

## Open Source Software Stack and Standards – Integration and GIS for Everyone

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- **Abstract**

Open source software (OSS) is becoming established as a dominant method for delivering business process operations and solutions, creeping into our everyday life and gaining political salience. This has impacted heavily on businesses, requiring them to rethink their business models to stay competitive.

London Borough of Hackney's (LBH) GIS team has adopted and implemented a web mapping application with this growing alternative with an open source software stack (GeoServer, OpenLayers, Extjs, GeoExt, Apache and Tomcat – [www.map.hackney.gov.uk](http://www.map.hackney.gov.uk)). This is to achieve applications integration, sharing and management of geographic information for council business.

This paper seeks to explore the concept of OSS stack using an open source web mapping application developed for LBH to allow sharing of geographic information and motivation for the selection of particular OSS stack in the application development process. In so doing, the paper will also discuss the architecture adopted for Hackney's case, benefits realised, challenges faced, future direction and will conclude by summing up the process of change and shift towards open source software from reliance on proprietary software products.

**Keywords:** Open source software stack, integration, standards and geographic information sharing.

- **Introduction**

Open source software is a software technology of the commons that is developed voluntarily by the masses and freely available to all and “adheres to the licensing terms specified by the open source project” (Krogh & Hippel, 2003). It is gradually becoming an important “economic and social phenomenon” (Krogh & Hippel, 2003) creeping into our everyday lives. It is engendering business process reengineering so that commercial enterprises can stay competitive. There are countless numbers of OSS projects around, especially in the Geographic Information field; some examples are GeoServer, OpenLayers, GeoExt, Quantum GIS, PostGIS etc. The OSS world is grouped into two: developers of the software (contributions of code) and users of OSS to meet business needs. In this case LBH falls within the latter.

- **The Concept of Open Source**

“OSS is a term for software published under licenses that do not give any private intellectual property rights to the developers” (Osterloh & Rota, 2007). Contributions to the development process are made by enthusiastic volunteers, non-paid members of the OSS community investing their free time and private resources for a common good in software development. These software projects are available on the internet for free download, can be distributed freely, permission to view source code is allowed, changes can be made, debug or code can be developed further.

There are many licensing regimes regulating OSS projects based on the copyleft model<sup>1</sup>. One of the most popular OSS licensing is the GNU General Public License. It requires that all OSS components be made available in their entirety as free software, which is the exact opposite of the requirements of conventional proprietary software governed by the copyright licence.

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<sup>1</sup> A licensing allowing free use, distribution, and modification with some conditions of OSS.

- **Theoretical Perspectives**

Krogh & Hippel, (2003) argue that OSS represents a unique innovation model which they call the “private-collective” model. The private part of the model infers that private investment in innovation is advanced if investors can appropriate the rewards on their investment. As a result, investors will try to avoid knowledge spillovers as far as possible and society may grant intellectual property rights to the inventors in the form of patents, copyrights and trade secrets. On the other hand, the collective action model applies to the production of public goods like basic research. For this model to work, some central agent (e.g. a university) has to grant selective incentives (e.g. monetary subsidies or reputation). Krogh & Hippel, (2003) view OSS as residing in the middle ground, between these models of innovation. There are sometimes some central agents handing out selective agents like Google and Ordnance Survey in the GIS field who provide financial support and reputation to programmers to develop and further open source projects like Google summer of code and the OS open spaces project based on OpenLayers. Moreover, contributions are self-rewarding i.e., “only programmers will contribute whose utility is greater when contributing than when free-riding” (Osterlo & Rota, 2007, p.159). In that way, OSS seems to combine the benefits of private investment and the collective action model while avoiding their downsides. These have helped shape the interests, paths and the willingness of the community of developers to champion the course of free good and the motivation for sharing “my” inventions and innovations for a common good.

- **Motivations For The Interests and Contributions to OSS**

Flowing from the theoretical perspectives, the motivations for increased contribution and participation to OSS projects have been spurred on by the following factors;

- Increased user satisfaction with innovation

Most software programmers engage in OSS development as a result of dissatisfaction with commercial software products and also to bring something new which might not be offered by

existing commercial alternatives. As a result, people try to innovate and bring new offerings to the market free of charge and wish others to continue and build on the innovative process in order to gain satisfaction from the process (Krogh & Hippel, 2003).

