Open Source Software Solution for Healthcare: The Case of Health Information System in Zanzibar

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Abstract. Through a case study of health information system in Zanzibar, Tanzania, the article discusses adoption of free and open source software (FOSS) through strategic transition from a free Microsoft based application to a full-fledged java based FOSS application. Throughout the article, the adoption challenges and opportunities are discussed. The article contributes to approaches to FOSS adoption. Three areas are identified: the technical capacity of the software surpassing licensing terms, the role of local champions in initiating changes, and the importance of user capacity building prior to project adoption especially for a transitional project.

Keywords: open source software, health information systems, healthcare, integration, capacity building.

1 Introduction

Computer software has become the backbone of human interaction in their activities [1]. However, costs of ownership and freedom to maintain the software have become a major concern [2]. With proprietary software, which is the traditional way of computing, clients are forced to pay high licence costs under strict copyright laws. The strict laws, accompanied with technical procedures to hide the source code, clients are left with no choice of alternative paths. Free and open source software (FOSS) philosophy is a counter approach to computerisation of information systems [3], [4], [5]. In developing countries, especially in the public sector, this is indeed a necessity. The poor countries characterised by high budget deficits cannot afford the expensive software for the automation of their information systems (IS).

This study focuses on the computerisation of public healthcare sector in developing countries. It is part of global efforts to develop health information systems (HIS) in developing countries, known as Health Information System Programme (HISP). HISP has been involved in developing HIS and the use of software data warehouse for HIS automation. Realising the financial situation of the healthcare sector and the need for creating dependable manpower to sustain the HIS, HISP adopted FOSS approach to

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its software products and strategy [6]. The article presents a case study for the HISP project in Zanzibar, Tanzania. The study outlines the implementation of FOSS through strategic transition from a free Microsoft based application that is distributed as open source to a full-fledged FOSS. The paper contributes to approaches to FOSS implementation.

2 Open Source Software for Health and HISP Agenda

While there is an increased awareness on how computers can help to improve healthcare service provision and management, there is also a huge increase on commercial investment for software products to support the sector. FOSS can therefore be an obvious choice in order to serve the larger number of population whose fate remains in the hand of poorly financed healthcare sector of their respective countries [7]. FOSS adaptation has recently seemed to be best alternative in healthcare sector. Many countries have made a considerable shift from proprietary to open source software [7], [8].

FOSS has two major benefits that have attracted this paradigm shift; first, the ability of client organization to have software with lower total cost of ownership, since the organisation will not buy the software, and that the availability of the source code reduces dependency to the business companies. Second, FOSS are believed to catalyse innovation since staff in the client organisation are encouraged to work to improve the software since the code is available and that various open source developer forums exist. [9], [10], [11]. These forums are the primary source of skill sharing among the developers' communities.

Thus, FOSS provides users with option to self support. These benefits give user freedom from 'vendor trap' [3]. Lungo and Kaasbøl [3] discuss a situation in the Tanzanian Ministry of Health where a hard coded software that was developed by a commercial organisation resulted into HIS failure because serious bugs that led to software malfunctioning could not be rectified. This was due to the fact that the licensing terms did not allow for the release of the code.

The HISP project is based on providing support to less resourced countries in the global south by developing and implementing software solution for the public healthcare sector and strengthening information use to facilitate healthcare planning, monitoring and evaluation. From the beginning HISP adopted FOSS approach where a software data warehouse solution called District Health Information Software (DHIS) was developed and distributed freely with code available and free to change [6]. The first version of DHIS, (released as DHIS 1.3 and later DHIS 1.4) was Microsoft Access based. The software development and distribution followed FOSS philosophy, although underneath it used proprietary software at both the database and operating system level. Thus the software was extended and adapted to reflect requirements of specific countries. In India, for example, the local HISP team employed the local capacity to develop a range of add on functionalities related to reporting, presentation, and visualization of data [6].

Despite its wide use, DHIS version 1 had one major setback; the reliance of Microsoft Office locked the departments of health in HISP implementation countries to rely on one operating system and forced the purchase of Office package for all computers. This was an indirect cost to the free software. In turn DHIS version 2 –a java based application which is platform independent was developed. In addition the new version is web based and enhances integration with geographical information systems (GIS). At the database level, DHIS 2 uses PostgreSQL and MySQL, both are free databases systems. A number of countries have shifted from DHIS 1 to DHIS 2, and newly enrolled countries have directly adopted DHIS 2.

