SURVEY OF OPEN SOURCE HEALTH INFORMATION SYSTEMS

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ABSTRACT

Due to the Health Information Technology for Economic and Clinical Health Act (HITECH), the US medical industry has been given a directive to transition to electronic health records. Electronic Health Records will enhance efficiency and quality of patient care. In this paper, open-source health information systems are surveyed.These systems include electronic medical records, electronic health records and personal health record systems. Their functionality, implementation technologies used, and security features are discussed.

KEYWORDS

Electronic Health Records, Health information systems, Electronic medical records, Personal health records

1. INTRODUCTION

In 2009, President Obama signed into law, the American Recovery and Reinvestment Act (ARRA). This was a $787 billion stimulus package that was designed to create new jobs while saving existing ones and to spur economic activity. Within the stimulus package was the HITECH (Health Information Technology for Economic and Clinical Health) Act. It was designed to meet the goal made by President Obama to computerize all of America's medical records by 2014. According to the president, this will improve the quality of our health care while lowering its costs. It will also cut waste, eliminate red tape, and reduce the need to repeat expensive medical tests. Though it just won't save billions of dollars and thousands of jobs, it will save lives by reducing the deadly but preventable medical errors that pervade our health care system[1]."

Electronic health records (EHR) can be defined as a longitudinal collection of electronic health information about individual patients and populations [2]. It includes such data as contact information, medical history and insurance information, family history, records of hospitalizations, list of medications taken or currently prescribed, and allergies which can all be shared with various hospitals or doctors' offices if necessary. Because EHRs are designed to make it easier to share and use a patient's health care record, it will be easier for providers to be better at managing a patient's care. Furthermore, benefits of EHR systems that have been identified include reducing medical errors, improving quality of care, conserving physician time, sharing patient information among healthcare practitioners, and workflow efficiency [3].

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Health Information Systems are systems for the collection and processing of data from various sources, and using the information for policy making and management of health services. Health information systems can be categorized into three different groups—electronic medical records, electronic health records, and personal health records. Currently, there are many types of open source health information systems in use. Open source health information systems give many health care providers the opportunity to use electronic health records without having to incur large costs. Also, they are able to make modifications to the software in order to suit their needs. An electronic medical record is an electronic record of a patient's health information that can be created, gathered, and managed by doctors and their staff within one healthcare organization whereas an electronic health record is an electronic record of a patient's health information that adheres to national standards. It can also be created and managed by doctors and their staff across more than one health care organization.A personal health record is an electronic record of an individual's health information that, in similarity with the electronic health record has to conform to national standards but is controlled by that individual [4]. In this paper,some existing open source health information systems will be surveyed and analyzed in terms of their functionality, implementation technology used and also whether or not they have security features in place which would satisfy the HIPAA security rule.

2.ELECTRONIC MEDICAL RECORDS

In this section, six electronic medical records will be discussed.

2.1 ClearHealth

ClearHealth was developed in 2003 by David Ulhman. It is a web-based open-source practice management and electronic medical records (EMR) system written in the PHP programming language. Its design is basedon VISTA (Veterans Health Information Systems and Technology Architecture) which is the Department of Veterans affairs Health Information Technology (IT) system.

ClearHealth offers three products with the base product being the only open source product offered. It is intended for individuals and small practices to set up by themselves. The base product uses the same codebase as all the other options that are available but it is set up with different configuration options. The software from ClearHealth is offered under the GNU GPL (General Public License). The features of ClearHealth include Electronic Medical Records (EMR), medical billing, medical accounts receivable, scheduling, and access control functions.

ClearHealth was designed with HIPAA compliant security features in place. The security was implemented using the PHPGacl (PHP General Access Control Lists) toolkit[5]. The PHPGacl is a PHP based access control list script that allows powerful permission to be added to software applications. Through the use of the toolkit role based access control can be implemented. Some security features include the fact that the admin section will often not be displayed. The admin section allows you to configure it so that it can be customized to meet the needs of your office or practice. Also each user, once created in ClearHealth, is assigned a security role. The roles determine what menu or sections that particular user has access to. There is also a timer which allows for automatic logoff which is also a security feature[6].

2.2 Caisis

Caisis is a web-based cancer data management system that was designed to bridge the gap between research and clinical practice (FAQ). It is an open source system which is primarily used by researchers as a tool to manage their patient data. Its functionality allows for the integration of customized electronic medical records.The project began in 2002 to serve as a replacement for an outdated research database at Memorial Sloan-Kettering Cancer Center (MSKCC). As the number of people using the database and the requirements needed expanded, a search was held to find a commercially available database that would meet their requirements. Since a number of systems were reviewed and none could meet some of their most basic requirements: cost effectiveness in terms of both ownership and maintenance, straightforward administration by a small group, and the flexibility and expandability to meet the evolving needs of a fast-paced, research oriented hospital, a team from the hospital was created and became in charge of developing the open source system[7]. Today, the system is free to download and install under the GPL.

