

Comprehensive Patient Health Care System for the Saudi Hospitals using Information and Mobile Computing Technologies

A. A. Siddiqi*
M. Ahmed*
Y. M. Alginahi*
A. Alharby*

ABSTRACT

Information Technology (I.T) forms an important part of the healthcare solution. Accurate and up-to-date information is essential to continuous quality improvement in any organization, and particularly in an area as complex as healthcare. Therefore, diverse information systems must be integrated across the healthcare enterprise. The knowledge base in the medical field is large, complex, and growing rapidly. It includes scientific knowledge, as well as familiarity with the day-to-day business of providing healthcare. It is crucial to identify the processes in the healthcare sector that would be benefitted from the support of Information Technology. The paper is focused on the use of Comprehensive Patient Healthcare System (CPHS) comprising two large subsystems, Computerized Patient Record System (CPRS) and Mobile Computing Clinical System (M.C.C.S) as an application of state-of-the-art information and mobile computing technologies in Saudi Arabia hospitals as part of an ongoing research project. Significantly, the use of such technologies with highly efficient techniques for essential information gathering in a timely and cost effective manner in hospital sites is critical in order to understand how to enhance quality health care services to improve the life of patients and rapid

* Taibah University, KSA, asiddiqi@taibahu.edu.sa

decision making. It would therefore be expected that the project would facilitate optimal hospital resource utilization for medical purposes in Saudi Arabia. This development would therefore pave the way for opening new venues in which such highly advanced information and mobile computing technologies are employed in the hospitals and other sectors beyond the field of medical care.

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KEYWORDS

Comprehensive Patient Healthcare System (CPHS); Computerized Patient Record System (CPRS); Mobile Computing Clinical System (MCCS); Information Communication Technology (ICT); Mobile Technology

INTRODUCTION

The greatest challenge in the new integrated healthcare delivery is to provide comprehensive, reliable, relevant, accessible, and timely patient information to healthcare providers. Health Care (Harris, 2004; Hannah, Ball, & Edwards, 2005; Kohn, 2006; & ISO/TC 215, 2007) is one of the last industries yet to undergo full computerization. Although we currently call up prescriptions, diagnosis, laboratory results, order tests, and bill patients using computerized systems, many facilities are still using age-old manual methods for recording clinical information and physicals, nursing notes, assessments, and treatment plans. A recent international survey of health care organizations found that almost 30% of hospitals/clinics have computerized the documentation process with computer-based patient records. It is estimated that only about 15 to 20 % of physician offices and 20 to 25 % of hospitals have made the

investment, but a recent study shows that one-third of small practices have computerized medical records in their plans for the next two years (**Red Orbit, 2009**).

Accurate information regarding family health history is one of the criteria for many of the practice guidelines. Any medical information should be recorded. Even illnesses that do not seem important to the patients may ultimately allow a physician to make a more accurate diagnosis or to begin screening for certain conditions as soon as possible. A little documentation can go a long way towards preserving an individual's health, prolonging their life and preventing the development of certain ancestral illnesses such as young-age heart attack.

Combining Information Technology (IT), Mobile Computing technology (**Adelstein, Gupta, Richard III & Schwiebert, 2005; Boukerche, 2005; Wigley, Moth & Foot; Mobile Computing, 2009**), and Wireless networking technology, the "MobileNurseTM" (**Implementation of Mobile, 2001**), a prototype of mobile nursing information system using Personal Digital Assistant (PDA) has been recently used for retrieving patient information such as, physician orders and test results at anywhere or anytime. It could enable nurses to provide point-of care by reducing time-consuming, redundant paperwork, hence, ultimately, it could improve the quality of care (**Marge, 2003**).

With the use of PDAs in clinical environment, nurses can spend more time with patients and provide '*hand on*' care by reducing time-consuming, redundant paper work. Ultimately, it could improve the quality of care. Intel Corporation is hoping to transform the bedside manner of hospital nursing staff and doctors by replacing traditional paper-based patient notes with an interactive tablet-computer. The mobile clinical assistant (MCA), which has been co-designed by Intel

and Motion Computing, could allow clinical staff to instantly access and update all centrally stored patient details at the bedside. The device is currently being field tested in United Kingdom hospitals. The MCA could offer safe wireless connectivity to access patient information and physician's orders (**Corder, 2007**).