3 Research Settings and Methods

This research was conducted in Zanzibar, Tanzania as part of HISP efforts to develop HIS in developing countries. The management of HIS in Zanzibar is shaped by the healthcare administration hierarchy. Data are usually collected and collated into monthly reporting forms at the health facilities that are later sent to the district for entry into the software data warehouse. Data from the districts are transmitted to the higher levels –zonal offices, HMIS Unit and the health programmes. This reporting structure, in principle, gives authority for data quality check and analysis at all levels. There are ten districts (same as political administrative districts) two zones (Unguja and Pemba).

The paper presents a case study for the project implementation from the period of 2008 to April 2011. Data collection is based on first hand experience by both authors who have intensively involved in day to day activities, which involve software configuration and installation, user training, support and supervision, and project planning and management. Thus, data collection is based on qualitative methods mainly participant observations, discussions, and meetings. During all these activities, notes were kept and later analysed. In order to build a deep understanding of the process of FOSS adoption, we adopted interpretive approach guiding both data collection and analysis. Walsham [12] describes the capacity of interpretive approach in understanding social phenomena where the subject attributes meaning to such phenomena.

4 Analysis of HIS Project Implementation in Zanzibar

Efforts to computerise HIS in Zanzibar dates back to 2005 when HISP was assigned the task to develop and implement integrated information system for collecting and processing routine health management data. For the software solution, DHIS 1.4 was adapted and installed for routine use at the district, zonal and national levels as well as the hospitals [13], [14]. For certain reasons, both administrative and technical, the development led to designing two distinct information systems operating in two separate databases, although the guiding principle was that of integration. The first database comprised primary healthcare data mainly from the small health facilities. The system comprised data from general outpatient, immunisation, maternity, and

reproductive and child health. This system was commonly known as district system. The second database comprised hospital data collected from various wards and specialisation clinics of all hospitals, commonly known as hospital system. The two systems share data collected from maternity wards, general outpatient (OPD), Sexually Transmitted Infections (STI), and HIV testing and counselling.

This posed a consistency challenge since data are manually entered into the two systems and when updates are made they are not made in both. The two systems have different database files but share the same application (front-end) making users able to switch different databases from the same computer using the same application. Reports were prepared using built in DHIS custom reports and pivot tables. Pivot tables provided reporting tools with great flexibility where users could adjust the templates to prepare different reports.

4.1 Limitations to DHIS 1.4

DHIS 1.4 faced several constraints that lead to technical and managerial problems. Technically DHIS 1.4 was based on Microsoft Access and runs on Microsoft Windows platform. Although the software customisation is possible, this forced the ministry of health to commit itself to buying license for Microsoft Office. While this was supposed to be the case, the implementation team often ended up using pirates since the computers were already installed with pirate software. With the tendency of using pirates, the implementation team also faced another challenge –the compatibility challenge. DHIS is developed within the HISP network reflecting needs and requirements of several implementation countries. The availability of pirates often resulted into districts and other implementation sites to have higher version of Microsoft Office compared to what a particular DHIS release is optimised for.

For example, when Microsoft released Office 2007, licenses and even pirates were readily available but DHIS releases were developed under Office 2003. This caused several problems leading to DHIS to malfunction. The implementation team had to either roll back to Office 2003, the case of which users were never happy, or keep DHIS malfunction and report to global DHIS developers. For a long period pivot tables that were developed in Excel 2007 could not work in 2003 despite saving in compatibility mode, until DHIS was enhanced for Office 2007. In a nutshell, despite its unprecedented use, DHIS 1.4 lacked version flexibility in relation to Microsoft Office computing –its platform.