- Competitive dynamics

Some OSS projects are developed to offer competition to existing commercial versions which users find expensive to buy or have to enter into restrictive licensing arrangements. Developers therefore see the need to develop alternative versions that generate mass following. Examples are the OpenOffice to compete with Microsoft Office products and PostGIS database software competing with Oracle and MS SQL Server. Krogh & Hippel, (2003, p.1155) state that "diffusion of technologies in the presence of network externalities can explain why open source software is becoming widespread in an environment previously dominated by established proprietary standards".

- Reputation motives

Through user forums and mailing lists, contributors to open source projects are credited with their contributions thereby helping them raise their reputation amongst peers. This also raises their profile in the job market especially to commercial companies and also the ability to provide paid support services and further development on the open source projects (Osterloh & Rota, 2007).

- Selective benefits that accrue to commercial firms

Most commercial firms are now engaged in supporting OSS innovation model by providing both financial and human resources to OSS developments. Some even go to the extent of incorporating aspects of the OSS components in their commercial software products. Examples are Google who run Google summer of code to help OSS projects, as well as Ordnance Survey of UK helps in the development of Openlayers because they use it as the underlying javascript library for their Open Spaces application for the sharing and distribution of geographic information. Some firms have grown out of OSS projects or have been bought and incorporated into commercial products. For

example, Red Hat sells support services to Linux and Dotted Eyes in the UK sells support for GeoServer and OpenLayers applications (Osterloh & Rota, 2007).

- Enjoyment

Krogh & Hippel, (2003), believe that many players of the OSS community stress that the key motives for participation are having fun, learning and public display of one's capabilities. Programmers have intrinsic fun in sparing their private resources to develop software which sometimes sub-consciously wouldn't be aware of the amount of time they have invested in OSS projects (Osterloh & Rota, 2007).

- Pro-social motives

OSS contributors feel rewarded and appreciate the sense of "helping others" or giving something back to like-minded people (Faraj and Wasko, 2001). Contributors reply to entire discussion forums - to personal questions and sometimes take personal charge to see to the resolution of problems (Osterloh & Rota, 2007).

Increased user satisfaction with innovation, competitive dynamics, reputation motives, selective benefits that accrue to commercial firms, enjoyment, pro-social motives are some of the reasons developers spend endless resources to make OSS projects viable and worthwhile.

- **Background to Hackney**

London Borough of Hackney is one of the inner London Boroughs situated in the East of London. It caters to a population of about 220,000 with a workforce of about 4,000. It relies heavily on a huge ICT infrastructure to deliver council services to its population. However, most of the ICT infrastructure has been procured from commercial companies at a huge cost, especially applications software. The increasing popularity of open source software implementation has the possibility of reducing ICT infrastructure cost; however, there has not been a conscious effort to move in that direction. This is due to the fact that there is no clear-cut open source adoption

policy or strategy to facilitate the process. Meanwhile, the council has seen cuts to its budget and has to find alternative ways of delivering ICT projects. A critical look at open alternative will suffice in an era of cuts.

- **Open Source Policy at London Borough of Hackney**

With the rise and maturity of Open Source software products many organisations are deriving the benefits of their implementation in an era of cuts to local authority budgets whilst sustaining the provision of frontline services. At the national level, the government backs and promotes the use of OSS - the use of open services such as open data, open government etc. As an example, the Government stated that "...the UK Government will consider OSS solutions alongside proprietary ones in IT procurements. Contracts will be awarded on a value for money basis and UK Government will only use products for interoperability that support open standards and specifications in all future IT developments". (Office of Government Commerce (OGC), 2002). However, national initiatives have not been translated to Hackney where there is no clear-cut OSS policy for implementation. The Council's policy is to "buy-not-make business applications as this allows it to focus on its core business and take advantage of the economies of scale that buying from the marketplace brings with it" (London Borough of Hackney, 2006). The benefits of OSS have not been fully explored. OSS is not only about money but getting value for money as expressed by the national policy.

- **Implementation of Open source software stacks products by Hackney's GIS Team - Map.Hackney 2.0**

Most OSS research has focussed inward on the OSS phenomenon itself. However, there has been less research focus on outward consumers of OSS and the manner in which proprietary software can be co-deployed with OSS in an overall IS infrastructure set up within an organisation

(Fitzgerald & Kenny, 2003). This case study is a reflection of Hackney Council being a consumer of outward OSS.

According to Bonaccorsi and Rossi, (2003), any successful OSS project begins because an individual or an organisation faces a problem that needs specific software in order to be solved. Hackney found itself in a similar situation with its public facing internet web map application from a commercial vendor. The product was not responsive to technological advancement within the industry, instability and unreliability of the web mapping product and a host of other problems experienced over the years of using the product. In an era of cuts there was no capital investment to procure a new web mapping application.