The "**dbMotion**" (**dbMotion, 2009**), is an innovative provider of medical informatics. It develops and markets the dbMotion Solution that securely shares medical information, creating a Virtual Patient Record by logically connecting a group of care providers and organizations without data centralization or replacement of existing information systems. Medical Net Systems "**Encounter Suite**" (**Encountersuite, n.a**), is a unique, secure **Web-based E-Medical Records** (EMRs), served up by an application service provider. It has several unique features - a Patient Generated Medical History that collects patient's information and forms a comprehensive history, an adaptable physical exam in a point-and-click-format, and an assessment and plan that produces a comprehensive evaluation of a patient's medical conditions while minimizing workload and increasing efficiency.

The "**e Clinitek**" (**2007**), is a system designed to help doctors to manage patient's records. Patient's record could comprise of his/her chronic conditions or perfect systems, which have helped in diagnosing the problem or it, could provide daily routine checkup details like blood pressure, pulses etc. The system is also capable to let one to enter the operation photographs or pictures related to Ultrasound, CTScan, Xray etc. Instant Medical History (**Instant Medical History, 2009**), interviews patients to begin gathering the subjective history prior to the encounter. Branching logic enables patients to progress quickly through adjustable questionnaires from an extensive medical knowledgebase. Sophisticated technology

enables this information to be transferred to EMRs or print-outs for the chart.

In this paper, the proposed research is aimed at KSA hospitals. This proposed Comprehensive Patient Healthcare System (CPHS) comprises two large subsystems, Computerized Patient Record System (CPRS), and Mobile Computing Clinical System (MCCS), which will then be integrated together.

The quest to establish a modern health care system that could meet all the needs of the citizens in Saudi Arabia began in earnest with the introduction of the first of the five-year development plans in 1970^{**}. With most of the necessary hospitals and other medical facilities either established or under construction, the emphasis in Saudi health care in recent years has steadily shifted to improving the quality of care and broadening the scope of specialized fields of medicine covered by the Saudi network.

METHODOLOGY

The need for information and communication technology innovation is increasing in use of computer-based patient records. Timely access to data related to the patient at hand is critical, especially, in health care environment requiring rapid clinical decision making. Patients seek information, which is about their health conditions. Therefore, systems that enable nurses and support staff to share information with patients at any time are also needed, regardless of place. There are many new technologies, which are being developed to improve the efficiency and productivity of hospital staff. The proposed research project aims to use tools and technologies which are deemed the future technologies. These include Wi-Fi Wireless Technology, PDAs, Java, Client Server model, SQL/Oracle, and Rational Unified Process (RUP) model for

software engineering (Gibbs, 2006). In addition all modern IT technologies shall also be put in place.

The research project proposal sets out to investigate, design and develop a comprehensive healthcare system, which could easily be deployed in any general hospital or healthcare centers. Server-side programming and client-side programming for the mobile devices would be the core issues of this design and research methodology. The main scientific and technical issues concerned to the proposed research would fall into following categories.

- **Information Technology**
- **Mobile Computing Technology**
- **Wireless Technology**
- **Human Computer Interaction**

INFORMATION TECHNOLOGY

Information technology forms an important part of the proposed healthcare solution. Accurate and up-to-date information is essential for continuous quality improvement in any organization, and particularly in an area as complex as healthcare. This research and design methodology includes integration of CPRS and MCCA, which would yield great results in providing quality healthcare.

Software tools will be used to assist with broad and accurate knowledge acquisition from healthcare providers and to help determine the business case for reengineering and technology development. The tools developed under this proposal will provide maximum flexibility for healthcare systems development. For example, the development of information brokers, which translate

and transfer knowledge among many vocabularies, databases, and information systems, can enable interoperability of new and existing applications.

