A Service-Oriented Approach to Electronic Medical Records in Developing Countries

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Abstract

Although significant strides have been taken towards the adaptation of Electronic Medical Records, it has not reached fully maturity yet in terms of its implementation and use. Regardless, the implementation of electronic medical records, especially in developing countries, will greatly improve the quality of healthcare and present opportunities to contribute to the improvement of health worldwide. For this paper, I plan to focus on the implementation of electronic medical record systems through the use of service-oriented architecture principles in the context of the limited resources and the lack of infrastructure often present in developing countries. I conclude the paper by considering various non-technical factors associated with health information systems.

Introduction

Health Information Technology is a newly blossoming field that has only recently started to receive much attention. One important aspect of HIT that has shown a lot of promise is the Electronic Medical Record. Originally conceived as a means to simply document patient records electronically, EMR has expanded in a matter of years to enable quick and easy acquisition and retrieval of all of a patient's medical information (Sood et al., 2008). As a result of a great deal of expansion in Internet and cellular technologies, there has been a lot of research done to find new and innovative ways for such technology to expand the scope of EMR systems even farther beyond just data entry during a hospital visit.

Despite much growth in terms of technology development, however, there seems to be no standard framework for EMR. This problem can be seen most prevalently in the United States, where the health care system is highly diverse and decentralized. As a result, it is difficult for data to be easily translated electronically across various different systems. Additionally, medical practitioners have and continue to use various different methods to document rendered care. Medical records can take the form of documents that are hand-written, typed, dictated (sometimes into recorded audio) and transcribed, or created with a paper or computer check-off system (invariably augmented with free-text) (Heinze et al, 2001).

There are many instances in the developing world where we see these and additional problems, which make the implementation of any sort of EMR challenging, including limited resources, lack of health care infrastructure, and a need for proper training of health personnel. Regardless of these issues, the use of EMR in developing countries has the potential to play as significant a role as in developed countries, if not even more so. In addition to the various benefits that EMR provide to a healthcare system (Frasier et al., 2005), there is a necessity for excellent information management to assist in the research to combat various health crises, such as HIV/AIDS and tuberculosis, for which the

pathophysiology is not fully understood and continues to change in response to interventions (Frasier et al., 2005).

Service-Oriented Architecture is a flexible set of design principles that integrates a wide set of otherwise disparate systems by developing functionality as a suite of interoperable services that adhere to the various protocols necessary for various domains (Nano & Zisman, 2007). A healthcare system based on a SOA has the potential to address many of the issues faced by health systems around the world by 1) extending the utilization of medical applications to different types of people including physicians, medical staff, personnel with limited trainings, and in some cases patients, 2) allowing for the coordination of various different types of multimedia inputs and outputs (text, images, and speech), and 3) creating a system that is flexible, nimble, and highly equipped for system changes (Kart & Moser, 2008).

This paper will be broken down into several parts. First, I plan to briefly explore HIT initiatives in the developing world in a review of literature. In this section, I will also further define SOA and illustrate its use in EMR within developed countries. Second, I plan to illustrate the potential application of SOA on different health systems, of varying levels of maturity, within developing countries. In the last section, I plan to explore the various non-technical considerations that must be taken into account when implementing a project of this nature.

Review of Literature

Much research has been done concerning the application of EMR in a number of clinical settings within numerous developing countries. Although many of the implementations explored were hardly complete or ideal, they serve as a basis from which to pursue other types of projects and provide us with a preliminary list of considerations to ensure success. Some of these implementations include functions for more efficient patient registration and visit-data collection, treatment regimen reporting, drug and medical inventory and tracking, patient management, and prescription (Frasier et al., 2005). Among these services, many utilized Internet based services, of which some required satellite based access. Other services utilized technologies such as a standalone database, touch-screen interfaces, and Personal Digital Assistants. From observing these implementations, it becomes evident that even with adverse logistical challenges, as well as limited amount of resources and a shortage of IT expertise, EMR systems can still be implemented successfully and have a significant impact on the productivity of a health system, regardless of how comprehensive they are (Frasier et al., 2005).

In addition to these pilot projects, which often tend to be isolated cases, an extensive amount of research has been focused on providing developing countries with the tools necessary to create an EMR custom tailored to fit their own different needs. In the United States, we see a variety of open source tools specifically designed for EMR such as OpenEMR, Care 2X, and VistA. For developing countries, however, OpenMRS is currently the most widely use open source package, as it is the most ideal for use in both a clinical and research setting (Mamlin & Biondoch, 2005). The API is designed in Java using Hibernate as an object/relational persistence layer between the code and the data

model, which is patient centric. The implementation uses HL7 as the primary mode of transmitting data between external applications and the repository and additionally supports and stores mappings between local concepts and existing standards, such as LOINC, ICD-10, SNOMED, and CPT (Mamlin et. al, 2006).

