DESIGN, ARCHITECTURE, STANDARDS AND PROTOCOLS FOR PATIENT INFORMATION SYSTEMS

Khurram Zeeshan Haider[1], Farhan Aadil[2], Rabia Attiqa[3]
khuram.zeeshan@uettaxila.edu.pk, farhanaadil@uettaxila.edu.pk, rabia_attiqa@yahoo.com
[1, 2] Department of Computer Engineering, University of Engineering & Technology, Taxila, Pakistan
[3]Wah Engineering College, University of Wah

Abstract
Electronic Medical Record (EMR) (sometimes also referred to as Electronic Health Record (HER) or Patient Information System (PIS)) systems are emerging as an essential part of the modern healthcare framework. EMR systems have now become an integrated, enterprise-wide providing access to patient healthcare data. EMR systems also serve as a core component of Clinical Decision Support System (CDSS). EMR systems promise to facilitate healthcare professionals with the necessary information to improve patient care efficiently and effectively. Though there has not been a great deal of research to provide a guideline for successful EMR systems implementation. This review paper provides a literature review of EMR from an architectural perspective and also lists some global EMR standards and protocols widely used in the development of EMR systems.

Index Terms- Electronic Medical Record (EMR), Clinical Decision Support System (CDSS).

1 INTRODUCTION
EMRs can be defined as a software suite of integrated functionalities built around a common database. Such functionalities are not limited to, but typically include Electronic Health Records, Diagnostic Tools, Patient Billing, and Electronic Prescribing, Practice Management [1]. These modular functionalities are found at various integration levels. The term “electronic medical record” and terms such as “electronic health record (EHR)”, and “computerized patient record” are sometimes used to describe a person’s medical history in electronic form [1]. EMR software allows the users to create, store, edit, and retrieve patient charts on a computer. A successful EMR project allows a practice to replace its paper charts with electronic charts. This offers tremendous productivity and efficiency benefits to a practice. By storing all the data, an EMR replaces the racks of chart folders with a computer. EMR is not only a database application of patient medical records to retrieve and manipulate patient information but it also acts as a diagnosis tool and useful information can be used to facilitate doctors and physicians to make their job more efficient and easy.

Literature review yields that healthcare are lagging the application of information technology (IT) as compared to other fields. Healthcare is considered as knowledge based enterprise, but knowledge is not taken as the part of the value proposition which is the major cause of minimal academic research into healthcare information, compared to other industries. The EMR systems have emerged recently and a lot of research has been done of late. The information obtained from EMR is also being used in warehousing to develop clinical decision support systems (CDSS). It is evident from the literature that there will be great benefits from the integration of the healthcare and information technology disciplines. The EMR implementation is also critical in the sense that it has to work with as much sensitive data as somebody’s health. This reflects the importance of need for successful implementation of an EMR system.

With rapidly growing importance of information technology in the healthcare area, medical practitioners should have access to sound theoretical and practically relevant research to train them in the adoption, implementation, and use of such systems. EMR rely on real-time access to a common database, on a platform that aims to systematize, integrate, and streamline business processes and workflow. Wang et al. have discussed the effectiveness of Web Technology for their Web based intelligent on-line Monitoring system for Intensive Care Units (IMI) [12]. EMR systems provide accurate and timely information which could sometimes be very helpful in saving somebody's life. To illustrate; in 2004, the American Medical Association reported 98000 preventable deaths per year due to information errors [1].

Warehousing of EMR data and data mining techniques allow mining for information that will allow healthcare providers to predict risks and measure medical care against benchmarks. The EMR has been augmented by a component that utilizes current technological developments such as internet technology to create a more complete source of healthcare data management [6].

EMRs are the inevitable next step in the continued progress of healthcare. Medicine, perhaps the most information-intensive of all professions, is now ready— after many false starts—to take advantage of the advances in information technology that have transformed our society [2].

An EMR directly impacts patient care therefore making a successful transition to EMR may be the most important project that a medical practice can undertake. EMRs deal with information which involves the lives of the physicians, nurses, administrative staff, and the patients themselves. This makes the impact of an EMR implementation substantial. An unsuccessful project can be frustrating and expensive and even dangerous because as mentioned earlier; EMR involves the lives of the physicians, nurses, administrative staff, and the patients themselves. A successful EMR project has the potential of improving the clinical and administrative efficiency of medical practices, as well as enhancing overall quality of care [2].

