

Open Source and Free, Web-based Medical Software

Chris Paton, Muzaffar A Malik

*Department of Information Science, University of Otago
Dunedin, New Zealand*

Abstract

Open Source Software (OSS) is now in use in hospitals across the world and free web-based software applications are developing apace. Companies such as Google and Mozilla are inventing new business models, offering their customers free software and deriving revenue by channelling users into profitable services such as web search. In a virtuous circle, many of these types of businesses use web-based applications and OSS themselves to develop and deliver their products.

In this paper, we examine the rise of free web applications and OSS in health care. We discuss the recent changes in software application delivery and business models and look at how healthcare organisations in both developed and developing countries can take advantage of new business models to ensure financial sustainability of healthcare software projects.

1. Introduction

One of the major tenets of Open Source Software (OSS) is that users do not need to pay to license the software. This philosophy is now being applied to a new generation of web-based applications. They may not be free to download, modify and distribute, like true OSS applications, but many web applications are free for end-users and some have open Application Programming Interfaces (APIs) so that users can extend and customise the applications to suit their needs (refer table 1).

Table1: Differentiating open source and web-based software

	Open Source Software	Free, Web Based Applications
Free to use	Yes	Yes
Free to modify source code	Yes	No
Free to distribute modified versions	Yes	No
Maintenance requirements	High	Low

Developers of free software have, in the past, found it difficult to build sustainable businesses by giving away their products for free. However, new business models have been developed that have allowed companies who give away their products for free to make substantial profits and provide continuing customer support and product development.

Free web applications and OSS is of particular interest for healthcare organisations in developing countries[1]. If developers can give away their products for free then users, no matter where they are in the world, will be able to benefit.

2. Open Source Software (OSS)

The history of the OSS movement is described in the book *The Cathedral and the Bazaar* [2]. The Free Software Foundation (FSF), led by Richard Stallman, was established in the early 1980s and commenced work on a freely available version of the Unix Operating System. The aim of the project was to liberate researchers and enthusiasts from the expensive licensing arrangements required for operating systems like Unix and enable them to modify the software without need for permission. The new Operating System was named GNU (a so-called "recursive" acronym, GNUs Not Unix). The FSF produced most elements required for a complete operating system but development of the "kernel" or core of the operating system fell behind development of the other tools. At the same time, a developer named Linus Torvalds was working on a free Unix kernel called Linux. By combining the applications developed for the GNU operating system with the Linux kernel, a fully functional operating system named GNU/Linux was possible.

The Free Software Foundation released software under the Gnu Public License (GPL). This licence enabled users to distribute, share and modify the source code of the applications they used. Over the years, the GNU/Linux operating system has grown in popularity and many different software stacks based on the Linux kernel and GNU tools have been distributed. Popular distributions include RedHat, Debian, Knoppix and Ubuntu, although there are many others.

In 1998, the term "Open Source Software" was coined as a replacement to the term Free Software, as it was felt that Open Source Software reflected a more business-friendly image and would encourage uptake in corporate environments. It also emphasises the fact that the software source code is able to be freely modified, which differentiates Open Source Software from simply free software with unmodifiable source code. In order to qualify as Open Source Software, the software copyright licence must comply with strict criteria including free distribution and free availability of the source code.

One of the most successful implementations of OSS is the so-called LAMP software stack. LAMP stands for Linux, Apache, MySQL and PHP/Python/Perl. Apache is the web server software that allows a computer to act as a server of web pages on the World Wide Web. Apache is distributed under its own Apache Open Source licence and accounts for some 50 percent of web servers on the Internet [3]. MySQL is an OSS database application now owned by Sun Microsystems. MySQL allows web-developers to create database driven applications such as Blogs, Wikis, Discussion Forums and Content Management Systems. PHP, Python and Perl are Open Source programming languages commonly used by web developers, often to allow interaction with a MySQL database.

