Open Source Software for the Medical Field and its Cultivation in Japan

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Abstract. Despite the recognized benefits of electronic medical records and electronic health care data, many organizations have not implemented such a system. The cost of licensing proprietary systems and customizing them to meet an organization's needs are major barriers. Other barriers include great uncertainty about the chosen system continuing to be best for the organization, whether the new system will integrate with their existing IT systems, and whether it will remain viable over time and as technology changes. Many of these problems can be addressed through the use of open source software (OSS). OSS computer code is free and available for download by anyone. There are no license fees for OSS and the software can be freely modified by an organization to its specific needs. In addition, OSS-based medical record systems are attractive to medical organizations because they offer the ability to avoid a 'lock-in' state. At present there are more than 150 health-related OSS projects, some of which have achieved worldwide distribution and use. Implementing electronic record keeping in Japan presents similar barriers, namely high costs, organizational inflexibility, and restrictions associated with implementing proprietary software systems. To address these barriers, the Japan Medical Association has developed and made available an OSS-based information and communication infrastructure. The project is called ORCA, for Online Receipt Computer Advantage. Today, more than 14,000 medical providers in Japan are using computer products from the ORCA project. In this article, we address the use of OSS in Japan's health care system.

Keywords: EHR, health care, medicine

1 Introduction

The benefits of electronic health care record (EHR) systems are increasingly apparent, but many health care organizations have yet to implement them. This is due less to skepticism about their benefits and more to commercial considerations. Inadequate capital to purchase software and ongoing annual maintenance costs are significant barriers for many organizations [1]. Other barriers include uncertainty in committing to a particular vendor and concerns about compatibility of the chosen vendor's system with existing and future systems.

This global problem also affects Japan. We estimate that implementation of a proprietary EHR system in a Japanese hospital would cost approximately US$10,000 per hospital bed. To fully implement an EHR system for the roughly 150,000 medical organizations in Japan, the Japan Medical Association (JMA) estimates a cost of US$180 billion over a 10-year period. Given the size of the Japanese medical market, about US$300 billion per year, this is not a viable consideration without significant cost reductions.

One approach to reducing the high cost of implementing a clinical information system is to integrate various existing systems. However, lack of a standard protocol for data transfer between systems makes communication among many different systems very problematic. A potential solution to the issue of high EHR implementation costs is to use open source software.

2 Open Source Software

Open source software (OSS) is any computer software for which the human-readable source code, made available under a copyright license or in the public domain, meets the Open Source Definition [2]. The OSD requires free distribution of the software, inclusion of all program source code, and permission to distribute modified and derived works under the same terms as the license of the original software. The software license agreement should not be specific to a product, must not restrict other software use, and must be technology neutral. This permits everyone to use, change, and improve the software, and to redistribute it in modified or unmodified form. Such an open system offers considerable commercial and technical benefits. The availability of OSS source code allows software designers to avoid coding basic routines and algorithms from scratch and to instead concentrate on system development and efficiency. Proactive use of OSS promotes low costs and short delivery times. The framework and protocols used for the Internet are prime examples of open source approaches.

The primary advantage of using OSS is that an organization (user) gains assurance in the future availability of the system, has full ownership of all data, and by avoiding 'vendor lock-in' can expect timely and useful software customization as the system expands. Organizations can readily adapt OSS to their specific needs, performing any necessary customization themselves or via an independent third party. These options stand in marked contrast to proprietary software, where the organization is dependent on the vendor's willingness to perform any customization, usually has little control over how quickly modifications are made, and will inevitably pay a substantial fee for them. The organization has no control over a vendor's decision to change data format or even structure.

3 OSS in the Medical Field

A wide range of OSS solutions are already used in the health care system. Many are general operating systems or business applications (e.g., Linux, Apache, OpenOffice.org), but a large number are health care domain specific (Table1). As of December 2009 there were more than 150 health care-related OSS applications available for download from SorceForge.

Two widely used applications for supporting patient and clinical management are OpenEMR and VistA. OpenEMR supports medical practice management, electronic medical records, prescription writing, and medical billing [3]. It is used in the United States, Puerto Rico, Australia, Sweden, Holland, Israel, India, Malaysia, Nepal, and Kenya. VistA is an integrated, comprehensive clinical information system supporting clinical, administrative, financial, and infrastructure functions [4]. It was developed by the U.S. Department of Veterans Affairs to serve more than 4 million veterans cared for in its 150 hospitals and 700 clinics. VistA has been adopted for use by several other health institutions in the United States and other countries, including hospitals in Egypt, Germany, and Mexico.

OSS applications are also used in various specialized medical fields. For example, radiological imaging and visualization facilities use MicroDicom for primary processing and preservation of medical images using the DICOM format [5]. Practitioners working on the prevention and surveillance of infectious diseases use OpenMRS, a system designed specifically for developing countries with resident populations suffering from diseases such as HIV and tuberculosis [6]. The OpenMRS project supported student-led software innovations during the 2007 Google Summer of Code. Medical research is supported by OpenClinica, a web-based platform for managing clinical studies [7].