Clinical decision support(CDS) can be (and has been) built starting from complementary knowledge representation models, for instance rule-based representations or workflow models to mention just a few [4] and EMR are the primary data source for CDS .

In spite of all the advantages of an EMR system there are some risk factors involved with EMR systems as well. There are also privacy and security fears associated with having people's medical records and history electronically accessible, although the relative newness of the technology means that little data exists regarding actual security breaches in these systems [1]. The EMR is relatively very young, compared to other industries in which IT is being used, with most articles from the last four years. Physicians, healthcare organizations, patients, insurance companies, pharmacies, and all other stakeholders in the healthcare value chain have a vested interest in successful implementation of these enterprise software systems [1]. There is also a need for proper training of medical practitioners to encourage the use of EMR. Physicians, especially those in private practice, are often overbooked with patients and may see the learning curve of an EMR system as too great a hindrance to workflow [1]. The physicians' behavior towards the use of technology will highly be influenced with the ease of use, EMR performance, time and financial constraints. There are some articles in the literature that depict the resistance of physicians towards the use of EMR. Strictly speaking, the EMR should have the capacity to help the physicians to make their job simple and efficient rather then being an overburden for them. The increasing use of integrated EMR systems is a relatively recent phenomenon; theory regarding the implementation process is sparse. Physicians are supposed to enjoy two major sorts of benefits from EMR system. Physicians will be able to a) see more patients in a day, due to time and workflow efficiencies offered by EMR systems or b) spend more quality time with the same number of patients.

1.1 Guidelines for Successful Implementation of EMR System

William et al. [1] suggest the following guidelines for the successful implementation of EMR.

P1: Accomplishment of EMR or CPR projects depends on a clear business case for the project. For the accomplishment of the project, in pleasing circumstances, the calculated and cost effective explanation of the project is essential; on other hand it is also important to the healthcare organization's ability to assess the success of the project.

P2: Strong support from the practice physician(s) is indispensable for successful execution of EMR projects. In the case of EMR/CPR implementations, physician support can be seen as executive or top management support. There are previously some evidences that physician owned practices are less likely to adopt EMRs than practices owned by a healthcare organization [10], so physician buy-in is critical.

P3: Successful EMR implementation projects will be marked by an internal project "champion". For EMR implementations, *champion* will not necessarily be the practice doctor(s). While, physician support is essential, due to the time constraints of their practice, many physicians will not be able to play the role of project champion.

*P4: In unbeaten EMR or CPR implementation projects there will be a vigilant and purposeful planning phase. The p*lanning phase involves converting the business case into explicit goals and objectives for the implementation process. The same activity is performed while project resources are acquired.

P5: Presence of a project manager with strong project management skill and experience will lead the implementation of EMR project to success. Healthcare organizations, especially smaller practices, may lack workers with project management experience and will need to look to independent consultants or vendor consultants to fill that need.

P6: Attractive EMR implementation projects will be marked by a willingness to change workflow and procedures on the part of the practice. Most complex and firmly incorporated software systems, such as EMR/ERP systems, are only configurable to a point, and typically require the adopting organization to be conventional their business processes to the software. According to William et al. business process reengineering (BPR) has become an accepted part of the price of implementing an enterprise information system and the implementation of EMR systems is likely no different. The theoretical model is displayed in figure 1 as given in [1].