In the field of health care there are several ongoing initiatives to promote the use of OSS. The International Medical Informatics Association (IMIA) has an Open Source Working Group [4] as does the American Medical Informatics Association (AMIA). The Open Source Healthcare Alliance (OSHCA) is a non-profit group established to encourage the use of Free and Open Source Software in health care.

Open source medical software is not only a phenomenon of developed countries; it is also gaining ground in resource-constrained developing countries:

FLOSS [Free/Libre/Open Source Software] related activity seems to be taking place in countries like India, China and Taiwan . . . followed by South Korea, Malaysia, Singapore and Thailand. The rest of the Indian subcontinent (Bangladesh, Pakistan, Sri Lanka, Nepal and others) having a medium level activity, while [the] Arab world (with the exception of Israel) seems to be the least active zone, only Afghanistan and North Korea being at the very end. . . . In Africa, South Africa tops the list, closely followed by Kenya, Namibia and Nigeria. And significant activity is starting in Ethiopia, Ghana and Zambia [5].

The above would refer to both open and closed source medical software developed both locally as well as that which was developed elsewhere but only implemented (without or without customisation) in one of the countries named above. Nevertheless, there is a rising number of open source medical software from developing countries. A well-known open source example for medical software developed by, and implemented in, developing countries is OpenMRS. Mamlin et al [6] report that it was initially a Microsoft-Access based system,

developed in Kenya to support the treatment of HIV/AIDS and TB patients, and was first termed AMRS (for AMPATH Medical Record System). It is now called OpenMRS and is a web application based on MySQL database, programmed in Java, compliant with HL7 and contains the medical terminology dictionaries. Although the software is still primarily used for HIV/AIDS and TB care, there is nothing about the code or infrastructure that limits it to these domains [6]. The software has been implemented in Kenya, Rwanda and South Africa and is being piloted in Lesotho, Malawi, South Africa, Tanzania, Uganda and Zambia [7].

Another large, customisable open source medical software project is DHIS (District Health Information Software) [8]. This was developed by the health information system programme (HISP) in South Africa, which aims at "strengthening and further developing HMIS in public health in an expanding network of developing countries including Mozambique, Malawi, Tanzania (mainland and Zanzibar), Ethiopia, Botswana, Indian and Vietnam" [8].

In addition, there are numerous local open source systems that can be either *wholly* or *partially* open source. PaRIS (Patient Record Information System), for instance, is an application for primary health care in Indonesia and is a full open source software [9]. HIV-EMR in rural Haiti, on the other hand, is a partially open source application developed using open source software (Linux, Apache, Tomcat Java Servlet) but uses the commercially-licensed Oracle software as its database management system [10]. Its developers were however considering shifting to an OSS database management system. Fraser et al [10] also list some other open source medical software produced or customised in developing countries, mainly in the field of telemedicine. These include RAFT in Mali, IPATH in South Africa and the Pacific, and Telemedmail in South Africa and Peru.

Table 2: Open Source Software and Free, Web Based Applications referenced in this paper

Open Source Software		
Ubuntu Linux	Operating System	http://www.ubuntu.com/
Apache	Web Server	http://www.apache.org/
MySQL	Database Management System	http://www.mysql.com/
Mozilla Firefox	Web Browser	http://www.firefox.com/
OpenMRS	Medical Records System	http://openmrs.org/
DHIS	District Health Information System	http://www.hisp.org/
OpenVista	Medical Records System	http://sourceforge.net/projects/openvista
Free, Web Based Applications		
Google Docs	Word Processor	http://docs.google.com/
Google Spreadsheet	Spreadsheet Application	http://docs.google.com/
Epocrates Online	Drug Reference	http://online.epocrates.com/
Practice Fusion	Medical Records System	http://www.practicefusion.com/
Microsoft HealthVault	Personal Health Record	http://www.healthvault.com/
Google Health	Personal Health Record	http://www.google.com/health

2.1. Free Web-based Applications

In recent times a suite of web technologies have come together that can allow the development of fully featured applications delivered through the web browser. These technologies include server side databases, AJAX (Asynchronous JavaScript and XML), web frameworks and Application Programming Interfaces (APIs).

