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Adaptation of Open Source Software for Healthcare in India: Case of CARE2X

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Abstract: There are numbers of challenges in modern healthcare industry of developing countries such as India. The main challenge for a healthcare organization is to provide quality care using affordable pricing strategy. High quality care incorporates effective treatment and on time care to patients. Information and communication technology can play an important role in improving these services by managing the resources efficiently since they can help in enhancing organizational productivity and performance. Now a days, ICT plays a key role in managing the patient records, information sharing and processing the data to get useful information. A low cost, well managed HMIS can overcome the financial limitations. The emergence of Open Source Software has presented a better opportunity for developing countries. This study aims at investigating the impact of using Open Source Software on the Indian healthcare industry and identifying its potential advantages and disadvantages along with the complexities in its use. Furthermore, it aims at analysing the performance of open source customized HMIS for client hospitals in India. Herein, CARE2X is identified as Open Source Software which is customized for Indian hospitals. CARE2X is one of the most popular open source healthcare systems released under general public license GPL v2.0. CARE2X has been customized and deployed at histology and cytology pathology department of two premiere client hospitals in India.

Key words: e-Healthcare, HMIS, Open Source Software, CARE2X, FOSS

INTRODUCTION

The technological innovation and promotion of the 21st century have changed the way human beings interact. The predecessors of this revolution were the agricultural and industrial revolution. In recent times, microprocessors have been invented by Ford as part of developing a space vehicle which would land on the moon and would return to earth in an efficient and timely manner. There is no doubt that Information Technology (IT) has impacted human life in all aspects and therefore, IT regulations, shareholders and customers have increased significantly over the last two decades. Consequently, businesses have been compelled to adopt IT as part of their corporate and business strategy and have aligned it with their business goals and operations to improve their business performance and productivity. Notable sectors that have implemented and adopted IT include entertainment, aviation, automobile, retail, education, trading, healthcare, banking and communication. As its demand is increasing exponentially, there are lot of scope for new researches and ideas in field of information technology.

In earlier days when IT was in its development phase, proprietary software was the only option for organizations and therefore, all the customers and stakeholders were dictating by some companies and paying high price.

After certain stage, IT reached its mature stage and therefore, IT users and stakeholders started looking for low price and some degree of freedom. Consequently, these new requirements from stakeholders encouraged researchers and developers to look towards another philosophy of software and Open Source Software philosophy came into picture. This new philosophy gave freedom to users that user can use, change and at the same time can access to source code to retrieve it as required usage. Under open source philosophy user is free to redistribute the modified enhanced or unmodified software (Marsan and Pare, 2013). With the rise of internet this term open source is gaining popularity day by day. Now a days, acceptability of open source is so high that some of the most famous proprietary software is getting hard competition. Some of the reasons behind high popularity of OSS are low ownership cost, less issue of software piracy, availability of source code which gives freedom of customizability and scalability and easy online support availability.

The healthcare industry in developing countries like India is undergoing a rapid change. Reports, statistics and figures suggest that its total worth in the year 2020 will be US $280 billion industry (Cognizant 20-20 Insights). Currently, the healthcare market in India is estimated at US $100 billion and it is expected that very soon

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it will reach over US $160 billion by end of 2017 (Golechha, 2015)". Information Technology (IT) has positively impacted healthcare.

Healthcare Information Technology (HIT) or e-Healthcare is based on information technology and electronic communication. It uses IT to improve its services. In the modern age of the computer where the majority of the industries are running by adopting IT, healthcare sector in countries such as India are far behind in terms to IT adoption and implementation. The adoption of information technology can help to enhance the health care sector in an efficient manner.

To overcome the several challenges faced by healthcare, information sharing is very essential. The scope of information sharing in the healthcare sector must be broad and diverse and not limited to hospitals and healthcare institutions. Presently, the goal of the hospitals and organizations is to connect the patient care services (Zakaria *et al*., 2009), patient data and facilities such as clinical laboratories, rehabilitation centres, laboratories, health agencies and healthcare centres.