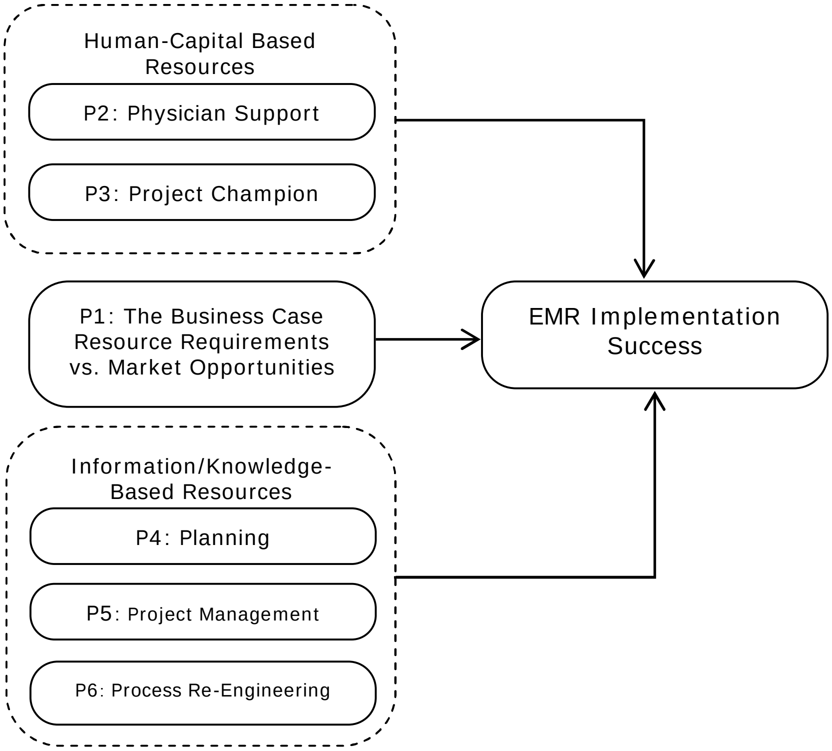

Fig. 1: Theoretical model of an EMR System.

1.2 Advantages of EMR

An EMR building organization Wolf Medical System lists following major benefits of EMR [2].

Improved Patient Care: An EMR can dramatically improve patient care by sharing information easily, accessing and retrieving information quickly and easily, improving office communication, pro-actively managing patient care by using robust follow-up systems and rules engines. EMR also helps facilitating higher quality documentation (legible, organized, complete), providing built-in protocols and reminders (including health maintenance), and improving medication management.

Revenue Enhancement: An EMR can impact the top line of a practice by allowing physicians to invest time savings into seeing more patients. In addition, the robust follow-up system will ensure that patients are being seen appropriately for follow-up.

Improved Administrative Efficiency: Successful EMR sites are more efficient than traditional offices. These improvements can be attributed to the following:

1) Fewer chart pulls and less filing
2) Universal access to the chart (by more than one person at a time) and less searching for lost charts
3) Reduction in phone tag
4) Improved internal office communication
5) Fewer call-backs from pharmacies
6) Easier compliance with chart requests and chart audits

Improved Effectiveness: Adoption of an EMR allows you to practice in ways that you cannot with a paper chart. One such example is the graphing of electronic lab results versus medications. Creation of powerful rules for reminders – e.g. Diabetic patient that has not had a

HbA1c in the past 6 months, automatic graphing of growth curves integrated tools for calculation of expected peak flow, mini-mental status, depression scores etc are also among the evidences of improved effectiveness provided by an EMR. Automatic calculation of cardiac risk and Automatic Drug Interaction checks for Drug to Drug, Drug to Allergy or Drug to Condition reactions are possible with EMRs.

Less Stress for Physicians: With the move to an EMR most physicians notice a definite decrease in stress as they become confident that their EMR will prompt them with appropriate reminders for patient care – they no longer need to hold everything in their heads! Along with this, the ease of access to the system from the home, hospital or office allows physicians to go home after their last patient leaves the office and finish up any remaining work from home as needed. Finally many offices note a real improvement in office morale due to the improvement in communication that results from the adoption of an EMR.

2 EMR Architecture

The overall architecture of an EMR system is given in Figure 2 as depicted in [9].

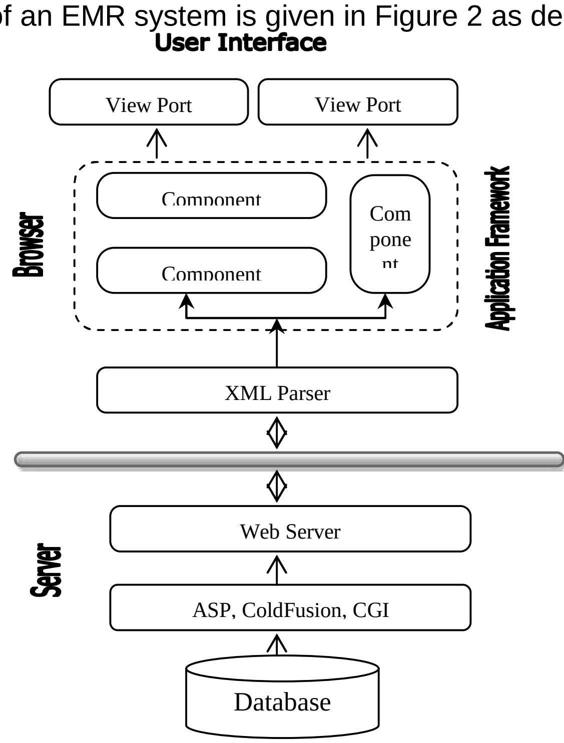

Fig. 2: Architecture of EMR.