It was out of desperation, serendipity or the need to think out of the box and also from interactions with the OSS community that the GIS team at LBH implemented a proof of concept demonstration of OSS stack as an alternative web map interface to replace the commercial version. Management realised the value and quality of the alternative that they accepted for implementation the OSS equivalent, ushering in a new era of OSS implementation in LBH.

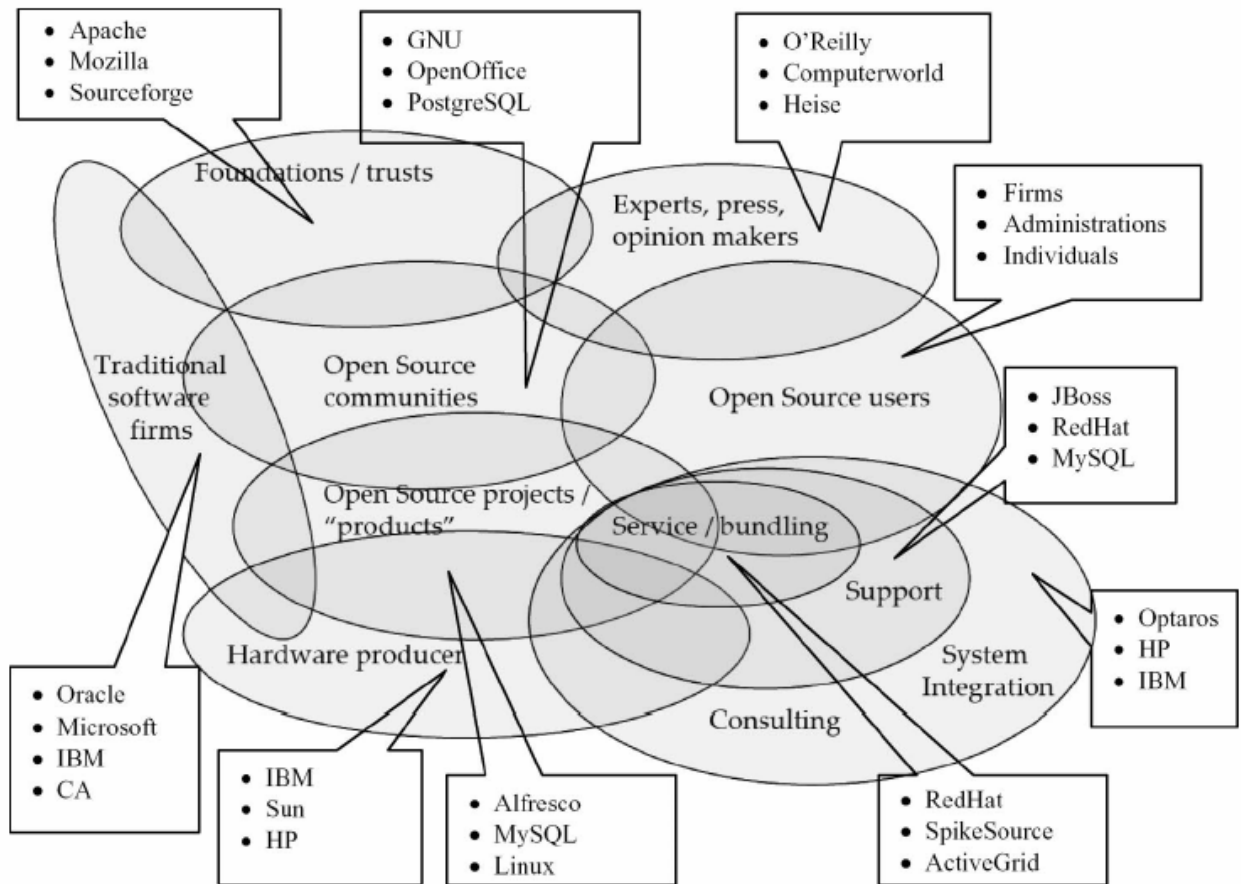
The distinctiveness of OSS products lies in the variety of software on offer that can be combined to realise a specific purpose. This provides the opportunity to pick and choose various components to achieve the desired application development that meets business needs. Hackney Council has tapped into this opportunity by implementing an OSS stack to develop Map.Hackney 2.0 with the use of GeoServer, OpenLayers, Extjs, GeoExt, GeoWebCache and Apache Tomcat. These various components play specific roles all working together to make the web application a reality and a success.