In order to provide the most cost-effective and best possible care, the majority of the healthcare service providers are making efforts to develop a regional network to support patient data management and patient data sharing. Healthcare IT can significantly improve such networks. However, it should be noted that there are obstacles in employing the IT systems in the healthcare organizations. In recent times, there are only few Indian government hospitals that are located in urban areas have employed electronic medical records which is the fundamental condition for the employment and promotion of information sharing and management in the healthcare sector. EMRs are present and they are stored in software which is protected by the law. In some cases, these formats are not compatible with other formats and therefore, integration is considered to be the main issue in EMR. Integration is needed to efficiently support EMR and information sharing across various networks.

Another factor that is deemed to be an obstacle in the implementation of management of EMRs and HMISs is cost and expense. Providers focus on getting solutions which are economical and not expensive. However, most of the available propriety software are expensive and adds up to the operational costs of the organization. Furthermore, clinicians and physicians need to be trained which adds to the cost. Finally, maintenance and providing support for such networks also adds up to the costs.

The promise of low cost, high revenue and better care has not been achieved even though different health Information Technology (IT) applications and EHRs are getting adopted by some hospitals and physician practices. So, what are the reasons behind the derailment of the revolution of healthcare IT? Why there is so much gap in reality and projections even these projections are just a few years ago? Why the reality so much less inspiring?

Technology is not the answer to the above mentioned questions. The problems exist because of proprietary software and the inadequacies of its business model. It should be noted that this business model has failed to meet the needs and requirements of the healthcare sector in an efficient manner.

A roadmap for healthcare industries to use healthcare IT to truly improvement of care provided and enhancement of improving hospital and healthcare operations and providing excellent care to patients is proffered by open source business model which is the contemporary business model of IT based software. The acceptance of the Open Source Business model is growing very fast after the adoption of Linux, Red Hat, MySQL, JBoss which offer Open Source Software to its clients (Doss, 2014).

Hospital pricing is also very high and therefore, it should be noted that health IT alone won't change it but it can have a significant impact on the pricing. This fact is also well known that most physicians are very less thrilled with their EHR systems. There are something still lagging in current healthcare applications and EHRs.

Currently, the main problem in the propriety software business problems is workability and interoperability. The costs associated with the implementation of IT within the healthcare organizations can exhaust their financial resources.

In terms of economy of the nation such costs can affect it in a negative manner. Propriety software is expensive is not readily available and is complex. Their implementation and maintenance requires expertise of industry leaders. Because of such barriers, the use of information technology in the healthcare sector is considered to be daunting task. In rural part of India, the situation of the hospitals and clinics is same as in the last decade. But now situation is improving in urban India as most of the private hospitals and physicians had implemented EHR systems or some other HMIS.

At the same time, the govt. of India has started giving importance to Open Source Software and working on a long term strategic plan for adaptation of Open Source Software in multiple sectors. Open source solutions for healthcare can be a boon in such developing countries like India because of low entry cost and easy customization of system as per needs of different hospitals and clinics.

This research seeks to bring into perspective the benefits and challenges in adaptation of Open Source Software in developing country like India and presents a description of efforts made to customize the existing open source HIS CARE2X for client hospitals in India. The system has been modified to work according to workflow of the hospital and additional reports, forms have been added to CARE2X.

Open Source Software philosophy, roots and challenges: Open Source Software is based on the concept that it is available to the users without any costs. Furthermore, it is available readily to all users. It is considered to a new concept from healthcare perspective irrespective of the fact that it had been used previously in the software industry. Open Source Software had been developed during the early days of the computer sector. First landmark in the history of Open Source Software development was the creation of Berkeley Software Distribution during the 1970s. Berkeley Software Distribution was released as alternative for UNIX operating system of AT and T. After that the second major achievement in Open Source Software movement came into 1980 and 1990s. During this time, the world wide web along with key network protocols had been developed. They were based on Open Source Software. In the 1990s another major development of open source linux operating system which changed the perspective of market towards Open Source Software. Now, it was accepted that open source process can deliver viable technology. Today, open source projects have grown significantly since it has been adopted by several sectors including health care industry. The Open Source Software is known to be different from tradition type of software in several ways. First, businesses in the open source arena is not derived from licensing, most of their revenues for Open Source Software comes from ancillary products and services. Second, open source projects are introduced by the company. However, they are designed and developed by different group of developers who work independently or are from different organizations. Rapid evolution and innovation of Open Source Software get a high level of external contribution. Third is download of Open Source Software is very easy, evaluation, testing and adaptation of open source is much more quick and swift as compared to traditional software. The download of conventional software is lengthy and is composed of a long cycle. Fourthly, the Open Source Software is onsidered to be flexible and is based on sharing, thus, it is not solely available to a single entity or vendor.