EMRs may also be implemented as a web portal. There is a wide range of web portals, such as search engines, available for public. These portals provide an interface to present data in an organized manner i.e. a straight forward means to access the data. Public as well as corporate portals provide access to potentially vast amounts of complex, distributed information through a Web browser. These are based on Web technologies and usually are accessed through the Web browser. Medical information itself is quite vast, complex and is distributed in different locations. Medical portals can also be made available via web and can provide the medical community with access to medical information through the Web browser. Appropriate portals and channels within those portals can be defined to provide access from the desk of the physician, the hospital administrator, the insurer or the consumer of health services [3].

Public such as Yahoo! and Google permit searching by query and by browsing hierarchical classifications of the Web-based information with each sub-tree or branch of the hierarchical classification rooted at the portal representing a major subject area such as education, health or entertainment etc. These sub-trees within portals are termed as “channels” of information. Corporate portals or enterprise information portals have been developed over the last few years. A corporate portal permits enterprise information to be made available across the company, normally through the Web [3]. A corporate portal can be thought of as a database view, i.e., the information channels within the portal are analogous to database attributes and portals may be defined differently for different individuals. These information channels permit access to information on the Web, and this Web-based information may be in a Web markup language such as HTML (Hypertext Markup Language) or XML (eXtensible Markup Language), in databases, in spreadsheets, or in word processing documents[3].

A patient sees a doctor who assesses health (and may or may not record it) and suggests the treatment for the patient based upon his/her present condition. At initial encounter the clinician collects information about patient health and today, most often, records the information on paper. Prior information about health status or lab information is often difficult to obtain, and the new information, when hand written on a piece of paper may also be unavailable for subsequent use at other locations [3].

The purpose of EMR is to accelerate the appropriate use of information technology to provide useful support for access to medical information for healthcare, research, teaching, health services administration and patient care. Ideally, a patient should have access to decision support tools to be informed about the need for a medical visit. Some of the patient information is fixed; some varies with the passage of time. In order to provide fixed and varied information, electronic information tools are needed which should be portable, fast, easy to use, connected to both a large valid database of medical knowledge and to the patient record, and will be a servant of patients as well as doctors. Over the last few years, there has been a shift from administrative health systems concerned primarily with billing procedures to clinical information systems that provide support for providers of health care [3]. Such clinical information systems may build on an EMR as a way to unify the data, even though that data may come from many sources and be of many different types. However, vendors at the May, 1999, TEPR Conference (Towards an Electronic Patient Record) indicated that while the use of administrative systems is almost universal for billing, less than five percent of physicians are using an electronic patient record [3]. According to the Computer-based Patient Record Institute (CPRI), A computer-based patient record (CPR) is electronically maintained information about an individual’s lifetime health status and health care [3]. CPRs are also referred as Electronic Medical Records (EMRs). The content of CPR or EMR normally consists of medical history, laboratory test results, x-ray and/or CT scan images, current medications, etc. and these databases are not to enormous or huge, there are independent work stations at individual care sites with least connectivity requirements. With the maturity of the internet and World Wide Web (WWW), most system vendors are now presenting a web based clinical and medical systems. Most of these new systems are based, at least in part, on XML, the eXtensible Markup Language, defined by the World Wide Web Consortium (W3C) – a forum for information, commerce, communication, and collective understanding [3]. Most customers of health care desire web-access to the data due to uncomplicated access to appropriate health information. The major benefit of Web-based EMRs or CPRs is that these medical information systems grow to be more accessible to a wider range of users than ever before.

Even though doctors generally regulate with new information technology very gradually, the accessibility of any data or information, at any time, from any place, transforms the dynamics. Access of any data means access to multiple types of data and information including hand-written patient histories, medical images (X-Rays, CT scans etc.), lab reports, prescribing profiles etc. This information is also reachable 24 hours a day, 7 days a week, e.g., medical images (X-Rays, CT scans etc.) are available through the World Wide Web even though the bureau or workplace is closed. The data or information can be accessed straightforwardly without any restriction of particular place for it i.e. data can be accessed through the home computer, or from doctor's desktop, or from a PDA (Personal Digital Assistant) connected to internet over wireless network. In this case the issues like security and privacy emerges, therefore the essential information should be available to the appropriate personnel(s) only. EMRs/CPRs should also ensure transparency of use, transparency of use is a fundamental attribute.