## Map.Hackney2.0 Open Source Alternative



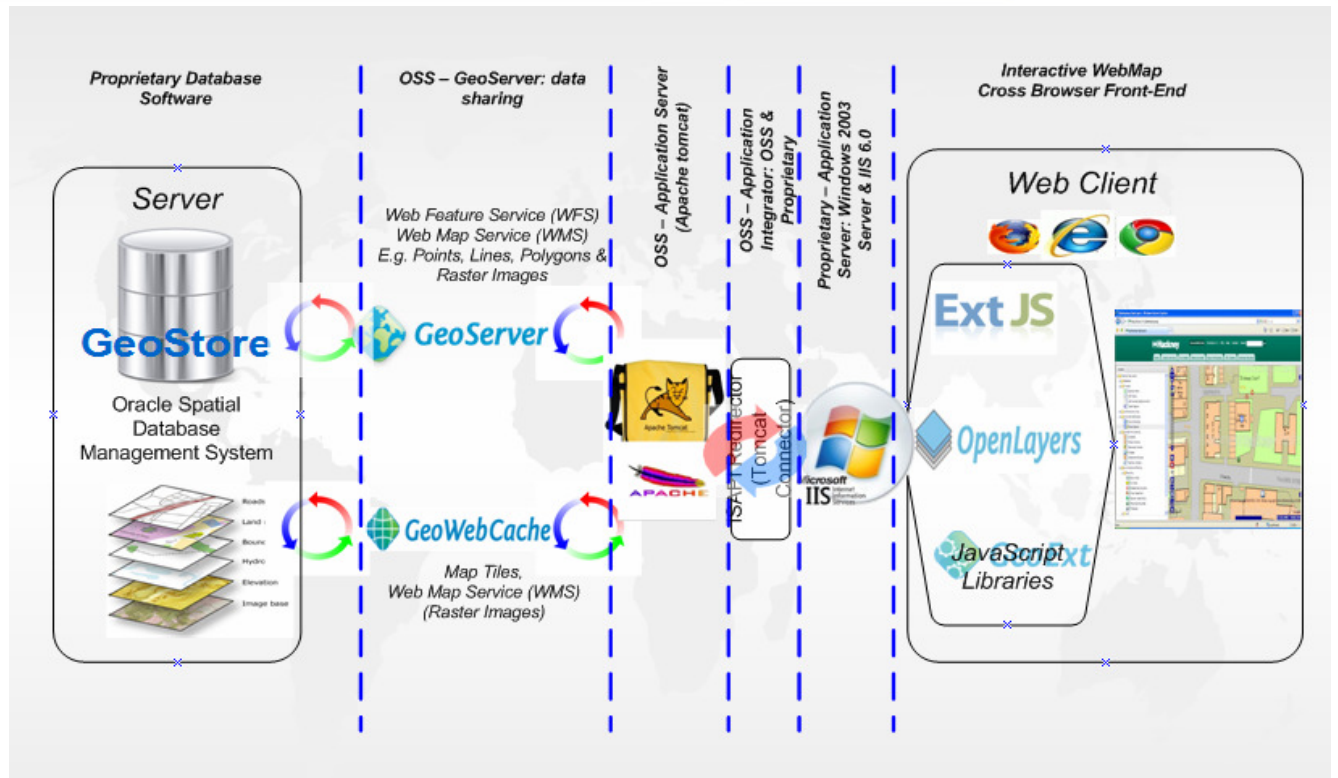
**Figure 1: Map.Hackney2.0 OSS Stack Components.**

In addition to using these free software components, they were smoothly integrated with commercial software as well. Kuelnel, (2008), believes that OSS and commercial software are fused together, co-existing within the software ecosystem for decades and have played a key part in the evolution of OSS. This is represented by his ecosystem diagram below which defines the interrelationships and integration between proprietary and OSS products;