To understand the Open Source Software, it is essential to understand its main characteristics which are discussed as follows.

Software licensing model: Open Source Software has a free license and it is readily available to users. Licenses used have different terms and conditions.

Political philosophy: The philosophy of the Open Source Software is the product is available at free of cost and the source code can be changed, altered and modified according to the user's requirements. Furthermore, after modification, the user can distribute the product. However, it should be noted that the Open Source Software is not always available freely. Some of the software is on sale but the code is available with it.

Software development model: The Open Source Software development process requires the collaboration and cooperation of individuals who have similar interests. The collaborative approach is used by developers and is similar to that of medical industry.

New business model: The Open Source Software has successfully created support services, product modifications offers and consulting services which is the new business model.

Feedback: The feedback of the end user in the open source product is important to identify user needs and requirements. Depending on the type of user, the product can be modified and enhanced.

MATERIALS AND METHODS

How OSS is different from other software? The analysis of literature suggests that Open Source Software is significantly different from other types of software since it is freely available and can be distributed by the end user without facing any issues. Although, the creator of the software has the copyright of the product, the license of the product allows end users to distribute or modify it accordingly. The user can freely distribute the product with or without modifications (Pankaja and Raj, 2013). The difference between OSS and other software can be explained with following points.

In term of creation: Open Source Software is developed by the developers who are small part of the software industry and are committed to develop IT Software. Although, they are not directly given rewards for their products, these are used by organizations. It should be noted that the healthcare software project leaders are the individuals, who have introduced the project in the first place. One such example is of David Forslund who is the developer and founder of the openemed project. His

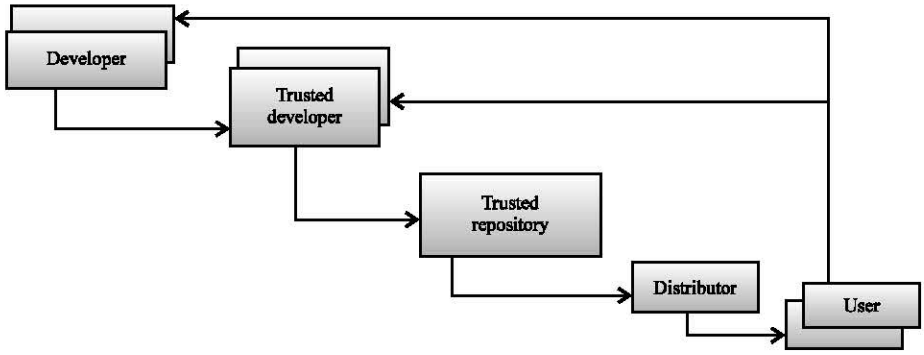

Fig. 1: Open Source Software development basic model

responsibilities include reviewing the product development and promoting developers to develop the program while reviewing them simultaneously. The procedure that involves the review of the work done by the contributors and recognizing their endeavours and elevating their privileges is defined as meritocracy. The product could be designed by the senior. The development of the product is dependent on the resources which are available to the developers. Confidentiality agreements are signed between the programmers and the employer. The employer would own the end product which would be programmed by the programmer. If the programmer leaves the job, he/she won't have the copyright of the code since the employer owns it. Software development also requires testing. In the open source community, the testing of the software is done by testing work of other developers. The advantage of the Open Source Software is that it is readily available and can be downloaded by any user.

Thus, any individual can test it and use it to identify its strengths and weaknesses and can report its bugs or offer fixes. In the healthcare domain, the testing of the software is dependent on several individuals including programmers, physicians, administrative personnel and consumers. In this way, users can report the bugs found in the software and can report them to the developer. It should be noted that the testing of the software can be done by a separate quality assurance group or by the developers themselves.

In some cases, the company makes the beta versions of the product which is only available to few parties. The version is not shared by new customers but with old customers and developers and secured by non-disclosure agreements. Empirical research suggests that this approach can significantly identify errors or problems earlier as compared to propriety software development phase (Fig. 1).