2.1 Medical Portals

Many systems provide portal like access across an intranet, rather than on the Web itself [3]. One such system is InfoClique[11] which is an intranet-based system that defines views by user type; health system administrator, clinical care coordinator, intranet staff, physician, physician office staff, and clergy. These views provide the access to the users based upon the rights of the users' group. In the InfoClique system, all data from the various systems are downloaded several times a day to either SQL servers or text files on one of two computers and these computers provide the intranet access for the users [3]. One major advantage of using EMR as a Web portal it that downloads to centralized servers are not required. This is due to the fact that, each contributing system contains a repository of accessible data. The system that first gets the data makes the data to the Web application, thus making the new data available to the users without downloading the data to the centralized server.

Three-tier architecture is most commonly used in particular for Web applications. Shepherd et al. [3] also presented three-tier architecture of the portal system. The components of the architecture are connected by the Internet. All three tiers are built on the Internet using Internet and Web technologies. The first tier consists of the access devices of the users. In most cases, these will be desktop computers running standard Web browsers, but with the interfaces configured for the appropriate portal. Each user would have access through a portal that would provide access to the required data. The hand held devices would connect to the Internet through a standard wireless communications system. The third tier consists of the data repositories and applications at the appropriate servers to which the user requires access. Second tier is the glue that makes this possible and consists of a proxy Web server and a suite of programs and databases. Data communications between the first and third tiers flow through and are controlled by this middle tier. It provides security and access to the data and applications in the third tier. When record of a patient is requested, that information may also distributed across many other Websites. The middle tier will identify the distributed parts of this virtual record and integrate them via a hypertext link structure, displayable in a Web browser at the first tier. In this system, once the second tier delivers the link to the first tier, the first tier can access the bottom or third tier directly without necessarily going through the middle tier again. This hypertext structure differs from the W3-EMRS architecture in that each tier-three server in the W3-EMRS architecture converts the required data to the Health Level 7 (HL7) message format and sends these messages to the middle tier. This middle tier, called the Agglutinator, integrates the data and converts the result into an HTML page and sends this page to the client in the first tier.

Users' portals can be accessed through a web browser. These portals can be made secure by password authentication. The portal software acts as the user's gateway to the required data and applications in the third tier. Access to JDBC (Java Database Connectivity) and ODBC (Open Database Connectivity) compliant databases in the third tier can be made directly over the Web through the use of appropriate device drivers in the second tier [3]. For non-Web compliant databases and resources, appropriate messaging protocols can be used between the second and third tiers to retrieve this data [3]. There are many messaging standards and protocols for the exchange of medical data. HL7 protocol standards are widely used for the electronic interchange of clinical, financial and administrative information among different health care oriented computer systems. Data Interchange Standard HL7 version 3 Clinical Document Architecture (CDA) is a XML encoded standard that specifies the structure and semantics of clinical documents for data storage. In case of a hand-held device portal, the middle tier will have to specially format the data for display on the device and balance the data flow due to the limited size of the target device and the limited bandwidth of the wireless communications network.

The distributed nature and workings of such a medical portal system should be transparent to the user. User is blind to the middle tier. There are three types of interaction between the first tier and the third tier, through the middle tier [3]. These are pull, push and update.

Pull: Pull is used as a standard Web technology to view a Web document or information in a Web accessible database. The relevant information is displayed to the user in the client browser whenever the user clicks a link or types in a Web server. In case of a medical portal, the user would download a patient record by requesting or pulling that information from the server. The request to pull goes to the middle tier which finds the information at the appropriate third-tier servers and returns that information to the user [3].

Push: When a Web server pushes information to the client browser, push occurs even though the user does not request for any information from the Web server. Push technology has been tested successfully for a real-time patient monitoring system [13]. Shepherd et al. illustrate that there are three types of push; continuous, periodic and triggered. A continuous push is the comparable of monitoring a device that is transferring continuous information. They gave an example of monitoring a patient’s heart rate over a period of time. They elucidate the periodic push as if the server is sending information to the client browser at regular intervals. According to Shepherd et al. the example in this scenario might be a server that pushes stock market quotations every five minutes. The triggered push is enlightened by them as, when information is sent from the server to the client on the occurrence of a particular event, i.e., the event triggers the push, and an example of a triggered push would be the notification that a lab report is now available.[3]

Update: Update is the third and increasingly important portal interaction via which the information is updated on the web server. The user must be able to update or add information and this update must be made to data held by the appropriate third-tier server. The update occurs at the third tier via middle tier from the user. Such updates might include the entry of new observations during a physical examination, admission to a hospital, payment of a bill, new guidelines for care, etc. The update of pulled information might take place at the server but will not be visible to the user until the next pull (or download) of that information while the update of pushed information will be seen on the next push of that information from the server to the client [3]. For a triggered or continuous push, the client will receive that information immediately. If, however, the push is periodic, the client will have to wait on the average of half the length of the period before the server pushes the updated information back to the client [3].