OpenMRS is particularly significant in the discussion of SOA, as it is designed for re-usability, interoperability, and flexibility, which ultimately works back to scalability and the integration and collaboration of multiple systems both inside and outside of a health care system (Mamlin et. al, 2006). Generally, SOA works by using defined protocols, established by the different services that use the system, to define how different services send and receive messages from each other, through the use of metadata. In practice, this greatly reduces the time of implementation, especially in established systems, as it will rarely require major systematic changes to enforce adherence to any specific standards. This concept not only plays a critical role in terms of medical protocols, but also allows for a smooth integration between systems with major systematic differences.

This can be more easily seen by taking a look at a couple of EMR systems based on the SOA. Kart & Moser (2008) describe a prototype that "uses SOA to enforce basic software architecture principles and provide interoperability between different computing platforms and applications that communicate with each other". The actual services revolve around the clinic, pharmacy, and patient modules. Various devices can interact with these modules, including desktop and server computers, Personal Digital Assistants and smart phones, and even electronic medical devices, such as blood pressure monitors. The e-healthcare system itself is built on an Apache Tomcat server and uses the Apache Axis2 framework, which provides the data bindings to generate Simple Object Access Protocol messages (used for the exchange of structured information over the web) without being concerned about constructing or parsing them. The system is implemented using the Java programming language and Plain Old Java Objects (POJO), based on the Spring framework, to ease development and debugging across different platforms. The system incorporates the use of external tools, including DynaSpeak speech recognition software, for use by a physician to enter information about a patient during an appointment, and to retrieve the information later using his or her PDA. DynaSpeak "supports multiple different languages, adapts to different accents, and doesn't require training prior to use" (Kart & Moser, 2008). The system also uses Atom along with additional software to "enable the sharing and communication between heterogeneous platforms" when there is limited or no connectivity (Kart & Moser, 2008). In other words, this allows physicians, nurses, and pharmacists to access information offline, which has practical implications when there is an emergency, such as an earthquake or a hurricane, which limits network communication (Kart & Moser, 2008).

Another example of the implementation of an EMR system using SOA is the MammoGrid Project. This project, as the name suggests, is a Grid application, which refers to the combination of resources from a number of different domains to achieve a common goal. In this case, the project is intended for the management and coordination of medical image data within federated mammogram databases across Europe (Amendolia, 2004). Through the use of 'virtual organizations', a collaborative effort can be made to conduct epidemiological studies, statistical analysis, advanced image processing, radiographic education, and eventually tele-diagnosis over a vast number of regions with different protocols, lifestyles, and diagnoses procedures (Amendolia, 2004;

Raghupathi & Hesh, 2007). Although this project primarily focuses on the application of Web services, as opposed to the previous example that focused on a more robust application in other forms of care, it is significant to observe the implications of such a project in the context of expanding EMR and HIT into developing countries (Raghupathi & Hesh, 2007). The integration between various systems across borders, in terms of research and even in terms of specialized care, is made feasible through the use SOA principles in implementation.

Solutions

Based on these examples, we can examine ways in which to potentially enhance current health systems in developing countries through the implementation of a form of EMR using SOA principles. In order to illustrate this, we can first look at a specific instance in the Alto Amazonas province of Peru. In this rural area, similar to other rural areas around the world, primary healthcare is organized around two types of care centers: 1) Health Posts (HP), which are located in small towns of no more than a thousand people and are the most common way for citizen to get access to care, and 2) Health Centers (HC), which for the most part handle severe case referral, pharmaceutical deliveries, and epidemiological management. A 'health micronet' is a network of several HPs under the coordination of one HC, which collectively make up the basic unit of the primary health system (Martinez et al., 2004). For a long time, these health micronets in the Alto Amazonas province were fairly disjoint and had limited access to electricity, telephone networks, and proper medical training, in addition to an inadequate infrastructure for transportation. In 2002, the Enlace Hispano Americano de Salud (EHAS) started an initiative to develop a system that facilitated the exchange of information within the various healh micronets in the Alto Amazonas using a combination of VHF, HF and WiFi, as well as telephone services for voice and data communication (Martinez et al., 2004). Information exchange occurred through e-mail, and was utilized for epidemiological reporting, training of medical personnel, and patient referral. The project proved to be a success, as the active involvement of those who used the system in addition to its financial benefit led the project to become sustainable over time (Martinez et al. 2007).

