Building a National Electronic Health Record Infrastructure on top of an Innovative Open Source Mobile Platform Using a Cloud-based Server Infrastructure

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Abstract: **There have been many technical challenges in building Electronic Health Record systems for developing countries that have been overcome and addressed in the recent past. The Sana Mobile telemedicine system provides an innovative, mobile-based, end-to-end infrastructure and platform for medical diagnosis and treatment. The system is highly customizable, with an easy to use Android-based mobile phone interface, built on top of several Open Source technologies. The Philippine General Hospital is currently incorporating Sana within its current EMRS implementation. Another innovation is the advent and availability of Expert Systems that provide diagnosis and treatment options to doctors through the use of evidence based medicine and statistical analysis methods.**

The next challenge to hurdle is to expand Sana to address data privacy and data security issues in a national context. One of the main issues in designing an eHealth system in a national context is protecting the identity and privacy of the individual person, while, at the same time, making his or her medical information available to the national government for statistical and research purposes. A second issue has to do with allowing the system to scale rapidly, once deemed necessary, to accommodate hundreds of thousands, if not millions of patient electronic medical records without suffering any performance or network degradation issues.

This paper expounds on these issues, as well as the proposed solution to ensure an effective implementation of Sana at the national level.

Introduction

We now live in an inter-connected world. There are over 6 billion mobile phones worldwide, for a population of 7 billion people [1], and the fastest growth of mobile users is in developing countries, reaching over 75% of the population [2].

Among the latest advancements in mobile technology are Android based smart phones. These phones allow intuitive, user-friendly applications to be built, that can capture detailed patient information and store the data on the phone. These records are then transmitted to a central Electronic Medical Record system, through various methods of transmission.

The other technology that has come of age is the commercial availability of cloud based computing as a service [3]. Cloud computing allows for affordable, subscription based, instant deployment of servers for telemedicine and eHealth systems. There is also now available, cognitive computing systems that help doctors to diagnose patients medical illnesses, using the vast amounts of medical literature already published [4].

In order to harness these latest advances in technology for healthcare in developing countries, issues of data privacy, and data security of patient medical records have to be addressed on a national or governmental perspective. Affordability and availability of the information technology solution should also be addressed. It is these issues that this paper aims to address, and to provide a path to a resolution of the issues stated.

Components of a National eHealth System

Mobile-based open-source telemedicine deployment platform.
The first component needed for a national eHealth system is the mobile platform that will deliver the medical information from the patient to the doctor. The Sana Mobile Telemedicine System is an Android cell phone based, standard-focused open-source system that allows for the creation of highly customizable workflows. It connects to a back-end open-source electronic Medical Record System (OpenMRS), and allows for reliable operation on unreliable networks through its synchronization, packetization and multi-modal transfer abilities [5].

The Sana Mobile Telemedicine system has the following features [6]:

- It interfaces with point-of-care diagnostic tools through the attachment of portable medical devices to the mobile phone.
- It allows guidelines, checklists, medical procedures and protocols to be

saved on the phone, bringing evidence based Medicine into the hands of a health worker or nurse at a clinic.

- It streamlines triage and referral system which includes initial assessment, initiation of diagnostic procedures, appropriate physical examination, and documentation.
- It facilitates coordination of care, care standardization and quality monitoring through the use of Electronic Medical Records.

Components of Sana

There are four components of Sana. These are: the Sana Android Phone client, the Mobile Dispatch Server, the SMS Server (Kannel), and the Electronic Medical Record System(OpenMRS) [6].

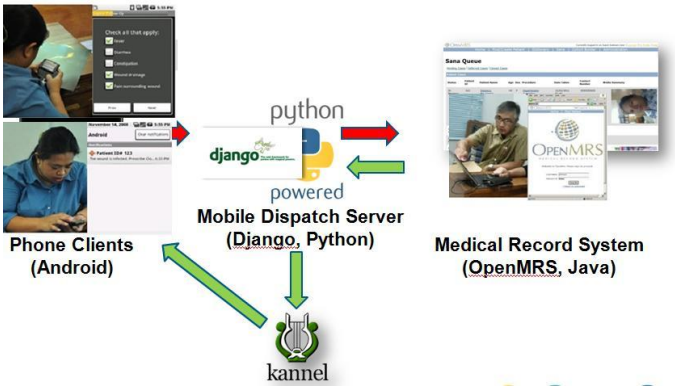

Fig. 1 Components of Sana

Phone Client – Android Phone

The Sana phone client is an application written for the Android phone. This phone client allows multiple procedures to be stored onto the phone. Examples of procedures are: Hypertension questionnaire, Shortness of Breath Evaluation. The Health care worker Opens the Sana phone clients, selects a procedure and follows the workflow hard coded into the procedure when interviewing the patient. The Sana application guides the Health Care worker through the step-by-step questionnaire [6].