In the term of distribution of Open Source Software: A fundamental difference between the open source and traditional software is the way they are distributed. The former is readily available and therefore, it can be downloaded from different websites. The latter is available to users by sole vendors which can be purchased by them. In case of traditional software, the suppliers have the power to distribute it. However, in case of open software, this is not the case since it is available widely on different websites for download. Organizations can efficiently access them and get the software from these websites. In certain cases, upgrades are available at a fee. The benefit of using Open Source Software for organizations is that its costs of implementation and operating are relatively lower as compared to using conventional software. Furthermore, Open Source Software do not have infringement or copyright issues and therefore, users and organizations can use it without the need to pay any money. Open Source Software projects such as CARE2X.org, OpenHRE.org and OpenEMed.org are popularly used by healthcare organizations. Another type of open source project initiated is known as SourceForge.net which is started by third party.

In term of licencing: Much more freedom comes with open source licensing as compared to the commercial licensing. The Propriety Software has commercial license and therefore, it has several restrictions. Users cannot copy and redistribute, it since the product is solely owned by the vendor. In case of healthcare organizations, this is considered to be a major drawback since the application is needed to be implemented at all levels of the organization. On the other hand, open source licenses encourage users to download and redistribute it without facing any lawsuits or copy right violations.

Table 1: Pricing comparison of popular data bases

Database systems	Licence metric ($)	Licence fee ($)	Yearly per metric ($)	Licence per server ($)	Yearly support ($)	Total 3 years cost ($)
Oracle database enterprise edition	2 Cores	47,500	10,450	285,000	62,700	473,100
MySQL enterprise edition	Server	N/A	5,000	N/A	5,000	15,000
Enterprise DB postgres plus advanced server	Socket	N/A	6,900	N/A	13,800	41,400

Industry's adaptation of Open Source Software: Traditional software vendors have experienced tough competition from the Open Source Software sector because they are available in binary form and OSS have open source code which can modified or changed according to customer needs and requirements. In recent times organizations such as jboss and red hat have promoted the open source products and services business model. Consequently, open source products have gained popularity across various business sectors.

Software vendors have strongly and readily accepted the open source model. However, critics assert that this model can threaten the IT sector. In case of healthcare, open source business model is considered to be an ideal approach which can help healthcare organizations to manage patient data and share it across various healthcare organizations to improve quality of care. In recent times, Open Source Software vendors are developing healthcare products such as healthcare information management systems, EMRs and patient data and healthcare management software.

There is no doubt that companies have become aware of open source model and have realized its significance and potential benefits. Proprietary organizations have acknowledged the significance of Open Source Software business and have adopted open source business model to a certain extent. Companies such as Microsoft offers open source software to selected customers through shared source program (Hauge *et al*., 2010). Users can view the source of the products which are visible.

Open source communities such as MySQL and JBoss are responsible for controlling the development and coding of the products which have been developed by them. These types of software's source code are available and the type of license used is open sourced license. Commercial licenses are also available and offered by these companies to their customers, based on their needs and requirements. Commercial licensed products have better features as compared to the open source version. However, it should be noted that the success of the proprietary software depends on the willingness of the customers to purchase the better version and support provided. Table 1 shows the pricing comparison between proprietary database oracle enterprise edition and open source databases like MySQL and Postgres.

A public company by the name of Red Hat provides open source operating system Linux. The open source model has proven to be beneficial for the companies. Suppliers of computers such as Dell, IBM, Apple and Hewlett Packard are known to be the main players of the healthcare sector since they are the main providers of computer systems across healthcare centres, hospitals, clinics and laboratories. The majority of the systems are compatible with Linux. However, the extent of using open source varies. For instances, Dell has limited support for Linux, Apache, JBoss Application Server and MySQL database. IBM and Hewlett Packard, on the other hand, have their own software and therefore, do not use Open Source Software since it can threaten their business performance. However, both are compatible with Linux. Open source applications have been designed for different sectors. However, applications such as enterprise resource planning and customer relationship management can be used in the healthcare sector in an efficient manner. However, it should be noted that the healthcare industry has not incorporated IT as its main priority and still lags behind other industries.