Another setback is related to the systems settings. Although working under integration slogan, under DHIS 1.4 two databases were developed and operated as independent information systems sharing only the data entry interface. This was mainly caused by DHIS technical capabilities to integrate the two systems which according to DHIS terms had two different organisational levels. DHIS registered organisation units in levels. Level one as the highest administrative level and the last level as the data collection level where data have to be registered. The hospital system had three levels (ward/clinic, hospital and national) while the district had four levels (health facility, district, zone and national). The software was designed to enter data at one common level only. This could be solved by introducing ‘zone’ dummy level, but

it was opposed by the administration claiming that putting a referral hospital (Mnazi Mmoja) under zonal management is against the set guidelines. In addition, integrating the two systems into one database could result into huge number of data elements, which after data entry for some time; the Microsoft Access database capacity would be surpassed. Thus, developing two systems remained the only choice.

As a consequence, the two systems led to data inconsistencies for those data that are required to be entered into both databases. For example, maternity data for every hospital had to be entered at two places; at the hospital itself (in hospital database) and at district office (for the district database). In the end these data must be similar. However, since updates for missing or incorrect data are usually made, in the end the two data sets representing the same hospital are never the same as updates in one database do not necessarily reflect the other. Different people were involved in data entry for the two systems. During the preparation of annual health information bulletin the two were totally different. The hospital officers had to be called to clarify. This scenario repeated itself every year.

In DHIS 1.4, reporting is done manually, though in electronic form. District officers, after entering the data have to export into txt or xml files that will later be emailed or sent using flash disk to higher levels (zones and HMIS office) which must download and import into their database. Programmes also rely on this procedure where HMIS office will export data and submit to them. This introduced unnecessary delay of the data. While in the past, programmes had direct access to data, the new procedures, while being successful in terms of coverage and capacity to share; were not good in dealing with timeliness. Timeliness was the emerging problem. The unnecessary bureaucracy in reporting caused mistrust from health programmes that contribute them to diverge from mainstream HIS. The HIV/AIDS programme for example, used this as an excuse for diverting from the mainstream HIS.

4.2 Adoption of DHIS 2

DHIS 2 was introduced to overcome the above stated problems and also to exploit the power of web applications as well as prospects of FOSS. The DHIS 2, a java-based software application that has option to use either MySQL or PostgreSQL database systems. In Zanzibar, PostgreSQL was chosen because it is more commonly used in HISP network, hence it has larger user and support base.

The first instance of DHIS 2 in Zanzibar was installed in 2008. The software was introduced by the international HISP consultants to solve the existing problems. The consultants also wanted to use the potentials the Zanzibar context give in order to make real use test of the software which by that time was relatively unstable. These attempts were unsuccessful due to concerns raised by the local HISP and HMIS staff on the capacity to leverage the change of software by the DHIS users. The local team emphasised on building user capacity using the previous software version (DHIS 1.4) focusing on capacity to analyse data and to prepare reports, the task which is very important irrespective of technology in use. Further, the team was not prepared to adopt new technologies by that time, weighing the workload the team already had.

Following evaluation of the project implementation in the beginning of 2010, the local HISP team agreed to upgrade from DHIS 1.4 to DHIS 2. The local team contacted the HISP international team to discuss the trends in DHIS technologies and share experience from countries who has implemented DHIS 2, notably India, which was in advanced stage in both development and use. The developers and implementers workshop that was held in Oslo, Norway in April 2010 was highly productive. A new database was configured and installed in the web server located at the HMIS office. This database deployed the advanced technical capabilities of DHIS 2 that gave opportunity to configure a comprehensive and integrated database that takes data sets from both the district and hospital databases that in the past had to be separately deployed.

The team agreed to pilot the new database for the period of one year. At the beginning, the decision was to select two hospitals and four districts, but later it was agreed to train all data entry staff in order to give time to practice before the official launching, and phasing out the DHIS 1.4. Data entry started in May but it was decided to include the January – April backlog, in order to have a full year coverage. Throughout the whole piloting period, the data entry staff were entering data twice. First, they had to enter data into DHIS 1.4, which was the official data reporting system and later enter the same data into DHIS 2. While this can be seen as a tiring work, the purpose was to expose users to the software in order to give them enough experience, at the same time the technical team (local HISP) used feedback as the way to enhance the software as well as learning user perception to the new technology. The data entry staff were paid for the extra work, this motivated them towards the new software. This was in contrary with the recommendations of international HISP team, which saw the task as redundant and wanted direct data import from DHIS 1.4 to DHIS 2.