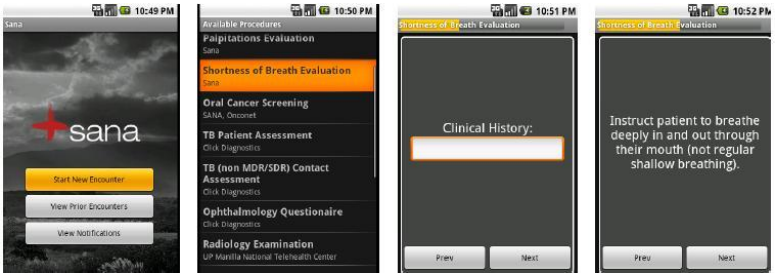

Fig. 2 Sana Phone Client phone interface screen shots

Sana provides a mobile-based telemedicine platform that is customizeable to the requirements of a particular setting. The use of open-source software makes Sana available to any organization that may want to implement the system, without having to pay for any software licenses.

System design to enable data privacy protection in a national context
The second component in building an national eHealth system is to address the data privacy and data security issues of patient medical information. We will expand the Sana mobile-telemedicine system and incorporate the system into a set of systems that will ensure data privacy and data security in a national context. These set of systems will comprise the Electronic Health Record system of a nation or government [12].

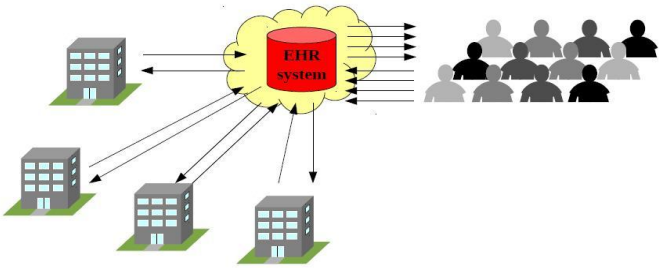

Fig. 4 Electronic Health Record system

Data privacy of Electronic Health Records
Data privacy in healthcare is currently defined and governed by laws and guidelines. The Health Information Portability and Accountability Act

(HIPAA)[7] in the United States is one such law that protects a patient's privacy of his or her Protected Health Information (PHI)[8].
In the Philippines, the data privacy act of 2012 [9] was signed into law on August, 2012, which puts in place measures to protect and preserve the integrity, security and confidentiality of personal data collected by government and private entities in their operations.

Implementation of Data Privacy and Data Security measures for Electronic Health records on a national scale has only recently gained visibility and importance. We have chosen to follow the Architecture and Security of a National eHealth Platform [12].

Data privacy of Electronic Health Records can be accomplished through de-identification of personal information from the medical records of the patient [10].

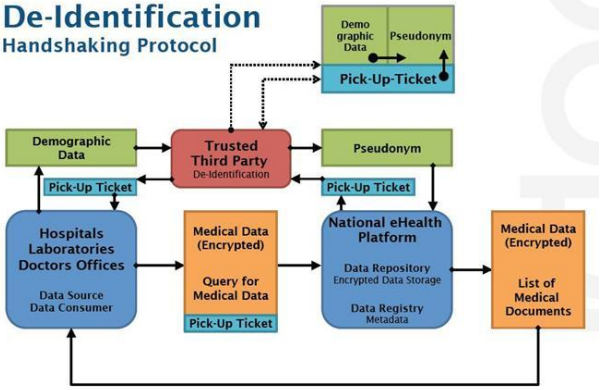

Fig. 5 De-Identification architecture

The de-identification procedure separates the medical information of a patient from his or her identity. This is accomplished through the use of pseudonyms [10]. The medical record of a patient is tagged with a pseudonym. The pseudonym and the patient identity pair are then stored at a Pseudonymized Medical Information Provider (PMIP) [12].

Data Security in Health Care

Data security in healthcare is also defined by laws and guidelines defined in each country. The HIPAA Security Rule focuses on assuring the availability, confidentiality, and integrity, of electronic protected health

information through a series of administrative, physical and technical safeguards [13].

Data Security in storing medical data in multiple locations
Data security is accomplished through the use of data encryption of medical data on all physical storage locations. Data encryption and decryption is done the the use of public and private keys using a Public Key Infrastructure and stored at a Trusted Third Party (TTP) organization [11].