2.2 Design Considerations

There are different types of portal interactions which have direct impact on the design of these portals. Handling of cache updates and security are influenced directly.

Cache updates: Most Web browsers keep the most recently viewed Web pages at the client in the cache to reduce network load and to decrease response time at the client. Whenever a client requests a page (pull), the browser first looks in the cache and, if the page is present, simply displays that page rather than go across the network to the server to pull the page again. This may cause problems for all volatile data that might be updated. Pushed data contains new or updated information for the user and will not be present in any document or information cached by the user. Similarly, the information at the server may be updated by one user while being pulled by another user. In this case, the user will not have access to the updated data even if the user does another pull as the browser will return the information resident in the cache, which is now out of date [3].

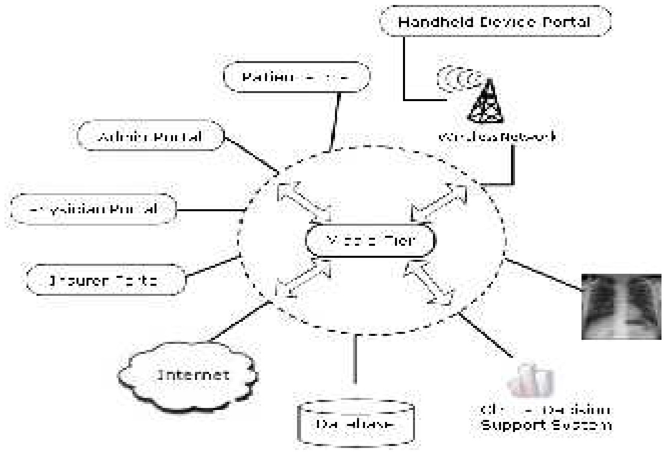

Fig. 3: Three tier architecture for a medical portal

This problem can be solved by not caching any data but this will affect the performance. Solutions implemented in distributed databases and operating systems for cache coherency can also tackle this problem.

Automatic link association: In this case when updating occurs appropriate links must be automatically generated among patient's records because, the data is not centralized. Rather, the data is maintained in Web-accessible databases in the third tier. There are two possibilities to do this. First, This entails either that the third tier Web server notify the middle tier so that these links can be generated or that sophisticated dynamic link algorithms be present in the middle tier. Figure 3 depicts the three tier architecture for a medical portal [3].

3 EMR Standards for Interoperability

Berkowicz et al. [9] suggest that viewing and manipulating clinical data in its original form becomes difficult for the physicians because available data is in heterogeneous form in nature. In 1987, HL7 was introduced standards for the electronic interchange of clinical, financial and administrative data. It defines a communication between two independent applications rather than between closely coupled, client-server type applications. This is basically a messaging format having broad content definitions. It only uses its own flexible syntax for messages. Thus, to validate the structure of a particular HL7 message can be difficult. We have selected XML as syntax for data exchange and document type definition (DTD) has been used to define and validate data structures. XML is a subset of SGML. It has recently been accepted by the W3 consortium as a standard. HL7 has a special interest group (SIG) for SGML/XML representation of health care information. It defines a communication between two independent applications, rather than between closely coupled, client-server type applications.

Although internet IETF standards have led to much success with transport and application development, there standards do not attempt to assign semantic meaning to the data that is sent from application to application across the Internet [5]. Semantic and data encoding standards such as Health Level-7 (HL7) and XML are emerging from other standard development organizations.

Among several other benefits that an EMR can provide, it provides increased legibility and distributed access, to the most basic level. More benefits can be achieved by carefully structuring the data such that knowledge acquisition and data interoperability can be done efficiently. Implemented optimally, an EMR application should improve communication, enhance clinical decision making, improve compliance with documentation and treatment standards, minimize redundancy, enable context specific information presentation, integrate clinical documentation and billing functions, and facilitate quality improvement and clinical research [5]. The use of a well known standard for medical data can actually make feel these benefits. The lack of common standards for representing clinical data results in ambiguities effecting data structure and semantics. Some EMR standards – that can help enjoy the full benefits of an EMR – are discussed below.