Open Source Software current scenario in India: If we see the international scenario of adaptation of Open Source Software, OSS support service providers have completely revolutionized the IT sector and have changed the business models. Linux Foundation and Yeoman Technology Group collaborated for a joint research in the year 2013 and came to the conclusion that Linux Operating System usage has increased by 73% because of big data and cloud networking. Similar surveys have been conducted by other organization. In the year 2013, Netcraft conducted a survey and came to the conclusion that the share of Apache and Nginx webservers was estimated to be 65%. A gartner survey conducted in the year 2012 suggested that the market share of Android operating system is more than 40%. OSS is also commonly used in the entertainment industry for animations such as weta digital, pixal and dreamworks.

A 2013 Survey (Goldman Sachs, IDC) demonstrated that Google's Android-Linux platform has >40% market share as compared to other computing platforms. Gartner predicted that by 2014, the platform will be used by more than one billion users and by 2017; the usage of Android devices will increase significantly as compared to other platforms.

Table 2: Open source initiatives taken by some states of India (MCIT, GOI)

States	OSS initiatives
Kerala	In Kerala, the state government has adopted OSS in the IT and e-Governance sector
Tamil Nadu	Tamil Nadu is in the phase of adopting OSS. The government of Tamil Nadu have adopted OSS for different purposes such as management of pension for retired individuals, registration of properties, land recovery management and office file management. Furthermore, ORCA has been developed to assist individuals, who cannot see
Uttaranchal	State of Uttaranchal has adopted OSS for e-Governance and IT education in the state. It has collaborated with IBM which is considered to be the first project of its kind since it is the first e-Governance Project in India that has been implemented by IBM
Assam	Assam government has devised OSS policy to implement it across various government agencies and departments. Furthermore, OSS training has been started for educational institutes
West Bengal	The IT Department of West Bengal Government has adopted OSS to adopt e-Governance, using Linux platform. The regional network comprises of 277 panchayats who are located at the Burdwan district

For countries such as India, the OSS can offer several benefits. Many endeavours have been taken by the govt. of India to promote OSS nation-wide. OSS has been used for many e-Governance projects with the collaboration of public agencies such as NIC and CDAC. OSS adoption can have positive influence in India. It is considered to be an ideal IT solution since it is cost effectiveness, can be modified and changed according to user requirement, improving the efficiency of different organization, etc. OSS model benefits also include generation of employment opportunities for the locals, improving economic conditions for the local industry and reducing piracy. The e-Subshrut lite and Bahmni are some of the well-known Open Source Software developed in India for healthcare. But the reach of these applications are very limited. Very few hospitals are using these systems. Different states of India are taking initiatives to adopt opens source software. States like Kerala and Tamil Nadu are leaders in adopting the open source initiatives in India. Table 2 shows some of the initiatives taken by different states of India.

RESULTS AND DISCUSSION

Open Source Software a better alternative for healthcare in India: The analysis of literature suggests that Open Source Software is readily available and is easy to use which makes it an attractive option for the healthcare organizations. OSS are found at websites from where these software can be easily downloaded.

Users who download the software do not face any lawsuits if they distribute or modify the software according to their needs and requirements. Furthermore, they are not required to pay the license fee which the users have to pay if they purchase a propriety software. Furthermore, hospitals or payers can fully use the software and integrate it within the organization without the need of additional costs and resources. Programmers can effectively modify the source code because it is visible and therefore, issues and problems can be identified to make the desired changes. In open source projects, the participants of the community are connected to one another and have mutual aim. Their primary goal is to develop software which is readily available to all users.

The cost of the software development in case of Open Source Software is achieved by providing support which because of the supply and demand. The main advantage of the Open Source Software is that it has multiple vendors, thus, reducing the dependency on single vendor which is evident in the case of propriety software. Users can efficient get the software from any source. The most significant benefit of open source is that has low cost, it is flexible and allows users to modify according to their requirements. However, the less dependency on the single vendor makes it ideal for healthcare organizations. It should be noted that the development of software in the next 10 years for the healthcare sector would require sophisticated and developed applications along with infrastructure which would promote EMRs in an efficient manner and would help in ensuring that it can be shared among health information networks at regional and national levels. Thus, vendor-neutral open source platform is considered to be an ideal option for improving healthcare organization efficiency while at the same time, reducing operational costs and providing high quality, economical medical care to patients and providing them patient oriented care. Empirical research suggests that only 15% of the physicians have employed EMRs at large level (Nambisan, 2014). In case of sharing of records, the national network is required to achieve this but this is in the development phase. The major milestone that can be done in this case is the establishment of National Health Information by the Office of National Coordinator for Healthcare Information Technology Office. Although, critics are against the use of information technology in healthcare sector, studies suggest that healthcare and ITC aligned can help in improving the efficiency of the sector and can improve quality of care provided to