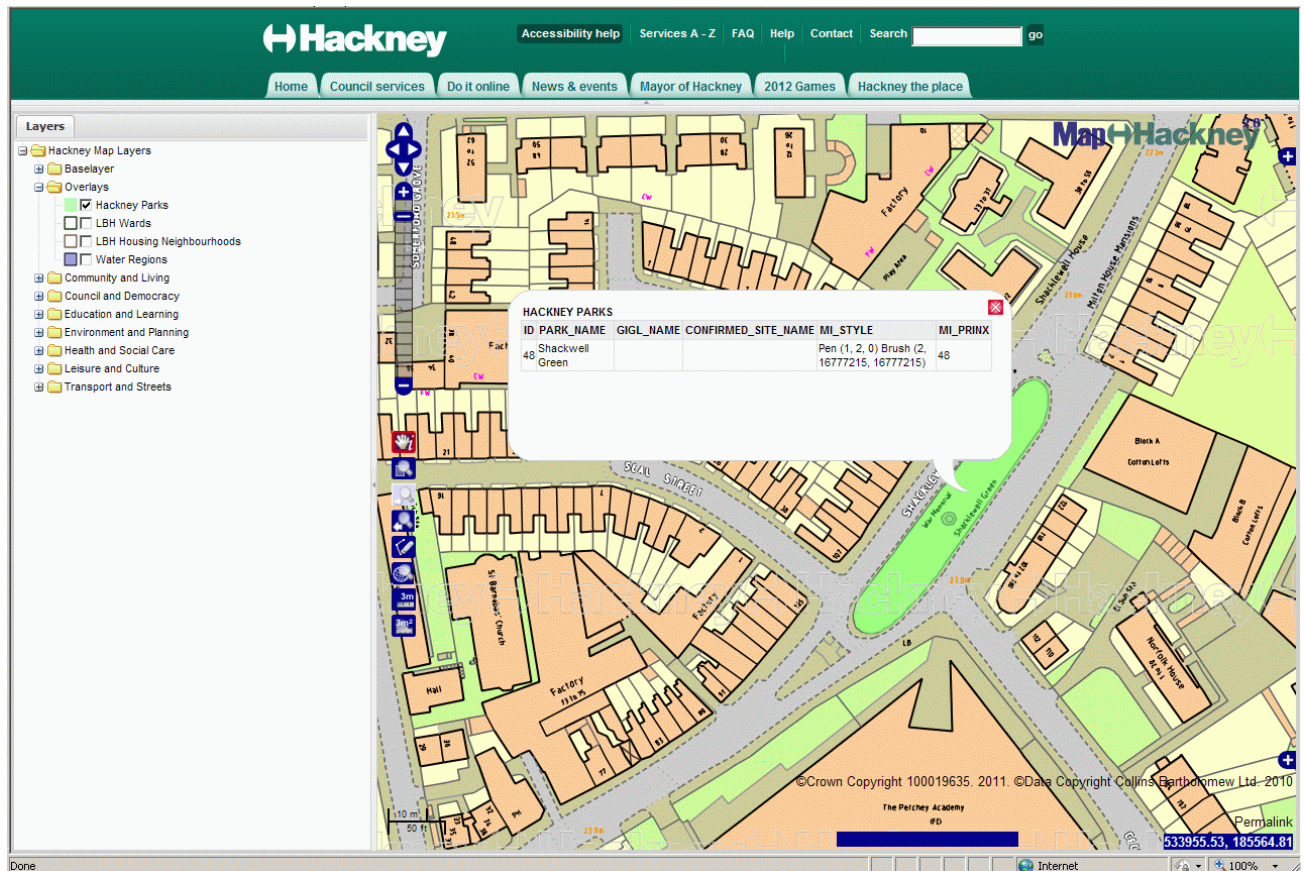
**Figure 1: The Open Source software ecosystem. Source: Kuelnel, (2008).**

The back-end database that fed spatial data was Oracle Spatial database management system and the web server enabling the publication of the web map application was Windows 2003 server with Microsoft IIS 6.0. The architecture below gives an overview of the implementation process of realising Map.Hackney 2.0 which will be explained later;



**Figure 2: Map.Hackney2.0 OSS Stack Architecture.**

The above architecture has produced the web map application with a snapshot below;



**Figure 3: Map.Hackney2.0 Interface**

### ➤ GeoServer

GeoServer plays an important role in the set-up of the web map application. It publishes and edits geospatial data from any major spatial data. It provides the link between the Oracle Spatial database and the web client by feeding the client with spatial data via Web feature services (WFS) and “high performance certified compliant” (OSGeo, 2011) Web Map Services (WMS). In addition, it also provides the data layers styling using OGC styled layer descriptor (SLD).

### ➤ GeoWebCache

The function of GeoWebCache is to tile and cache OS Mastermap for the whole of Hackney for quick retrieval and display, ensuring high performance of the application. It implements service

interfaces like WMS to serve tiled maps and runs as integrated component of GeoServer. However, it can be run as a stand-alone component.