Caisis is currently in use by institutions throughout various countries. Countries include Canada, United States, Brazil, Spain, Norway, Saudi Arabia, India, and Sweden. In order to have a successful installation, Caisis requires that the web server that will host the software have Windows Server 2000 and above, Internet Information Service 6 and above, and Microsoft .NET Framework 3.5/4.0. The database requires a Microsoft SQL server 2008++. Since Caisis is web-based it can be ran on Internet Explorer 7+, Firefox, Safari 3+, and Chrome 12+.

The Caisis security system strictly adheres to the guidelines set forth by HIPAA. Steps have been taken to limit unauthorized access to patient data or other security and confidentiality breaches. Once logged into the system, users can prevent unapproved access to entire sections of data [8].

2.3 OpenMRS

OpenMRS (Open Medical Record System), an open source medical record system platform was created in 2004 by Regenstrief Institute and Partners in Health. It is a software platform used by many countries around the world such as South Africa, Kenya, Rwanda, Lesotho, Zimbabwe, Mozambique, Uganda, Tanzania, Haiti, India, China, United States, Pakistan, and the Philippines. It was designed to be used for any individuals who need to establish a medical record system. Currently, there is only a portal for medical providers but the developers of OpenMRS are working to establish a personally controlled health record portal that will allow individuals to be in charge of their personal health record. It would be owned and available to be managed by the patient.

OpenMRS is programmed in Java and the core application works through a web-browser. It can run on UNIX, Microsoft and Mac operating systems platforms [9]. An added benefit of OpenMRS is that, the medical records system can be customized without having a vast programming background. A conceptual database structure is the basis of the system but is not dependent on the actual types of medical information required to be collected or on particular data collection forms, so it can be customized for different uses [10]. Information that is stored in OpenMRS is easy to summarize and analyze. It has the ability to store all diagnosis, tests, procedures, drugs and other general questions and potential answers. Since it is a client-server application, it can work in an environment where multipleclient computers are used to access the same information on a server[10].

Several layers contribute to the design of OpenMRS. They include the data model, the application programming interface (API), and the web application. The data model borrows form the Regenstrief model, which is based on a concept dictionary [11]. The API's design, which provides a "wrapper" around the data model, allows any developer to invoke method calls without having to understand the details of the data model. Web front-ends and modules that extend the core functions are included in the web application. An example of a module whose core function can be extended is the usage statistics module. It can be used to keep track of the usage of patient records by OpenMRS users[12].

Features of OpenMRS include the central concept dictionary, security, privilege-based access and a patient repository. The central concept dictionary provides definitions of all data thatare defined in a centralized dictionary. The security features of the application are based on user authentication. User roles and permission systems are based on what privileges a user is given access to. The patient repository allows for the creation and maintenance of patient data which includes the demographics of each patient, encounter data, and orders.

According to[9],OpenMRS provides the ability to create a super user role that is all-powerful leaving it vulnerable to an insider threat. A user with the administrator role can create any number of permissions and roles. Roles can be comprised of any number of permissions and built up from other defined roles. According to [11], some vulnerabilities were found within OpenMRS. Using the free edition of the tool, Acunetix, 22 alerts for cross-site scripting vulnerabilities were found. Other vulnerabilities found include J2EE Misconfiguration, and system information leak.

2.4 VistA

VistA (Veterans Health Information Systems and Technology Architecture) is the US Department of Veteran Affairs Health Electronic Health Record System. It was introduced in 1996 by the Chief Information Office to serve as an electronic health record for the VA[13]. It is built on a client-server architecture, which ties together workstations and personal computers with graphical user interfaces at Veterans Health Administration (VHA) facilities, as well as software developed by local medical facility staff. VistA also includes the links that allow commercial off-the-shelf software and products to be used with existing and future technologies. The VistA software is available to the public under a law called the Freedom of Information Act (FOIA).

Two main components, VA FileMan and Kernel make up the primary infrastructure of VistA. VA FileMan is a database management system that organizes the medical data, storing it in fields, records and files [14]. The Kernel provides the portability layer on top of the operating system, as well as management tools and shared services such as sign-on and security service, menu management, and error processing [14]. The structure of the VistA system enablesit to be integrated on a database level and all data between applications can be consistently shared.

2.5 WorldVistA

WorldVistA is an open source, GPL licensed, electronic record that is based on the VistA system, used by the US Department of Veterans Affairs (VA). It was established to further improve, through collaboration, the VistA electronic health record system. Byestablishing WorldVistA, thecreators wanted it to benefit patients throughout the U.S., not just the patients of the VA system.