4.3 Technological and Organisational Implication of DHIS 2

This section presents impacts of implementing DHIS 2 for the Zanzibar healthcare sector and focus on the advantages the software brought compared to its predecessor as well as challenges encountered.

Advantages. Although it is too early to assess the benefits that DHIS 2 has brought in comparison to its predecessor, initial advantages include:

Seamless integration. Due to technological capacity of DHIS 2, the problems resulting from deploying two systems –the district and hospital systems were solved. The new system comprises of only one database installed at a central server and all data can be easily accessed and shared between programmes and other stakeholders. This has been possible regardless of the differences in the organisational level between the systems because DHIS 2 is designed to allow data entry at different levels. In turn, this will result in improved data consistency since data entry and updates take place in a central server. DHIS 2 also came with new phenomenon of data element category meant to solve the problem of huge number of data elements.

Data element is the atomic unit of data which can routinely be recorded for a particular health facility, e.g. Malaria cases for pregnant women.

DHIS 2 combines several data elements as defined in DHIS 1.4 into only one data element with a matrix of categories. For example, confirmed malaria cases is considered to be one data element with three categories: sex (male or female), age (under 5 or 5 years and above) and attendance status (new or re-attendance). In DHIS 1.4 these were eight data elements, reduced to only one in DHIS 2. This has highly improved the database efficiency due to reduced workload. The data entry form has remained with the same format.

Efficiency in data reporting and feedback. The Web has revolutionised the reporting procedure. The aim here is to reduce the time taken from data entry until the programmes receive data. With the web application data are directly entered into central server and all authenticated users including programmes can directly access the data that they are authorised to access. This will attract those programmes which saw the integrated HIS as barrier to a timely reporting of data. Despite the fact that in 2010 the software was still in piloting stage, the immunisation programme decided to take initiatives to promote the application by deciding to directly shift to DHIS 2. Looking for the champion of change, the local HISP team provides constant support to the programme. The fact that the application is web based and run on one server provides opportunity for feedback to the district staff. Staff at the district can measure performance of their districts in comparison with other districts.

Improved data and information access. The web capacity of DHIS 2 enables data access beyond geographical limitations. The nature of the work of healthcare managers requires them to have frequent travel both within and outside the country. This will, and as the case has been for immunization programme, revolutionise data access and will guarantee data access at all the time regardless of where users are. This is a big success from the DHIS 1.4 which was a standalone system.

Improved information visualisation. One component of epidemiological questions is where diseases or certain health problems occur. Geographical information systems (GIS) add value to answering these types of questions. While DHIS 1.4 had GIS module functioning, the problem was that the underlying technologies were proprietary. In DHIS 2, GIS is embedded and uses a range of software applications ranging from proprietary to free and open source. The use of FOSS application in Zanzibar has made data visualisation easier and cheaper. The immunization programme, for example, has used the GIS to map immunisation coverage, identifying the risk factors, and planning for intervention.

Challenges. Despite the relatively short period of implementation, challenges have been evident. These are discussed below.

Internet speed. Despite a contract with the local Internet Service Provider (ISP) to provide a broadband internet to the ministry of health, the speed of the internet provided has been deteriorating every day posing doubt over the reliability of data. This challenge has been dealt by negotiating with the ISP to provide the reliable

service as agreed, while at the same time making backup solutions. One back up solution is to buy internet modem provided by local telecom operator and in case of severe shortfall staff can always use the services at the HMIS Unit headquarters or HMIS office in Pemba, thanks to the short distances from the offices to the district offices and hospitals.

Technical capacity at the HMIS office. Although DHIS 2 requires less technical support to operate compared to its predecessor, the shortage of skilled information technology personnel at the HMIS offices puts the situation into nearly the same risk. While the centralised database system has an advantage of centralised diagnostic system, hence reducing diagnostic efforts, it also poses a critical challenge when the personnel with that skill (currently one assisted by voluntary local HISP staff) fail to support the infrastructure.