3.1 Service Oriented Architecture

Both ***iRevive***[1] *and* ***BCSEMR***[2] are based on a service-oriented architecture providing the necessary agility and flexibility to link with the various internal and external healthcare systems that are essential to an independent, critical care environment. Both ***iRevive*** and ***BCSEMR*** exchange information via web services, which provides an API that is easy to program, thus promoting data exchange.

3.2 The Healthcare Information Technology Standards Panel

The importance of common standards to exchange medical information cannot be over emphasized. This topic was recently summarized in a report from the July 2006 hearing on the Functional Requirements for a Nationwide Health Information Network. The Healthcare Information Technology Standards Panel (HITSP) has defined a "Minimal Data Set" to describe many types of medical information at many levels. This minimal data set includes the semantic meaning of medical information that can be requested, acceptable responses, and the structure messages should take when exchanging information between applications. The recommendation from the HITSP committee includes a group of standards that harmonize many heterogeneous standardization efforts into a manageable group, in order to promote interoperability that will improve treatment and reduce costs.

3.3 Emerging EMR Standards

The many components of an EMR complicate the interoperability of health care applications. The key modules of a typical in-hospital EMR are administrative systems, clinical documentation, laboratory, radiology, pharmacy, and physician order entry. These areas have overlapping and competing standards, all of which have been developed by different organizations (e.g. HL7, CEN, and ASTM). Examples of overlapping terms include 11 different ways to define and spell "Total cholesterol" [Stanford and Thornton]. Below is a summary of some of the more important standards:

1. International Classification of Disease (ICD) is published by the World Health Organization. ICD is primarily used to identify a disease or problem for billing purposes.
2. Systematized Nomenclature of Medicine (SNOMED) was developed by a division of the College of American Pathologists to provide a "comprehensive, multi-axial, controlled terminology" [Stanford and Thornton] for indexing an entire medical record. SNOMED-CT (Clinical Terms) specifies the core file structure of SNOMED medical terms.
3. Logical Observation Identifiers, Names, and Codes (LOINC) is used to identify individual laboratory results, clinical observations, and diagnostic study observations.
4. Health Level 7 (HL7) is a messaging protocol for exchanging health care information. It includes several vocabularies, such as patient demographics. Unfortunately, there is poor backward compatibility between early and later versions of HL7; thus, there is poor compatibility between vendors who support different versions of the same standard.

1 iRevive is an out-of-hospital patient documentation application designed for Emergency Medical Care.
2 BCSEMR is a web based in-hospital patient documentation system developed at Harvard's BWH.

5. National EMS Information System (NEMSIS is a standard for pre-hospital care endorsed by the National Highway Traffic and Safety Administration (NHTSA). This is a domain focused standard for out of hospital emergency medical services.

HITSP is reconciling these often overlapping and inconsistent standards to enable a consistent elemental description of the EMR. It is adopting LOINC for assessing a patient's condition. This instrument consists of a set of questions and allowable answers. The questions and answers specified by LOINC use the vocabulary of other standards (e.g. HL7, SNOMED, and ICD-9) to semantically define the meaning of each message. HL7 is then used as the messaging standard for defining the flow of messages being exchanged.

4 Protocols for EMR

Janhke et al. [7] suggest that the CDS system is not able to directly query the native database or data structures underlying the EMR system. Rather, we need to rely on a core patient summary in a standardized format to be sent to the CDS component for the purpose of analysis. One challenge is to determine exactly what data elements should be considered in this core patient summary. If the summary is defined too comprehensive, it may put too many requirements on the EMR system to interface with the CDS components. Moreover, large data volume may decrease the speed of invoking the CDS function to an unacceptable level. On the other hand, if the summary is too small, the usefulness of the CDS system may be decreased, e.g., cholesterol screening may require reviewing up to ten years of lab data). One solution would be to define a multi-step protocol, which allows the CDS component to "*ask for more data*", if required during the analysis. However, care must be taken to keep the protocol simple in order to lower the cost of integrating the CDS component into EMR systems, i.e., to facilitate adoption as much as possible. Figure 4 depicts a stateless, optional multi-step protocol for EMR and CDS system [7].