4 Medical OSS in Japan

Japanese medical practices generally are subsidized by public health insurance programs. Doctors submit to the government details of medications prescribed and treatments administered to their patients for reimbursement. To meet the government's accounting rules a health insurance computing system called *'Receipt Computer'* was developed during the 1970s and released in the 1980s. The software was expensive to deploy, costing as much as US$50,000 to install, even in very small clinics or hospitals. Nevertheless, it was installed in 90% of clinics and hospitals in Japan because it was compliant with complex bureaucratic accounting procedures. The high cost of the software placed a financial strain on clinics. In addition, all data entered into the Receipt Computer system were locked in the vendor's proprietary format and could not be used for any other purpose or with any other systems without paying the vendor to develop additional software code.

To address the high costs of commercial software implementation and to avoid future dependency on a specific vendor or technology, the JMA decided to provide its members with an OSS-based information and communication infrastructure. The system needed to address two primary issues. The first was to provide a networked system with software for submitting claims for government reimbursement (referred to as a 'JMA standard receipt computer') and related applications at very low or no cost to JMA members. The second was to use knowledge and experience gained from developing the project to inform health care policymakers about the potential uses of OSS in other aspects of health management in Japan, particularly for maintaining electronic health care records. In 2000, the JMA released the Online Receipt Computer Advantage (ORCA) OSS-based reimbursement system [8].

All components of the JMA standard receipt computer are OSS-based (Table 2). The operating system platform is Debian GNU/Linux and Ubuntu Linux, and uses the PostgreSQL database system. The JMA provided standardized terminology databases about diseases, drugs, operations, and contraindications of drug combinations. MONTSUQI is a middleware system that monitors transactions between modules of the database system. Standard web environments cannot readily switch input methods on demand from a form field. The system was implemented with a rich client framework (customized gtk 1.2), because use of the Japanese language in the system requires input methods for Japanese letters, e.g., Kanji, Hiragana, and Katakana scripts. MONPE is a printing environment that allows for the design of a complex receipt form with many ruling lines.

Originally, OpenCOBOL was used to develop ORCA, because the software designer needed a fully compliant COBOL compiler. OpenCOBOL is now widely used for migrating legacy software systems to the Linux system [9]. The ORCA project has released other health system management products that use OSS [10]. IKENSHO tracks long-term care insurance documents required by the government. Today, nearly 14,000 medical providers in Japan use IKENSHO, and the number of participants is increasing. According to the ORCA website (last accessed: December 2009), 9019 clinics and hospitals (about 6 percent of the total) have adopted the JMA ORCA system. The software is free and can be installed by the organization themselves or by hiring a JMA-authorized vendor.

The potential applications of OSS solutions in the medical field are numerous and varied, and Japan established the Medical Open Software Council in 2004 to explore the possibilities. OpenDolphin was developed as a client part of the regional health care system and today is used in independent clinics across Japan [11]. OpenDolphin uses the standardized CLAIM protocol to connect to ORCA [12]. NOA is an EMR system originally developed by Dr. Ohashi for use in his clinic in Tokyo and released as an OSS application for public use [13]. Dr. Ohashi is a 67-year-old gynecologist, who developed NOA over the course of 20 years of practice.

One area where OSS may play a key role is in standardization of medical data transaction protocols. In Japan, there are very few vendors of medical

information systems and this limits competition, driving up the cost of information systems. Limited competition can stifle innovation, possibly resulting in a 'data lock-in' state, where a clinic or hospital cannot access data in unique ways as searches are limited to only the built-in functionality and features of the system. As well, a 'vendor lock-in' state can occur, where an organization cannot change to a new vendor if their current vendor does not provide the information necessary to allow automated migration of data to the new system. These issues do not arise with OSS, and consequently users and organizations can avoid lock-in situations.

As OSS applications become more common in the medical field, barriers to new vendors should be reduced, and more vendors will be attracted to the field. Increased competition should break the vendor oligopoly in Japan and lead to greater diversity of and lower costs for medical IT systems. Given that there is no one set of standards for operating a clinic or hospital, clinical information systems are usually customized to suit each organization, which increases initial implementation costs. With wider acceptance and use of OSS systems, the diversity of available clinical information systems will increase, making it more likely that one solution will be readily adaptable for use in a new organization, without the need for and cost of extensive customization.

5 Discussion

OSS offers great promise for realizing the vision of ubiquitous, low-cost, high-quality EHR systems to improve health care management. Eliminating annual license fees and avoiding dependency on a single vendor greatly reduces barriers to implementing an EHR system. OSS application make both of these possible, as well as offering open data access and facilitating EHR systems integration or data migration between systems.