patients. Research suggests that the implementation of national electronic healthcare information exchange systems with their supporting IT applications and infrastructure can efficiently save $77.8 billion. However, implementation of such networks would require investment of $156 billion in the next 5 years. Now, let's discuss why Open Source Software is ideal for healthcare sector. The process of providing healthcare to patients is based on cooperation and collaboration among physicians, nurses and administrative personnel. Using propriety software is not beneficial in the healthcare sector because of its inability to improve the operations of the organization in efficient and timely manner. It is expensive and time consuming process and clinical transformation requires joint efforts. If we talk about security concern if source code availability creating some risk for security threats on other hand it is giving freedom to user to implement strong security feature by modifying the source code. This feature is not available with proprietary software as it comes in black box. Open Source Software is having potential to address the all major barriers of adaptation of IT in healthcare.

One of the major advantages of Open Source Software is low cost. If we take the example of some hospitals using Open Source Software like CARE2X and OpenVista generally it cost 60-70% less cost as compare to other proprietary software (Amrollahi *et al*., 2014). Same time open source solutions successfully address the other major barriers like interoperability and adaptation. The mirth project is one of the pioneer examples of how open source eliminates the interoperability challenges (Bortis, 2008).

Major barriers in adaptation of Open Source Software in healthcare: Smaller healthcare organizations such as clinics, hospitals and healthcare centres do not participate in the development of the software. They recruit consultants or programmers who are in charge of developing or modifying the software. The security of the Open Source Software is considered to be a major issue. Some organizations have shied away from Open Source Software because of perceived security concerns and threats. The transparent nature of Open Source Software provides hackers the ability to view source code in an attempt to identify potential vulnerabilities. If properly maintained, drupal and wordpress are inherently no less secure than closed products but they do require ongoing maintenance to keep them secure. Open Source Software must be updated in order to prevent defacement, data loss and unauthorized access. Updating of plugins and modules should be done under definitive plan by organizations.

Some of the open source solutions like Drupal and WordPress and CARE2X offer several security features and capabilities such as login history, audit trails, version control, CAPTCHA validation and SSL certificate compatibility as well as LDAP, Kerberos and NTLM authentication.

Case of CARE2X Customization for Indian Client Hospitals: CARE2X has been customized for the requirement of Indian hospitals workflow. This customized CARE2X is deployed at two client hospitals and they are using it successfully. CARE2X is considered to be the open source environment which is based on Integrated Healthcare Environment (IHE) under GNU/GPL. In May 2002, the project had been started by releasing its beta version for the first time after a nurse showed dissatisfaction with the HIS. Since then, its development team has grown. The team comprises of 100 members from 20 different countries. The program is available to the users along with its source code. CARE2X HIS is based on different OSS such as Apache Webserver, MySQL's relational database management system and PHP script language.

CARE2X has for core components which operate at individual level. The components identified are: HIS-Hospital/Health service Information System, PM-Practice (GP) Management, CDS-Central Data Server, HXP-Health Xchange Protocol. CARE2X is high quality interface which has potential to configure completely for any clinical settings. It has been created by using different modules such as pharmacy, radiology, nursing, administration, in patient administration, etc. If a hospital is using network of different programs in its different departments there will be problem of non-compatibility with each other. CARE2X HIS resolves this issue since it has flexibility to integrate different networks, services and systems which are present in the healthcare organization.

Since, CARE2X HIS is based on SQL database to retrieve and store data, this reduces data redundancy, a major problem faced by hospitals with multiple applications. Based on this feature, it has also the ability to provide maintenance and security. Since, it is based on a web-based interface, it can be accessed through a simple browser.

CARE2X architecture: As MVC architecture is used for the system development, it is easy to maintain quality and business requirements for the user. HTML, JavaScript and CSS have been used to implement presentation tier, PHP to implement middle tier and MySQL to implement database layer. CARE2X architecture is shown in Fig. 2.