The following are the different layers that protect the privacy and security of patient medical records. For Data Privacy: Pseudonymization, ITconsent. For Data Security:Key Re-Encryption, Logging and Alert , Security Token, Timestamp , PKI for Signatures, Certificate Based Authentication [12].

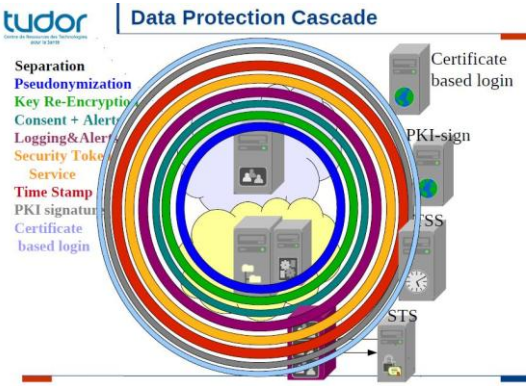

Fig. 7 Data protection layers for patient medical data

Cloud based server infrastructure
The third component in building an national eHealth system is to allow for a cost efficient deployment of the systems, and allow for expansion in an affordable manner. In order for us to properly scale the set of systems on a national scale, we will test our implementation using International Business Machines (IBM) Smart Cloud Enterprise platform [3]. This cloud based server deployment will allow us to grow the capacity of our servers quickly and cost effectively as the need arises due to growing numbers of electronic records and users.

We will not be encumbered by the lack of computing power and resources to scale the systems once we are ready to grow the systems on a national scale.

Use of Expert Systems in facilitating the diagnosis of patient illness
Within the past year, IBM has put into place a set of computer systems called Watson, that can process volumes of medical information, and provide recommended treatments to treat patient illnesses. This expert system can be used to help doctors provide quicker, more accurate diagnosis and treatment of patient illness [14]. For a national eHealth record system to be effective in providing medical care to the majority of a population, the set of systems installed must be able to allow for the quick, accurate, and efficient processing of patient diagnosis and treatment. IBM's Watson can put into the hands of doctors, an expert system that has thousands of medical journals in its memory, to apply the appropriate treatment, based on patient history, and current symptoms reported by the patient.

Next Steps to Take

Form a project team with Integrated Open Source Solutions
In order to bring together and apply the various available technologies discussed above, the next concrete step to take is to put together a team that will build the set of systems required for the project. The group will be composed of a software development team, a software quality control team, and a server administration team. Requirements definition, analysis, design, iterative development, phases will be followed, using the agile methodology. Approximate project duration will be one year. A budget will have to be allocated for the project development. Integrated Open Source Solutions [15] will lead the project and provide the manpower and project management requirements for the project.
Work with the Otorhinolarynology disivion of Philippine General Hospital
In order for us to test and gain feedback on the systems we are building, we have begun working with the Otorhinolarynology division of the Philippine General Hospital (PGH) [16]. PGH has mandated the use of OpenMRS as the common electronic medical record system that will be used by all the divisions of the hospital, and the Otorhinolarynology division was the first adopter of OpenMRS.
Use of Open Source Software to build systems
We will continue the spirit of Sana by building all of the systems necessary to achieve the stated objectives using 100% Open Source software. This

will allow the systems to be shared with others, and will allow for growth and collaboration to improve and to customize the systems in other countries.

Set up a source of trained I.T. staff

Through our partnership with Asia Pacific College [17], we will provide a continuous stream of I.T. staff, trained on the various technologies that we have used. This will provide the human resource required to sustain and expand the development of a National Electronic Health record system in the Philippines.

Conclusion

The use of an Open Source Software development platform allows various specialized groups to collaborate and build on top of each group's expertise. This is so well characterized in the Sana Mobile Telemedicine project, which makes use of several Open Source technologies to come up with an effective, working, low-cost solution to provide Remote Medical Diagnosis in low resource areas like the Philippines.

Expanding the scope of of the Sana telemedicine project to use it as a base technology for building a national electronic health record system is the next step required in achieving the goal of using information technology to provide affordable, accessible, universal health care in a developing country like the Philippines. The I.T. infrastructure already exists, in the form of cloud computing services, that will allow an electronic health record system to scale rapidly, and in a cost efficient manner, to accommodate the needs of the whole population of a country. With the availability of expert systems such as IBM's Watson to assist doctors, diagnosis and treatment of thousands of patients can be accomplished in an accurate and timely manner.

Incorporating all this latest technology available, and building the set of systems required on top of an Open Source platform is the ambitious challenge facing the development team that will be part of this project. This development will be led by Integrated Open Source Solutions.

This is a project whose time has come. The dream of being able to provide universal health care can now become a reality. It is with dedication, teamwork, and collaboration that we can all make this come true.

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