The WorldVistA system usesthe same architecture as VistA. Even though they share the same architecture, there have been some changes to the WorldVistA system. One such change was the addition of pediatric and obstetric functionality. This feature utilizes pediatric growth charts that also use open source software called PHP Growth Charts. WorldVistA was also designed with a wide array of modules. They include patient registration and management, order entry with reporting, a documentation library, and supplies/assets management.

2.6 OSCAR

OSCAR (Open Source Clinical Application Resource) is an open source electronic medical record software programthat was designed by doctors and is licensed under the General Public License. Its features include full billing capabilities, chronic disease management tools, and prescription features. You have the option of running OSCAR locally in an office setting or it can be reached using the internet. Since OSCAR is web-based it can run on any Windows, Linux, or Mac operating system. OSCAR also has a personal health record, called MyOSCAR which enables patient to have access to and manage their health records. They can also communicate with doctors, make requests for copies of their lab results, manage prescription renewals, and request or cancel appointments.

OSCAR is primarily written in JavaServer Pages (JSP) and served via the Apache Tomcat servlet container. The backend storage is a MySQL database, and the interface layer between Java and MySQL is Hibernate [15]. As a Tomcat web application, OSCAR generally follows the typical model-view-controller design pattern. This means that the model code (Data Access Objects, or DAOs) is separate from the controller code (servlets) and those are separated from the views (Java Server Pages, or JSPs) [15].

Transport layer security is used by OSCAR to encrypt the information flowing between the server and the browsers/clients or workstations connected to it[16]. When the communication is encrypted between the server and the workstations, the users are protected against those who would like to listen in on this communication. It is the same technology used by banks to secure their online banking sessions. To secure the workstation itself, OSCAR requires a double password in order for users to log in. The user sets up one password, while the other is set by the administrator of the OSCAR system.

3. ELECTRONIC HEALTH RECORDS

In this section two examples of electronic health records will be discussed. They are OpenEMR and Tolven.

3.1 OpenEMR

OpenEMR is an electronic health records and medical practice management application that can run on Windows, Linux, Mac OS X, as well as many other platforms. It was started in 1998 by a group of friends who wanted to create an EMR system for a friend’s mother who was a physician. They thought they could give the software away for free and charge for support. Initially, they decided to call it Medical Practice Professional. Eventually the name of the project became OpenEMR and a company named Synitech was formed around it. Synitech continued developing OpenEMR until version 2.0. In 2001 Synitech, turned the OpenEMR project development and leadership over to Walt Pennington and Penn Firm in San Diego, California. Once the developers decided to pursue other interests, the source files of OpenEMR were transferred to SourceForge. In 2011, OpenEMR was deemed Meaningful Use Certified for use in the United States by ICSA (International Computer Security Association) Labs which is an Independent Division of Verizon Business [17]. OpenEMR is now licensed under the General Public License (GPL), and can be considered a valid open source alternative for electronic health records and practice management software.

Features of OpenEMR include patient demographics and scheduling, electronic medical records, medical billing, and security. OpenEMR allows information such as the name, date of birth, sex, and primary provider to be tracked for each patient. These demographics help to distinguish each patient from the next as a form of identification. The patient scheduling feature of OpenEMR allows for a patient's scheduling data, as well as their patient and physician data to be shared among different practices and facilities. This feature also provides patients with notifications about their appointments through email and sms text messages. Electronic medical records provide an electronic record of a patient's medical history. Through the use of this feature a patient's medical history can be stored, retrieved and modified. OpenEMR, through its medical billing feature, support paper claims, insurance eligibility queries, insurance tracking, and accounts receivable. It is customizable to work with a clearing house using Electronic Remittance Advice (ERA), or HIPAA 835, an electronic transaction which provides claim payment information in the HIPAA mandated ACSX12 005010X221A format [17]. The ability to encrypt medical documents is part of the security features of OpenEMR. This is achieved through the use of the PHP mcrypt library [18]. Another feature of OpenEMR is its support of fine-grained per-user access controls which allows you to specify what each user has access to. Also the software can be remotely accessed from any web browser that has a valid security certificate installed. Furthermore, OpenEMR allows multi-language support which enables it to be used by different countries throughout the world. It supports languages such as Arabic, Chinese, Portuguese, Russian, Turkish, Ukrainian, and Vietnamese.Two choices are available if you want to include a patient portal within your version of OpenEMR. One option is a patient portal that is built within OpenEMR. The other option is to use a portal that was designed by a third party. It uses a set of application programming interfaces that are included within OpenEMR.