Technical goals to be achieved are:

- ◆ Reliable storage and retrieval of complex medical information for varied applications by CPRS
- ◆ Real-time, data-driven medical decisions
- ◆ Real-time data entry by mobile computing subsystem, M CCS
- ◆ Real-time transfer of complex medical records with accuracy, speed, and security
- ◆ Core security services (confidentiality, authentication, access control, integrity, non-repudiation, logging and audit)
- ◆ Methods for designing, building and maintaining scalable and secure systems

MOBILE COMPUTING TECHNOLOGY

In the design methodology, the main aim is to design the client software or user interface for the nursing staff. Designing user interfaces for PDAs pose unique challenges relative to design for traditional desktop applications. The most significant of these is reduced screen size. Thorough investigation would be conducted on the use of J2ME application models. J2ME (Java 2 Platform, Micro Edition) (**J2ME,2009**) is a technology that allows programmers to use the Java programming language and related tools to develop programs for mobile wireless information devices such as cellular phones and PDAs.

WIRELESS TECHNOLOGY

Wireless technology is making new innovations possible in the field of healthcare. Mobile and wireless technology, combining the

Wi-Fi network with care-critical applications and content is deemed to be the future technology used in the healthcare. The design methodology of the research proposal would include setting up a WiFi/802.11 wireless local area network standard. As part of research, an investigation would be made on connecting the PDAs with the centralized database server using Wi-Fi technology (**Leary & Roshan, 2003; Brisbin & Carty, 2002; O'Hara & Petrick, 1999; Upadhyaya, Chaudhury, Kwiat & Weiser, 2002; Network Security, 2009**).

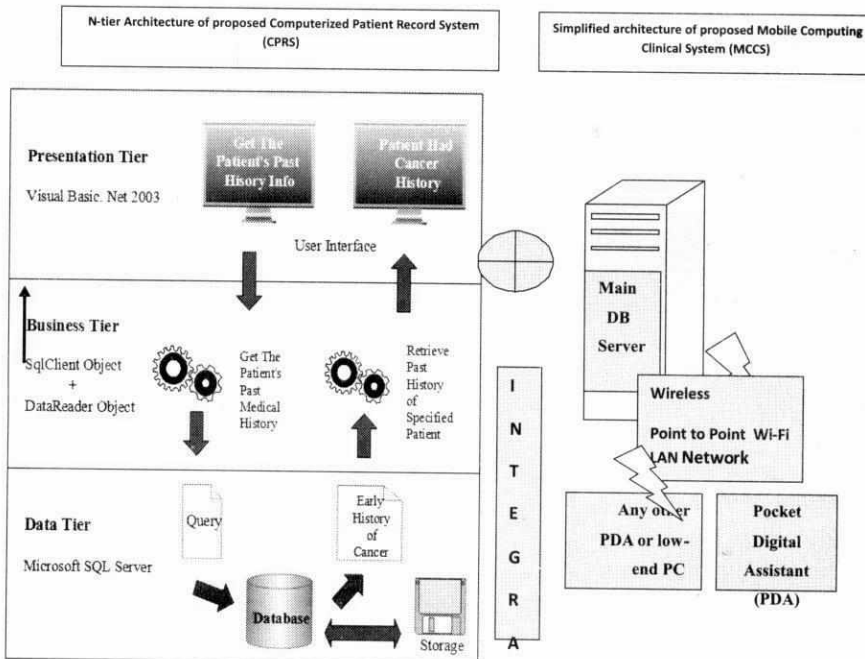
HUMAN COMPUTER INTERACTION

For any large scale software development, it is very important to address software engineering, Human Computer Interaction (HCI), and software project management issues. The proposed methodology is to adopt the Rational Unified Process (RUP) model, which includes the appropriate software development life cycle (SDLC) methodology, coding standards, quality assurance procedures on manuals, technical writing, system analysis, users requirements, design, implementation, and testing mechanisms (**Pressman, 2007; & Hughes & Cotterell, 2009**). As for HCI issues, the methodology would include the latest HCI standards for the PDA and system interface design for users and administrators. Moreover, other aspects of human computing, such as user friendliness, colouring schemes, and other Cognitive Sciences pertaining to users shall also be investigated. A great deal of efforts, time, and energy shall also be spent on the principles of software project management (SPM) (**Bechtold, 1999; Gibbs, 2006; Sommerville, 2007**).