### ➤ **OpenLayers**

OpenLayers is the front-end mapping library or engine that provides mapping capabilities to the client. Some of its capabilities are map display, ability to undertake navigation and measurements on a map, layers display or ability to switch on and off layers received via WFS and WMS made possible by GeoServer. The client provides a full selection of raster layer types, deals with many standard and popular protocols and data formats and allows client-side vector rendering. (FOSS4G, 2010).

### ➤ **Extjs**

Extjs is a cross browser JavaScript framework that enables the building of interactive rich internet applications offering various components such as widgets, layouts and charts. Map.Hackney 2.0 is encapsulated with the framework providing layout which offers desktop like web mapping application.

### ➤ **GeoExt**

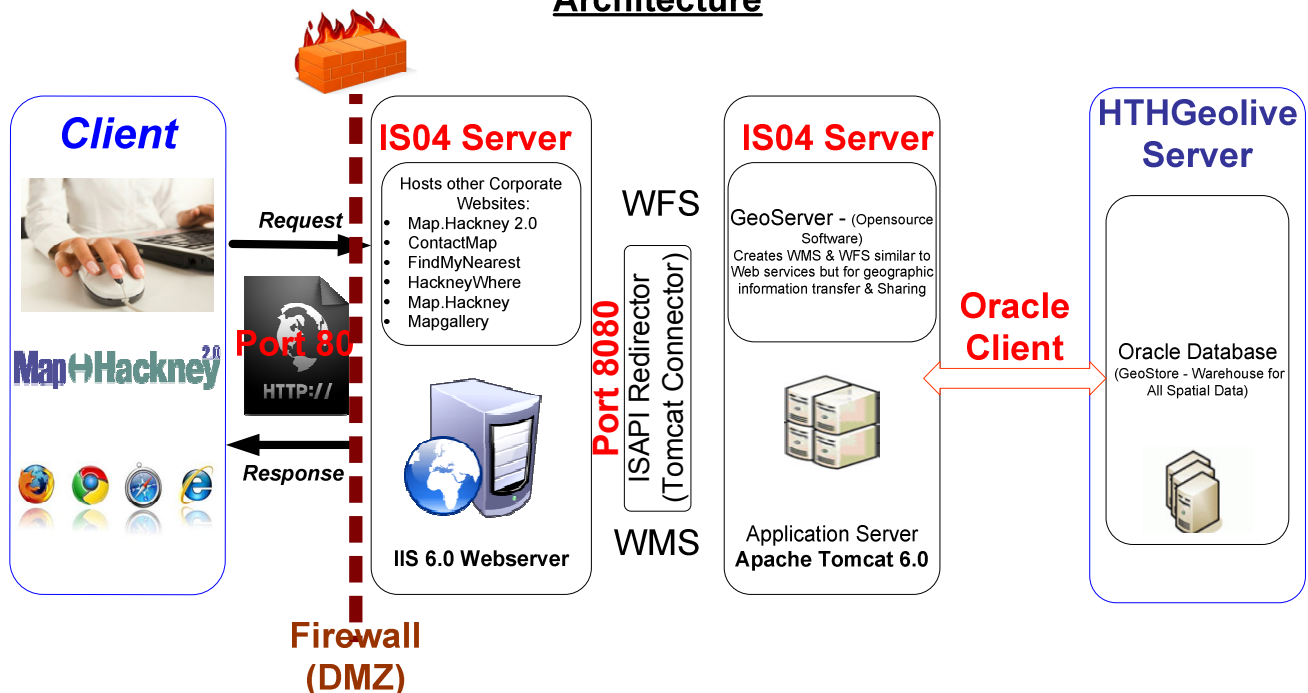
GeoExt, used in Map.Hackney 2.0 is a JavaScript library that provides the foundation for creating rich web mapping applications. It integrates the web mapping library OpenLayers with Extjs. GeoExt provides a suite of customizable widgets and data handling support that makes it easy to build applications for viewing, editing, and styling geospatial data (OpenGeo, 2011b).