Even though OpenEMR is a great example of open source practice management software, it still is subject to vulnerabilities. Through the use of a source code analysis tool, Fortify 360 v5, and IBM Rational Appscan v7.8 scripting vulnerabilities as well as implementation flaws were found [17]. Some of the authentication vulnerabilities in OpenEMR 4.1.1 are reported in [18]. For example, there is no forgotten password function to help users recover their passwords if they forgot it. The only way they will be able to access the account is for the user to call the administrator for a new password. It does not have an account lockout after a certain number of failed attempts.This feature can prevent hackers from attempting to guess user passwords [18].

3.2 Tolven

Tolven is an open source electronic record that utilizes the GNU-LPGL license. It is web-based and the Web browser is its primary tool for user interaction. The installation of Tolven is composed of three components. It is made up of a database, LDAP (Lightweight Directory Access Protocol) server, and the Tolven application server. PostgreSQL is the database used by Tolven which is also an open source product; the LDAP server is what Tolven users to hold identifying and demographical information about the user. The application server uses the LDAP server to authenticate users. Tolven is equipped with two user interfaces. The eCHR, electronic clinical health record is for physicians and other healthcare providers. It allows them to securely access healthcare information relating to an individual patient in a structured and easily accessible way [20]. The ePHR, electronic personal health record, allows patients to share personal health information regarding themselves and their loved ones in a protectedway.

The Tolven software uses some standard technologies such as Java, Enterprise Java Beans (EJB3), AJAX (Asynchronous JavaScript), and relational database [20]. It supports various data formats and Tolven's architecture is plug-in based.

The creators of Tolven have taken measures to ensure that Tolven is safe from some of the most critical vulnerabilities for Java applications. For example, to prevent SQL injections, queries in Tolven never add user input directly into the query string. All queries use strongly-type query parameters. In addition, all applicable queries are qualified by account [21].

4. PERSONAL HEALTH RECORDS

We earlier saw that OSCAR, OpenEMR, and OpenMRS have personal health records as part of their functionality. In this section, we will discuss a health information system that is completely apersonal health record.

4.1 Indivo

Indivo is a type of personally controlled health record that is open source and web based. It allows the patient to own and manage all their medical records that pertain to their medical history, essentially creating their own personal health record. The patients in turn, are able to provide their doctors with all pertinent medical information regarding their health quite easily.

Indivo is a three-tier system with a data storage tier, a business logic tier, and a user interface [22]. The central feature of Indivo is the Indivo API. The Indivo API allows the system to collect health records from various data sources and share those records with third parties. The business logic tier is comprised of the Indivo Server, which manages the documents that make up a personally controlled health record. Documents are made available to client applications using the Indivo Server through the Indivo API. The server also determines which documents are available to which users. The Indivo Server has two classes of security policies. One is server-based and explicitly type-permits or denies certain actions. The second policy type is user-based. It gives the patient the opportunity to indicate what privileges on specific portions of their health records other users have access to. The dual-class (server and individual) approach to access policies is a defining feature of the Indivo system [22].The data storage tier of Indivo is used to store the documents that make up a user's PHR. This tier is encrypted to protect users in case of theft or hardware loss. A separate physical server hosts the encryption keys to prevent decryption of patient data in the case that the storage machine is compromised. Also, each record stored in the system is fractured into loosely-related, encrypted data packets to mask the size of an individual record [22]. The graphical user interface (GUI) is responsible forensuring that the data contained in a patient's record is presented in a useful and understandable way. Since the GUI gets all the data for the health record from the Indivo Server, all the security policies are applied automatically as well. A single Indivo Server can support multiple user interfaces because the interfaces interact with the server as clients using a standard API.

5. CONCLUSION

There are several types of open source health information systems that are available for use by physicians and hospitals. While all the systems discussed in this paper are open source, every open source system is different even though they may share similarities. Both ClearHealth and WorldVistA are designed based on the VISTA system architecture. Most of the health information systems are web-based. They are ClearHealth, Caisis, OpenEMR, Indivo, OSCAR, and Tolven. ClearHealth, OpenEMR, and OSCAR include features that would be essential to a doctor's office. These features include medical billing, scheduling, electronic medical records, and security features designed to ensure HIPAA compliance. Tolven, OSCAR, and OpenEMR have designed features within their systems that would give administrators the option of allowing patients to be in charge of their own medical records. Furthermore, OpenMRS is in the process of establishing a patient portal that will also allow patients to control their medical records. Indivo gives patients total control of their medical records by allowing them to control who has access to their records. Each on the systems reviewed have security features in place. The features include access controls, encryption, and one systemOSCAR boasts security technology that isutilized by the banking industry.

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