than `show w' and `show c'; they could even be mouse-clicks or menu items--whatever suits your program.

You should also get your employer (if you work as a programmer) or your school, if any, to sign a "copyright disclaimer" for the program, if necessary. Here is a sample; alter the names:
Yoyodyne, Inc., hereby disclaims all copyright interest in the program `Gnomovision' (which makes passes at compilers) written by James Hacker.
signature of Ty Coon, 1 April 1989

Ty Coon, President of Vice
This General Public License does not permit incorporating your program into proprietary programs. If your program is a subroutine library, you may consider it more useful to permit linking proprietary applications with the library. If this is what you want to do, use the GNU Library General Public License instead of this License.

References

1. Al Khatib J., 2006, *Free Open Source as a Technology Transfer tool in the Arab World*, Master's Thesis, Fachhochschule Brandenburg-Technology and Innovation Management, Germany, viewed December 2006, < http://opensource.mit.edu/papers/Khatib_FOS.pdf>

2. Autodesk, *Annual Report Fiscal Year 2006*, viewed January 2007,< http://media.corporate-ir.net/media_files/irol/11/117861/reports/2006AR.pdf>

3. Bonaccorsi, A. et al, 2007, *How firms do business in the open innovation paradigm*, MIT Open source research community, viewed January 2007, < http://opensource.mit.edu/papers/paper_firm_involvement_MIT.pdf >

4. Christl A., 2006, *Proprietary to Open Source: A paradigm shift*, GISDevelopment.net , viewed December 2006, <http://www.gisdevelopment.net/magazine/years/2006/jan/18_1.htm>

5. Coar K., 07 July 2006, *The Open Source Definition*, The Open Source Initiative, viewed December 2006, <http://opensource.org/docs/osd>

6. DM Solutions, *Premiere Support – Go to the source*, DMSolutions.ca, viewed April 2007, <http://www.dmsolutions.ca/premiere/index.html>

7. ESRI, 23 March 2007, *ArcIMS Product Page* , viewed March 2007, <http://www.esri.com/software/arcgis/arcims/index.html>

8. FAO GeoNetwork, *The portal to spatial data and information*, viewed January 2007, < http://www.fao.org/geonetwork/srv/en/main.home >

9. Fogel, K., 2005, *Producing Open Source Software*, O'Reily, ISBN 0-596-00759-0

10. GDAL, GDAL raster formats, GDAL.org, viewed April 2007, < http://www.gdal.org/formats_list.html>

11. GDAL, *OGR vector formats*, GDAL.org, viewed April 2007, <http://www.gdal.org/ogr/ogr_formats.html>

12. Goulde, M. , 2005, *How firms should work with the open source ecosystem*, Forrester Research

13. Gurbani, V. K. et al, 2005, *a case study of open source tools and practices in a commercial setting*, Fifth Workshop on Open Source Software Engineering, ACM, ISBN 1-59593-127-9

14. Horanont T. et al, 2002, *A Comparative Assessment of Internet GIS Server Systems*, GIS Development, Vol.2005, viewed February 2007 <http://www.gisdevelopment.net/technology/gis/techgi071.htm>

15. Intergraph Corporation, *GeoMedia WebMap Product Page*, viewed March 2007, <http://www.intergraph.com/gmwm/default.asp>

16. ITC, 1 November 2006, *GRASS: Introduction*, viewed December 2006, < http://grass.itc.it/intro/general.php>

17. Lee J. & Lee W. W., 2006, *Going Open in Web GIS*, GIS Development, Vol.1 issue 3, viewed February 2007 , <http://www.gisdevelopment.net/magazine/malaysia/2006/july-sep/12_1.htm>

18. MapInfo, *MapInfo MapXtreme for Windows overview* , viewed March 2007, <http://extranet.mapinfo.com/products/Overview.cfm?productid=1101&productcategoryid=1>

19. MapServer, *Welcome to Mapserver*, viewed April 2007, <http://MapServer.gis.umn.edu>

20. MySQL, *Introduction to MySQL Spatial Support*, viewed December 2006, < http://dev.mysql.com/doc/refman/5.1/en/gis-introduction.html>

21. Net Applications, *Top Operating System Market Share Trend for June 2006 to February 2007*, viewed February 2007 < http://marketshare.hitslink.com/report.aspx?qprid=5>

22. NetCraft, *Market Share for Top Servers Across All Domains August 1995 - March 2007*, viewed March 2007 , <http://news.netcraft.com/archives/web_server_survey.html>

23. Open Geospatial Consortium, 19 July 2006, *OGC History (Abbreviated)*, viewed December 2006, <http://www.opengeospatial.org/ogc/history>

24. Open Geospatial Consortium, 20 January 2007, *All Registered Products*, viewed January 2007, <http://www.opengeospatial.org/resource/products>

25. Raghavan, V. et al, 2001, *Implementing Web GIS Applications using Open Source Software*, GISDevelopment.net, viewed December 2006, <http://www.gisdevelopment.net/technology/gis/techgi0062pf.htm >

26. Raymond, E., 2001, *The Cathedral and the Bazaar*, O'Reilly, ISBN 0596001088

27. Red Hat, 21 December 2006, *Red Hat reports Third Quarter Fiscal Year 2007 Results*, viewed January 2007, <http://www.redhat.com/about/news/prarchive/2006/earnings_2007q3.html>

28. Rossi, C. & Bonaccorsi, A., 2005, *Why profit oriented companies enter the open source field*, Fifth Workshop on Open Source Software Engineering, ACM, ISBN 1-59593-127-9

29. Sayer P., November 23 2006, *French National Assembly switches to Linux (Linux, Open Office and Firefox Favored)*, Pc advisor, viewed December 2006 , <http://www.pcadvisor.co.uk/news/index.cfm?newsid=7687>

30. Sun Microsystems, 13 November 2006, *Sun Opens Java*, viewed December 2006, <http://www.sun.com/2006-1113/feature/story.jsp>

31. Sun Microsystems, 26 October 2006, *Sun Microsystems Reports Results for First Quarter Fiscal Year 2007*, viewed December 2006, <http://www.sun.com/smi/Press/sunflash/2006-10/sunflash.20061026.1.xml >

32. Stewart, K. et al, 2005, *Observations on Patterns of Development in Open Source Software Projects*, Fifth Workshop on Open Source Software Engineering, ACM, ISBN 1-59593-127-9

33. St. Laurent, A. M., 2004, *Open Source and Free Software Licensing*, O'Reily, ISBN 0-596-00581-4

34. The Free Software Foundation, viewed January 2007, <http://www.fsf.org>