Although OSS have many attractive features, potential drawbacks to their use must be considered. Because OSS development depends primarily on volunteers within the OSS community for innovation, and products are usually provided *'as is'*, some organizations are skeptical about security, functionality, and availability. However, comparisons of OSS with proprietary software have been favorable [14]. For example, analysis of the source code for the Linux kernel indicates it has fewer software "bugs" [15], and is considered to be more reliable than proprietary operating systems [16, 17]. OSS developers have been shown to respond more quickly than proprietary software companies in releasing patches to identified vulnerabilities. Clinical information systems must have a high level of security to maintain patient privacy. OSS can theoretically be made more secure than proprietary software because it receives input from a more robust community of developers [14, 15, 16, 17].

As described earlier, the potential of OSS has been recognized in the medical field, and many health care-related OSS projects have achieved success [3, 4, 10]. However, many problems remain to be solved. OSS applications require many

developers with numerous skills and ideas to produce a high-quality product. As a consequence, OSS projects recruit developers worldwide (e.g., Google Summer of Software programs). Unfortunately, worldwide projects are rare in medicine, because each country has its own unique medical system and thus software cannot readily be shared without specific adaptations and a literal translation of the language. Where language is not a barrier, and medical practices are very similar or exactly the same, e.g., viewing and assessing radiological images, OSS applications can be implemented with minimal or no adaptation [5, 18, 19, 20]. Furthermore, despite differences in medical systems, the work flow of a hospital does not differ markedly among most countries, offering the potential for producing a unified, worldwide medical management application. To accomplish this, a worldwide project should separate common and local components (e.g., accounting, insurance claims, etc.) and standardize their interoperability.

With respect to implementation standards, Health Level 7-compliant OSS applications are available throughout the world [**?**]. The openEHR Project has standardized EHR programs according to their unique modeling method and released them under the ISO/EN 13606 standard [21]. The openEHR project gathered together more than 1500 developers and clinicians from 58 countries in December 2009. The openEHR development platform is being adapted to run on Eiffel, Java, Python, and Ruby platforms. OSS and open standard products have improved interoperability of the Internet, and can similarly improve the interoperability of medical systems.

In Japan, the JMA assesses whether or not a vendor has sufficient skill to support ORCA systems. Approved vendors are listed on the JMA website. Before the JMA started vendor authentication, unskilled vendors offered confusing or wrong advice to medical organizations. Implementation of the labeling program has improved vendor service and eliminated unqualified vendors from the medical information systems market. While many medical organizations have ready access to skilled, JMA-listed vendors, some remote medical providers lack access to a support service. OSS vendors typically locate their offices in urban areas for access to many other potential clients. While still unevenly distributed across the country, OSS support vendors are increasing in number. However, the knowledge and skill requirements are quite different than for most software support businesses. For every medical organization to have access to OSS support, Japan should actively cultivate the training of OSS developers. The medical OSS market is mature enough to sustain a large OSS vendor community. The ORCA project is one of the most successful OSS-based EHR projects globally, and its success might suggest actions for other countries to pursue.

OSS is sometimes used for purposes other than those intended by the developers. While the concept of OSS was not developed specifically for use in a clinical medicine environment, it has been adapted to those situations. Similarly, OSS applications developed for the medical field may be used in other fields, as has OpenCOBOL [9] or CGI.pm [22]. OSS should be enriched not only for clinical use but also for use by the entire OSS community, as open human intellectual property.

6 Conclusion

OSS has the potential to improve both clinical operations and the interoperability of medical systems. A number of promising OSS projects in the medical field may benefit medicine and increase human intellectual property.

Table 1. Some medical OSS projects

Project Name	Description	URL
VistA	U.S. Department of Veterans Affairs hospital information system, electronic health record.	http://worldvista.org/
OpenEMR	User friendly Medical Record	http://www.openemr.net/
MicroDicom	Radiology imaging and visualization tool	http://www.microdicom.com/
OpenMRS	Infectious Disease Management for developing country	http://www.opemrs.org/
OpenClinica	Clinical trial management software	http://www.openclinica.org/
ORCA	Information infrastructure for clinics / hospitals for Japan Medical Association	http://orca.med.or.jp
NOA	Electronic Medical Record	http://www.ocean.shinagawa.tokyo.jp/NOA_PROJECT/
OpenDolphin	Electronic medical record	http://www.digital-globe.co.jp/
openEHR	Specification standards for interoperability of clinical information	http://www.openehr.org/
ImageJ	Image processing software for biomedical research	http://rsb.info.nih.gov/ij/
XmedCon	Medical Image conversion toolkit	http://xmedcon.sorceforge.net/

Table 2. Components of JMA standard receipt software

Product Name	Description
PostgreSQL	Relational database management system.
MONTSUQI	Transaction monitor
MONPE	Report printing environment
OpenCOBOL	COBOL compiler
Debian GNU/Linux, Ubuntu Linux	OS environment

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