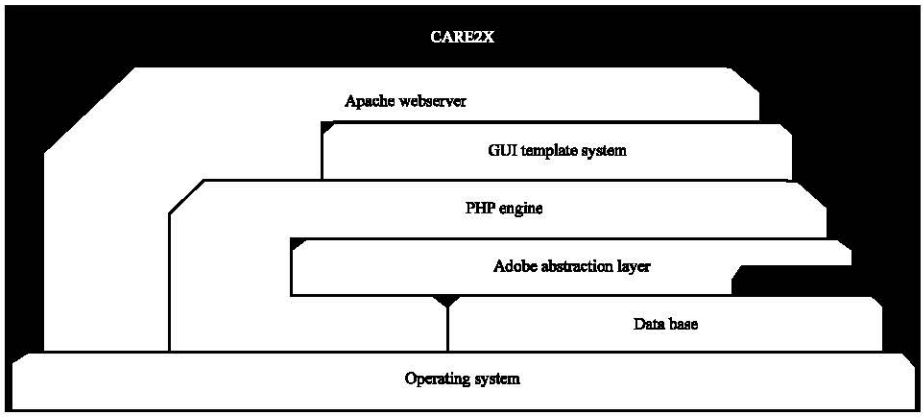

Fig. 2: MVC based CARE2X architecture (CARE2X.org)

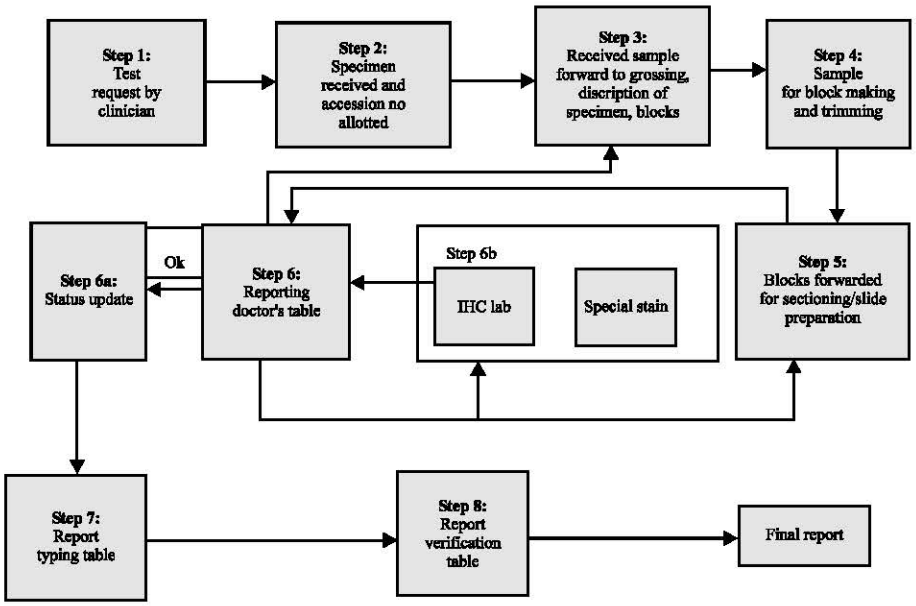

Fig. 3: Workflow of histology pathology

Requirements and workflow of pathology of client hospital: The main requirement of Pathology of client hospital (Urgent Care Hospital, New Delhi) is a low cost Pathology information management system which can cover the complete workflow of Lab and provide advance features like automatic accession key generation, sample tracking, interesting report management, disposal management, advance record search, role base authorization for security purpose. Approximately 100 people are using system at different levels for entering details of test conducted, report generation, tracking of samples, updating status and report search. There are two types of pathology in client hospital first one is Histology and second one is Cytology. Each pathology lab is divided into different labs like Grossing lab, block making lab, sectioning lab, IHC lab, special stain lab and reporting lab, etc. It can describe different steps of workflow of cytology lab.

Workflow of Cytology lab

Step 1: Clinician generates test request (Fig. 3). Test request form contains clinical diagnosis, name and nature of fluids; specimen collected date and collected by system automatically generates accession key according to name of fluids. And then, sample goes to be process.