Despite the success of the EHAS project to this day, there is a lot of room through which the system can improve, both in its own respect and in respect to the global community. By establishing a region wide EMR, the collection and management of patient data would further become efficient, allowing for the introduction of health maintenance programs and better patient tracking. Technology-wise, the introduction of an EMR would allow for the introduction of decision support systems to provide real-time assistance for medical personnel in making clinical diagnoses. On the international front, the Alto Amazonas region of Peru has a lot to contribute to the research of disease in rural areas. This will more so be the case with better epidemiological reporting and a higher quality of care as a result of adapting to EMR. When considering the adoption to EMR, however, it is important to keep in mind the context of the health system, as previously described. Most likely, not too many drastic changes will occur in terms of the technology they use and the resources made available to them. Through the

application of SOA principles, the implementation of a functional EMR is not beyond their reach. As described in Martinez et al. (2004), each HC interacts with a server permanently connected to the Internet in order to send/receive e-mails through a series of calls made throughout the day. Using e-mail protocol (or optionally a more light-weight protocol if possible) as a means of transferring EMR information, the HC servers can maintain a local EMR system, which they can use to update a secure statewide, Web-based EMR system as data comes in. Conversely, HCs can use the same protocols to push information onto the smaller-scale EMR systems managed at the local HPs, as data is requested for future patient visits. Health micronets can additionally utilize voice communication via VHF radio to transcribe patient information through an application such as DynaSpeak as a quicker means to report patient data to HCs and further reduce the amount of error in terms of data entry.

Consider another example; due to a lack of roads and infrastructure, the rural area of Mtwara, Tanzania remains relatively underdeveloped. As a result, clinicians must walk around to the various health facilities and homes in the area in order to diagnose child patients. Previously, clinicians would carry out diagnoses using a paper-based version of the Integrated Management of Childhood Illness (IMCI) protocols, which specifies a series of investigations for complaints and potential treatments based on the diagnosis (DeRenzi et al, 2008). As of 2008, research has been conducted to test the effectiveness of an electronic version of IMCI, called e-IMCI, that would run on PDAs. In DeRenzi et al (2008) it was shown that e-IMCI did a lot to increase the accuracy and efficiency of clinical visits, as it would reduce the amount of human error a clinician would make. Additionally, it made keeping a record of a patient visit convenient as all series of investigations are saved on the PDA. With the introduction of e-IMCI, there is potential for an increase in medical personnel working in the region, as the application's ease of use will lower the barriers of entry for people who may not have access to medical training that would be normally needed.

When observing a medical system with hardly any infrastructure, it is hard to see where potential growth can occur. On the other hand, with a system of only a limited magnitude, it might almost act as a fresh canvas on which to establish more efficient structures, without having to worry about a massive overhaul existing practices. With the success of e-IMCI and the expansion of medical staff working in Mtwara, the region could start honing in on patient-centric care for all ages, shifting more towards regular patient consultations rather than just occasional visits to the local children. With the assistance of EMR, the use of PDAs can systematically change the means by which care is provided. Patient information can be stored in a secure online EMR system that can be accessed from any computer with Internet access. Information, coded in the e-IMCI format, in addition to any other information (i.e., notes, pictures) can converted to a standard protocol, using SOA, and can be uploaded to specific patients' EMR through a secure application by a clinician upon their return. This would help to further reduce the amount of time a clinician spends with each patient by eliminating having to ask the same standard questions upon every visit, and allow a clinician to account for reoccurring conditions and history in future visits. Though the contribution of establishing a basic EMR system would still be small, it would increase the quality of care in the region by a tremendous amount.

Considerations

As with any development project, there are a number of non-technical considerations to keep in mind when implementing EMR systems. First, it is important to consider privacy, security, and patient safety when dealing with the health information of other individuals. Although different countries tend to have different views on security and confidentiality, it is important to consider social stigma, especially concerning issues that are most common in developing countries, such as AIDS/HIV (Sood et al., 2008). Second, as encountered in the cases above, it is important to understand what resources are available and/or already in place. Many implementations of EMR systems require the use of the Internet, but without the proper infrastructure, the project is doomed to fail from the start. On this note, it is also important to consider the costs versus the potential benefit to society; especially for a country with limited financial resources, although a project may have the potential to significantly reduce healthcare costs, it is still important to mitigate all potential risks beforehand (Wootton, 2001). Third, although information systems and technology have evolved to account from many unknowns, there is a level of risk as a result of human factors that technology cannot account for. Factors such as culture-specific beliefs and values, the role of government, etc., can contribute to the sustainability of a project after implementation. Much literature has suggested the use of participatory methods to promote local ownership and involvement (Jørn et. al, 2004). With this in mind, it may require additional coordination and correspondence with international organizations to extend the use of a country's health information for population health research, as different countries may have different perspectives in terms of their relationship with other countries.

Conclusion

EMR has a critical role to play in the quality of health systems worldwide. Through the use of SOA principles, EMR systems can be developed to overcome barriers such as interoperability, efficiency, and flexibility amidst change. With the introduction of new information technology, there is potential for EMR to extend to places where any sort of information systems was hardly imaginable. With the concurrent evolution of healthcare practices around the world, it is important to keep in mind the potential benefit HIT and SOA have to offer.

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