### ➤ **ISAPI Redirector**

The server environment is Microsoft Windows 2003 server with IIS for publishing web applications to council officers and the general public. IIS therefore cannot execute servlets and Java Server Pages (JSPs). However, in order to serve WMS and WFS from GeoServer to the client interface requires Java servlets such as Jetty, Apache Tomcat, and JBoss etc., which communicates virtually on a different port from IIS environment of Port 80. The Council's information security policy is to

only open Port 80 on IIS for web publishing. JK ISAPI redirector plug-in enables IIS to send servlet and JSP requests to Apache Tomcat and receive response to clients. It has been a key component of taking data from a remote Oracle database using GeoServer to a public facing client web mapping interface (Map.Hackney 2.0). The process is demonstrated in the diagram below;

### Map.Hackney 2.0: IIS 6.0 & Tomcat ISAPI Redirector Integration Architecture



**Figure 4: Apache Tomcat ISAPI Redirector Integration Architecture**

#### ➤ **Apache Tomcat**

This is an OSS implementation of the Java Servlet and Java server pages technologies. It provides HTTP server environment for Java code to run. GeoServer as one of the Components of OSS used in Map.Hackney 2.0 implementation is a java implementation programme that allows users to share and edit geospatial data. It is served using Apache Tomcat.

## ➤ **Open Standards**

Standards are key to the successful implementation of spatial data infrastructures. They are necessary to address specific interoperability challenges. OGC, 2011 states that “when standards are implemented in products or online services by two different software engineers working independently, the resulting components plug and play”. Most of the OSS stack used in the implementation of Map.Hackney 2.0 embraces the open standards and specifications developed by OGC. This has enabled realisation of issues of cross browser compatibilities of web map applications, interoperability achievements in integration of various GIS data formats and proprietary software systems. Geospatial data sharing is therefore becoming easier and easier amongst GIS technologies without necessary having to undertake costly and complicated data transformation and translation processes as was the case in times past.

- **Criteria for Selecting Open Source Software Stack for Implementation**

The OSS stack used to implement Map.Hackney 2.0 was not picked at random. Some of the factors that were considered and should serve as the basis for any future OSS stack selection processes were;

First and foremost, of the key concerns to OSS implementation is the availability of support for the various components. It was therefore an important consideration to analyse the level of activity and number of registered developers and users of the OSS stack. This gives an indication of interested users and active participants. As of 24<sup>th</sup> August 2011, there were 5,286 registered users and 7,882 unique topics in OpenLayers forum (OpenLayers forum, 2011). There are also availability of third party support services that an organisation could buy. In the UK, Dotted Eyes Ltd. was identified as one of the companies that were offering commercial support packages for OpenLayers, GeoServer and PostGIS.

Similarly, case studies were evaluated on how wide some of these applications have been taken up by the user community. It was realised that a diverse selection of researchers, NGOs, and commercial companies are actively involved in the OSS. For example, Ordnance Survey in UK OpenSpace product is underpinned by OpenLayers and uses GeoServer for the data sharing via the OpenData portal. BLOM Web Pictometry viewer is built on OpenLayers.

Another consideration was whether there is an umbrella organisation that charts the development path and regulates the activities of some of the OSS stack picked for implementation. OSGeo was identified providing such a function for the software stack used.

Not all, contributions and support offered by organisations and commercial companies was an important factor that ensures the longevity, predictability and credibility of OSS projects. With the backing of industry heavyweights, some of these OSS projects have survived the test of time and enticed more users and developers. For Instance, Google runs Google summer of code global programme that offers student developers stipends to write code for various open source software projects including GeoServer and OpenLayers (<http://code.google.com/soc/>). Also, Autodesk in 2005 released its MapGuide web API source code and Feature Data Objects (FDO) (Autodesk, 2006) to the open source community. Ordnance Survey of UK also provides support sponsorship packages to OpenLayers since their Open Spaces project is built on it.

- **Benefits Realised**

One of the initial benefits after publication of Map.Hackney2.0 was financial savings. The publication coincided with the renewal of maintenance and support licence of the then Hackney's web map application. It was cancelled straight away and a saving of £3000 realised. A total of

about £20,000 savings for not buying a new proprietary web mapping software in addition to the time and resources that could have gone into lengthy procurement processes.

Additionally, the OSS software stacks used have inherent flexibility and interoperability that ensures integration between different applications using the specifications of Open Geospatial Consortium. This has made it possible to smoothly integrate software applications, different databases and data formats. In Hackney's case, it has been possible to ensure that Apache Tomcat 6.0 communicates with Microsoft IIS 6.0, GeoServer reads multiple data formats and databases such as Oracle, MapInfo tab and ESRI shape files and publishes the information via WFS, WMS, GeoRSS, CSV, GeoJSON and GML. Hence data sharing within the council has become simplified.