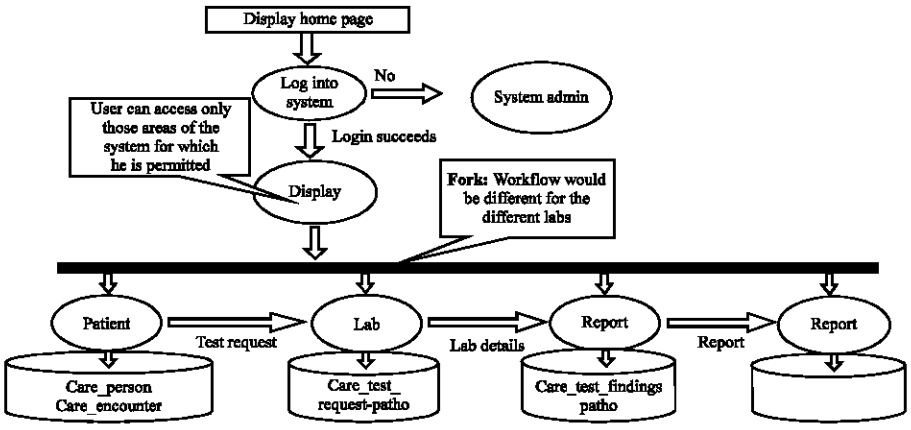

Fig. 4: DFD of customized pathology module of CAREX

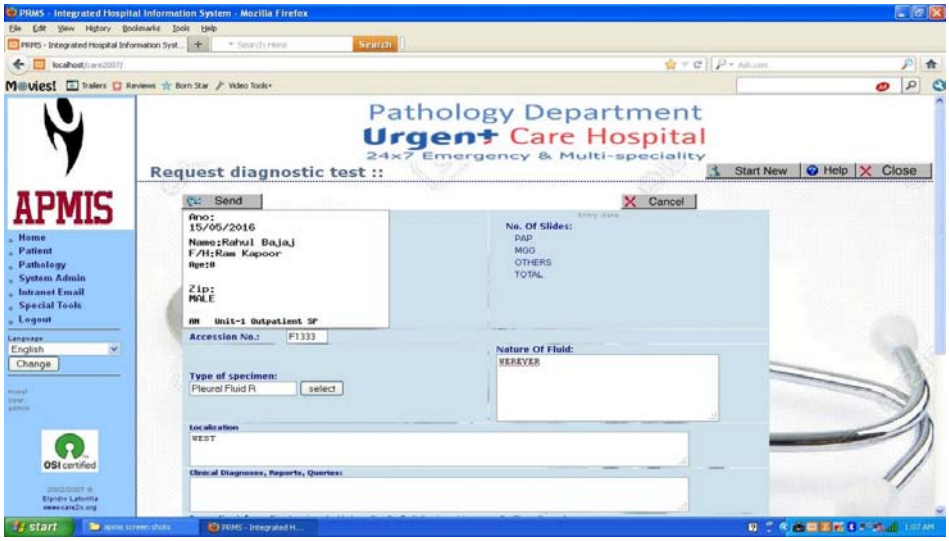

Fig. 5: Requesting a test in customized CARE2X

Step 2: Types and number of slides decided on processing table and then it forwarded to reporting table.

Step 3: On report generation table report can be generated. Otherwise it can be send back to special Stain lab, IHC lab, Stain all lab.

Step 4: After applying different type of special stains, IHC sample goes back to reporting table. Figure 3 shows the work flow of histology pathology of client hospital. Initially, pathology module of CARE2X was just with two forms one for test request and other for results entry. Once patient get discharge it was not possible to search his/her report. Now, it has been customized as a complete pathology information management system which covers the complete workflow of histopathology and cytopathology of client hospital with desired advance features. Figure 4 shows DFD of customized CARE2X pathology module.

The advance features of customized CARE2X includes sample tracking, view records of each labs, summary of each labs, advance reporting table with decision support, role based authentication for security, disposable management and interesting report management. Figure 5 shows to request for a specific test from a specific pathology in customized CARE2X environment at a client hospital. Figure 6 explains how a physician can use online evidences as a decision support tool at the time of reporting in customized CARE2X.

Fig. 6: Using cochrane library for decision support at time of reporting

CONCLUSION

Open Source Software is very useful for developing countries such as India since it is a low cost alternative for proprietary software. The benefits and challenges in adopting Open Source Software has been discussed. CARE2X is one of the most acceptable integral healthcare environments. CAREX has been customized to provide a low cost healthcare solution for a client hospital in India.

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