5 Adoption of FOSS for Zanzibar HIS

In this paper software migration process to open source software for Zanzibar HIS has been analysed. We now turn into the discussion over the FOSS adoption as experienced in the project. The project implementation process, challenges and opportunities identified shed light into how FOSS have been perceived and adopted.

5.1 Strategies for Adopting FOSS

From the beginning of project implementation DHIS 1.4 was implemented as open source, though did not meet all the criteria, for example, relying on Microsoft Access and Windows platform. The software enjoyed acceptance by its 'free' marketing banner but more importantly, the capacity of the software in handling the local HIS as well as the human resource base that accompany the software located in the global network of developers, implementers and users. Thus, apart from being free, that is, the ministry was not imposed with license fee, the attractor was also on the technical capability of the software to handle the newly designed HIS and its rich support base –the HISP network.

The process to adopt a full fledged FOSS, DHIS 2 seems to follow the same path. The motivations and arguments built were mainly on the software capability to solve the existing problems as well as a promise to more advanced features. In the study of the same project in Zanzibar, Lungo [15] pointed out the effects the licensing terms has for adoption of FOSS in information systems project. He asserts that, developers undermines the licensing terms because they do not have use incentives. This is in contrast to the conventional FOSS literature [16] which emphasise on license terms as an attractor to FOSS adoption. Additionally, this study reveals that the technical and functional capacity of the software surpassed the licensing attractor. In particular, the adopters were attracted by the software capability to provide seamless integration of the previously independent systems that caused data inconsistency and redundancy, improving reporting efficiency, improved data and information access and the embedded and flexible GIS features.

5.2 The Role of Local Champions in Adopting FOSS

Local champions play important role in FOSS adoption [15]. The first instance of DHIS 2, installed in 2008 by the international HISP consultants did not work. Local HISP and HMIS staff abandoned the efforts because they were not in line with local priorities, despite the fact that DHIS 2 could alleviate the existing problems and offer new potentials. When the local HISP and HMIS staff initiated the move, the international collaboration worked. Thus, the collaborative spirit of FOSS as shown in the HISP project works well when the local champions lead the move.

In this respect, we argue that whatever the potentials FOSS may give, it is very important to study the implementation environment beforehand. This implies that, there is a need to create local FOSS readiness before implementing the solutions. FOSS are built to improve freedom and independence from vendor reliance [3], [9], [11]. However, this freedom shall not be seen as only the freedom to not rely on the vendors but also freedom to choose the right FOSS solution at the right time. This will also help to build the sense of ownership from the beginning. The case presented has demonstrated rich ground for FOSS philosophy with regards to participation. This participation from the early stage championed by the locals is very important for project sustainability. The decision by the local team to delay adoption of DHIS 2 meant to build user capacity on data analysis was intended to build strong ground for the project takeoff.

5.3 Leveraging User Capacity through Hands on Practice

FOSS implementation for information systems project is different from the common infrastructure projects, due to separation between developers/implementers and users [15]. The case presented in this study demonstrates similar findings. In this regard, we argue that the prospective user base for any information systems project like DHIS 2 has to be well prepared before directly adopting the software, especially if it is the case of transition. The study shows that the decision by local HISP to delay adoption of DHIS 2 and put emphasis on developing user capacity for data processing and information visualization was meant to prepare users when transitioning to DHIS 2. Subsequently, this reduced the time to learn and hence develop user confidence on the new software. If the team had adopted DHIS 2 earlier, it would result in extra efforts in training and hence adding to a belief that FOSS are difficult to learn. The one year parallel running of the two software versions helped to develop confidence before a formal takeover.

6 Conclusion

In this article, we have discussed HIS implementation with a focus on adoption of FOSS for the automation of HIS. The case presented outlined the adoption process through strategic transition from a free Microsoft based application (DHIS 1.4) to a full-fledged java based FOSS application (DHIS 2). With the FOSS philosophy and implementation strategy being used in marketing and implementation of DHIS 1.4, the marketing of DHIS 2 was primarily based on its technical capacity rather than the

FOSS rhetoric. Lessons learned contribute to approaches to FOSS adoption. Three areas were identified: the technical capacity of the software surpassing licensing terms, the role of local champions in initiating changes, and importance of user capacity building prior to project adoption especially for a transitional project.

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