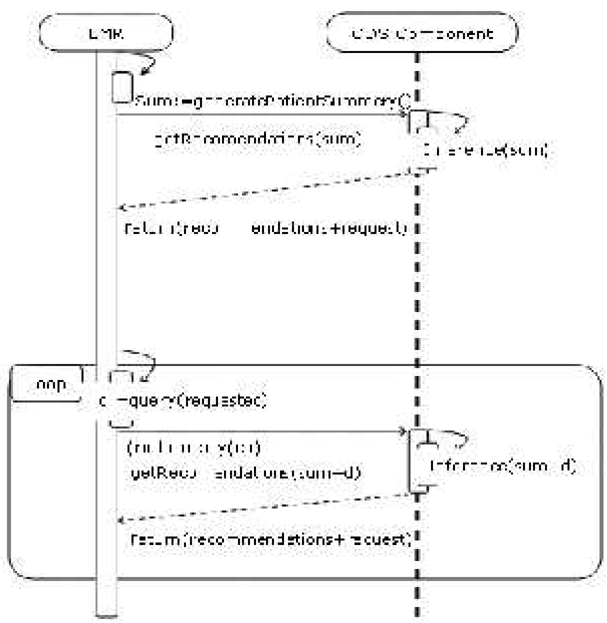

Fig. 4: Multi-step Protocol for EMR and CDS

5 Conclusion

The importance, advantages, architecture, standards, protocols and issues have been discussed in detail. Some guidelines have also been mentioned for a successful implementation of an EMR system. Literature review yields that EMR are becoming an increasingly vital facet of patient safety, quality of care, and efficiency. They reduce medical errors, capture complete patient information, decrease the risk of law suits, improve reimbursement for services, ease compliance with regulations, and clinical decision support. Medical record systems so far have been shown to do the job but significant problems are encountered in the management of many systems. Web-based systems for information management will be the first step in making systems workable. Such systems will eliminate the problems caused by frequent power outages that may affect data storage causing loss and damage to data storage and backup. This will set the stage for more comprehensive development of EMR and then Patient Health Records (PHR).

6 References

[1] MacKinnon, W.Wasserman, M.: Integrated Electronic Medical Record Systems: Critical Success Factors for Implementation. In: Proceedings of the 42nd Hawaii International Conference on System Sciences, pp. 1–10, 2009

[2] Wolf Medical Systems, A Guide to Electronic Medical Records, http://www.wolfmedical.com (accessed May 12, 2009)

[3] Shepherd, M., Zitner, D., Watters, C.: Medical Portals: Web-Based Access to Medical Information. In: Proceedings of the 33rd Hawaii International Conference on System Sciences, pp. 1–10, 2000

[4] Verlaene, K., Joosen, W., Verbaeten, P.: Arriclides: An Architecture Integrating Clinical Decision Support Models. In: Proceedings of the 40th Hawaii International Conference on System Sciences, pp. 135–144, 2007

[5] Gaynor, M., Myung, D., Gupta, A., Rawn, J., Moulton, S.: Interoperability of Medical Applications and Devices. In: Proceedings of the 41st Hawaii International Conference on System Sciences, pp. 241–250, 2008

[6] Sood, S.P., Nwabueze, S.N., Mbarika, W.A.V., Prakash, N., Chatterjee, S., Ray, P., Mishra, S.: Electronic Medical Records: A Review Comparing the Challenges in Developed and Developing Countries. In: Proceedings of the 41st Hawaii International Conference on System Sciences, pp. 248–257, 2008

[7] Weber-Jahnke, J.H., McCallum, G.: A Light-Weight Component for adding Decision Support to Electronic Medical Records. In: Proceedings of the 41st Hawaii International Conference on System Sciences, pp. 251–260, 2008

[8] Wiggins, C., Pumphery, L., Beachboard, J., Trimmer, K.: Entrepreneurial Governance in a Rural Family Practice Residency Program. In: Proceedings of the 39th Hawaii International Conference on System Sciences, pp. 97a–106a, 2006

[9] Berkowicz, D.A., Barnett, G.O., Chueh, H.C.: Component Architecture for Web Based EMR Applications. In: Proceedings of the AMIA Annual Fall Symposium, pp. 116–120, 1997

[10] Burt, C.W., Sisk, J.E.: Which Physicians and Practices are Using Electronic Medical Records? In: Health Affairs, pp. 1334–1343, 2005

[11] https://www.infoclique.com/ (accessed May 12, 2009)

[12] Wang, K., Kohane, I., Bradshaw, K.L., Fackler, J.F.: A Real Time Patient Monitoring System on the World Wide Web In: Proceedings of the AMIA Annual Fall Symposium, pp. 729–732, 1996