Furthermore, most scepticism and criticism of OSS software usage is based on the assumption of non-existent support as compared to contractual maintenance and support contracts signed with commercial software vendors. However, that assertion is actually a myth. There are vibrant communities of developers and users who are reviewing and responding to users' questions in various OSS forums such as GeoServer forum, OpenLayers forum, Extjs forum, etc. They have far more numbers than commercial software vendors and developers. These developers release nightly patches to bugs identified by users. Equally, some commercial software developers have repositioned themselves to offer support services to OSS projects such as Dotted Eyes in the UK and Autodesk who provide support services to their MapGuide webmap API after releasing it to the open source community. Hackney relied on OSS forums for the implementation of Map.Hackney2.0.

As compared to commercial versions, matured OSS projects, like GeoServer, OpenLayers, Extjs, and Apache Tomcat are known to be very stable and reliable software applications used by

thousands of people across the globe. Their value lies in their longevity and predictability. Bonccorsi & Rossi, (2003) conclude that some OSS projects are popular because of their "high degree of reliability and portability". Serving data from GeoServer as WFS and WMS to OpenLayers client interface with the Map.Hackney 2.0 has achieved remarkable results as compared to our previous version which even used a plug-in to display maps with the user needing administrative rights in order to install the plug-in.

Last but not least, there is a well organised umbrella organisation charting the development path of these OSS projects and also coordinating the efforts of the developers in order to come out with quality software products for the benefit of users like London Borough of Hackney and assures the organisation of durability and longevity.

- **Challenges Faced**

As with any project implementation, the process was not without challenges. To begin, there is no ICT strategy on OSS adoption and implementation. OSS project implementation initiatives depend on the employee's ability to convince management about the benefits of OSS projects and how best their implementation could benefit the organisation. It is down to the personal initiatives and resources to get OSS stack use of the ground.

In addition, the issue of support crops up again. The culture within LBH is reliance of maintenance contracts on software applications so that somebody somewhere can be called upon to fix software issues. It is therefore difficult for management to buy into the adoption of OSS projects without any contractual agreements as to who is going to provide support.

Similarly, there is inadequate understanding and support or limited experience from the Corporate IT technical support service and even amongst managers on OSS implementation. This made it

very difficult to communicate at a level playing field. Their thoughts on the implementation of unfamiliar software without any external support are a breach of Corporate IT security policy, introduction of malware to the corporate IT network. They could not also offer any system support because of lack of knowledge and such additions have not been agreed in the service level agreement reached.

Despite the success of OSS stack used, there is a limit to the amount of documentation available. Knowledge are scattered in forums, awkward internet sites and what might be on offer might not always be sufficient. A lot of time is therefore spent researching and digging to find the appropriate knowledge and resources to support the implementation process. It therefore requires extra effort to document the process as development proceeds.

- **Future Direction**

The future of OSS projects is bright, more and more projects are reaching maturity ensuring that users' needs are well catered for. In Hackney, the success of the Map.Hackney 2.0 has generated huge interests in OSS projects with the Master Data Management team manager writing her MPA thesis on the open source adoption in selected Local Authorities and commercial enterprises. The offshoot will be a process to lobby for the drafting of open source adoption and implementation strategy that can be tested on a pilot basis. The GIS team's effort in that direction could be used as a test case for the whole organisation.

Similarly, the Corporate GIS team intends to further the use of geospatial OSS products especially GeoServer to lead the sharing of spatial data via WMS and WFS for both departments within the council, its partners and contractors. With Hackney being an Olympics borough, the team would set up data sharing services with GeoServer to share and make spatial data for event planners,

users, mobile application developers and any other process that would benefit the successful hosting of the Olympics project.

The GIS team is also currently implementing a metadata extraction project of all the spatial data it holds. This will be made available for public consumption using OSS products of GeoNetWork and GeoNode. We have the vision of relying on the OSS projects to drive the business, enjoy product reliability and longevity and above all enjoy cost reductions in an era of cuts.

- **Conclusion**

Bonaccorsi & Rossi, (2003), believe that "...altruism might at most explain the behaviour of people writing software in their spare time but not the behaviour of those who have devoted considerable resources of time and intellect. But if it not altruism, why work for free?" Whatever the reasons, OSS projects have become the mainstream software products that offer free competition to commercial versions, and are used to meet business needs of both private and commercial organisations.

Sometimes no single OSS product can be used to solve a business problem. However, due to their versatility, interoperability and reliability, a stack of various products could be combined to achieve a desired result. That is the uniqueness of OSS products and is what has proved successful with Map.Hackney 2.0. OSS are gaining popularity, use current technologies, have come to stay, will be used to drive business processes and are integrated with commercial applications.

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