These tools can reduce development time and enable different web applications to interact with each other.

Although many web-based software companies are now keeping their core source code private, they are often using Open Source programming languages and databases and providing free access to APIs. These types of applications grow best in an open environment, with free access for users, open standards and the encouragement of developers to extend the programs through plug-in software.

Examples of medical web applications abound. Epocrates is a drug reference tool originally designed for use on PDAs. Epocrates Online [11] is a database driven webware application that allows health professionals to look up drug information and cross-reference drug interactions. Microsoft HealthVault and the upcoming Google Health are web-based Personal Health Record (PHR) applications. They allow individuals to keep their own medical records online and share them with their healthcare professionals. There is also a move to offer free web-based Electronic Medical Records applications, funded by Google adverts [12].

Not all software applications used by healthcare organisations are specifically medical. Web-based word processing, spreadsheet applications and presentation software can be used as a free replacement for desktop-based applications. Web applications are also available for business planning, for holding online meetings and a host of other business activities.

2.2. Business Models for Free Software

In a recent keynote speech to health informatics professionals, Eric Schmidt, CEO of Google, was asked about the business model for Google Health, a free Personal Health Record (PHR) product [13]. He replied that Google Health would be offered for free in the hope that users of the product would choose Google as their search engine. Google derived over USD \$4.83 billion in the fourth quarter of 2007 from users clicking on paid advertisements in its search engine results pages and from partners who agree to display Google's adverts on their web pages and applications [14]. This business is so lucrative that they are now willing to offer users a range of web based applications, developed at a cost of millions of dollars, simply in the hope that they will choose Google as their search engine.

As users move from buying packaged software to using free, web-based applications, new revenue streams such as online advertising are critical to future success. Although Google is a clear leader in search and contextual advertising, other companies are positioning themselves to compete in this market. This is exemplified by the recent attempt by Microsoft to purchase Yahoo Inc., a contender to Google in the search advertising space [15].

Mozilla is an OSS company that produces the Firefox web browser [16]. In 2006, Mozilla derived USD \$58 million (approx 90 percent of its income) from the Google search box it includes in the browser's top menu bar [17]. Mozilla partners with Google and receives a proportion of revenue from users who perform a search from Mozilla's search box and then click on paid advertisements in Google's search result pages.

Medical software companies are offering doctors free use of a web-based Electronic Medical Records (EMR) system and deriving revenue by displaying Google search advertisements to their users [12]. Other medical software companies are giving away OSS and generating income by providing paid support and installation services [18]. Medical web application companies are also deriving revenue from market research services based on surveying users [11].

3. Discussion

Free web applications and OSS are providing new opportunities for modern businesses and exciting possibilities for health care, especially in developing countries. Development and software costs can be reduced and access to health records and other online tools is much easier if applications are delivered over the internet.

There are some potential issues ahead for the future of free web-based software. Google is currently dominant in the online advertising market. They have it within their power to reduce the percentage share to partners if they choose to start competing in the same market. Users of free web applications in developing countries might find themselves barred from use of the applications if advertisers feel that users in developing countries are not part of their target market. It will be up to governments to regulate to ensure monopolies in online advertising don't

develop. It will be the responsibility of free web application and OSS businesses to be flexible in their business models and not be solely reliant on third parties for income.

The fact that Microsoft and Yahoo have so far been unable to seriously compete in the search advertising market demonstrates the high barrier of entry. New start-up companies are likely to have to compete by creating new markets rather than competing with the entrenched players. An example of this is Phorm, a controversial new start-up that is attempting to create an advertising model based on users browsing data at the level of ISPs rather than content or search term matching used by Google, Microsoft and Yahoo.

Another potential problem with web applications is the dependence on a live internet connection. The first generation of free web-based applications did not offer any back-up for users when they lost their Internet connection. If the connection goes down while a user is entering information, the data could be lost. Further, it was not possible to enter new data into these types of application when the Internet connection was not present. In a medical environment this could cause significant problems as patient progress could be delayed without access to the records or the ability to enter information during a temporary Internet outage.

One solution offered by Google Docs (a web-based word processor) is a plug-in application for the web browser called Google Gears. This application allows the user to continue working on a Google Document in "offline" mode. If the connection goes down, or the user is not within a wireless network, users can still work on documents which are saved locally and synchronised to the server when a connection is re-established. It might be possible for medical software to keep a cache of current patients' data on their local computers, updated by synchronising, so that in the event of a connection, outage staff can still work on current patients.

There are some important differences between free web-based applications, such as HealthVault and Epocrates, and OSS such as WorldVista and OpenMRS. The former do not allow downloading and modification of the source code, allowing only free use of the application. It may be that, as technology progresses, it will become less feasible to download and install a web application on a local network. If a web application is designed for use by millions of users in multiple countries, much of the core software functionality will be devoted to issues of scaling and load distribution. This scenario may still require OSS for development tools, web servers and programming languages, so it may be that free web applications and OSS will develop symbiotically but with different end-users and purposes.

Presently, however, there is still a need for OSS healthcare applications, not necessarily designed for wide distribution through the web, but for use in hospitals and clinics in developing countries. The 2004 SIDA report [19] refers to the "strategic opportunities that developing countries could exploit utilising the OSS phenomenon" (p7). While the SIDA report acknowledges the importance of OSS for developing countries through its lower costs and greater efficiency and effectiveness, it recommends a package framework that highlights the need to balance IT infrastructure, skills and policy status if OSS implementation is to succeed in a developing country. Therefore, the development of IT, infrastructure, skills and/or policy is a priority that needs to be addressed before progressing to implementing open source software.

In making the case of OSS for developing countries, Ghosh [20] points out the enormous cost of proprietary software in developing countries, the relationship between piracy rates and the unaffordable licence fees, and, based on these factors, the turning of developing countries towards OSS. Having said that, he points out that the most important reason for users to choose OSS is not the low costs associated with it but the higher stability and performance it delivers.

A common concern about OSS among health professionals is the lack of support when compared to proprietary software [21]. It should however be borne in mind that, as the SIDA report points out, implementation of open source software is not to be looked at in a vacuum of IT skills. The movement of open source medical software implementation might therefore be about altering the mindset, approach and relocation of resources to implement IT solutions in health care. While "open source software requires a background knowledge that needs only a relatively modest level of technical education"[22], one option that may be more helpful is to develop full formal in-house IT capacity. This would be conducive to open source implementation, provide the necessary

support for ongoing maintenance, lead to the engagement of end users more than the proprietary model would and, as a result, lead to a more customised, usable, efficient and cost-effective system.

Soriyan et al [23], talking about Primary and Hospital Information System (MINPHIS) made in Nigeria for implementation in Nigeria only, states that financial constraints prohibit "African software developers . . . to spend their free time in producing free software". That would have been the case early on but a lot of development in open source medical software has already taken place. Developers or implementers therefore should not be expected to start from scratch. OSS has led to the opportunity of leapfrogging in ICT [22]. However, what would be expected of users of OSS in developing countries is that they feed the code they have revised back to the open source knowledge base for others to benefit from and build on. This is the main thrust that has kept open source alive and led to development of its software in various disciplines.

On the flip side, advocates of open source should keep in mind the total cost of ownership (TCO) associated with implementation of medical software. Hardware and infrastructure costs may be taken for granted in developed countries but in developing countries, by and large, implementing medical software has to take these costs into account as usually there is nothing in place, and these costs and not the software costs tend to be the largest, albeit one-time, cost. Proprietary software developed in developing countries tends to be relatively cheap (if not free) when coupled with a maintenance contract. The larger saving, however, can be in license fees of things like database and web servers when employing open source technology.

The future seems bright for free software. Open Source Software technologies are powering many of the next-generation web applications and OSS medical projects are finding a niche in developing countries. Even web applications such as Google Health that do not release their core source code appear to be embracing the philosophy of free use for end users, data sharing and customisation achieved through the use of APIs and developer tools.

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