Traditionally doctors interview patients manually, and the records then are maintained by staff. This results in documentation errors, waste of time, inconvenience, and often wrong dosing and

prescriptions. This proposed Comprehensive Patient Healthcare System (CPHS) comprises two large subsystems, Computerized Patient Record System (CPRS), and Mobile Computing Clinical System (MCCS). After successful implementation of the two subsystems, the aim of the project is to integrate both. The CPRS would be developed by using modern technologies, as the old systems which have been developed in the past cannot cope to meet with the new demands and challenges in the modernization of health sector. Similarly, nursing staff fill the charts, check readings, and maintain the patient records. This old way of patient care is also prone to many problems, such as wrong information in charts, too much time spent on maintaining the charts, etc.

System Design Figure 1 Architecture for the Proposed Research Project



This also keeps the nursing staff away from patients, which is a waste of human time and energy. One of the sole responsibilities of a nurse is to be close to the patient, so as to provide the patient full attention and comfort. To automate the function of nursing staff, it is proposed to design and develop a mobile computing clinical system, which basically is about developing a digital environment where nurses and other clinical staff do not have to spend hours on just filling, correcting and maintaining the charts. The CPRS would also automate important information about patient, such as doctor's notes, lab tests and imaging results. It would also allow doctors to access the medical reports of patient's condition rapidly, which will help the doctors in decision-making process.

The MCCA deals with the automation of patient's vital signs information at the point of care using hand-held device, such as a PDA. Data capture and retrieval using a (PDA) by nursing staff enhances patient care and improves efficiency. MCCA is about developing a digital environment that would enable the clinical staff to use PDAs connected remotely to a central database (server), modern wireless communication technology, called Wi-Fi (**Adelstein, Gupta, Richard III & Golden, 2005; & Boukerche, 2005**). This subsystem would have decision supporting tools, which have algorithms running in background that can assist nursing staff at the point of care, so as to help capturing the data and reducing errors, because people forget to document!

This proposed product would facilitate electronic medical records and core business function for KSA general hospitals. The CPRS would be integrated with a MCCA through a wireless network. The patient's data would be captured using a personal digital assistant (PDA). The system will improve decision-making and patient care while easing overall workloads. As a result, this would largely

reduce paper work and filing while streamlining the day to day hospital operations.

Main objectives of this project are to:

- Design and develop a CPRS and MCCS by using the most modern information and communication technologies, which includes mobile computing, wireless networking, and use of smart hand-held devices, such as PDAs.
- Provide doctors, nursing staff, management, and administration of the KSA general hospitals with flexibility to access patient data any time and manipulate it as per the rights assigned.
- Provide nursing and other support staff with access to patient's data in real time using mobile computing technology like PDA connected to server, connected in wireless environment, such as Wi-Fi. Staff could reduce time, redundant paperwork, and consequently it would enable nursing staff to give more time to patients and to provide *'hands on'* care.
- Generate prescription automatically by selecting the diagnosis name.
- To provide doctors with facility of viewing the online lab reports, images, and other multimedia information pertaining to patient's record.
- Facilitate management of hospital to monitor daily activities performed by a doctor and his contribution to the hospital in terms of number of patients examined. It would minimize the time span, human resources and paper usage of data processing by providing convenient functions to search, view, edit and save patient's record.
- Search a patient record by simply entering a patient's name or

key in few characters of the patient's name. Since the patient file is clearly organized, user can quickly pinpoint the exact information needed. There is no more page by page searching of paper files. Information within the computerized files is complete and legible.

- Provide hospital staff access to their domain of information, i.e., a doctor can view only his set of information. Additionally, another level of security would allow nurses access to only a fixed set of patients data, and not all. This ensures that CPRS provides security at all levels and wards off unauthorized access.
- Perform statistical tests so as to monitor the effectiveness of the system.
- Provide the hospital management with sufficient data to do decision-making.
- Apply the software engineering techniques, specifically the software project management (SPM) principles and procedures during all stages of software development, so as to safeguard the quality assurance of the project.

The anticipated achievements and outputs are:

The core CPRS is to be designed and implemented in order to comprehensively automate patient records and the MCCS is to be designed and implemented in order to automate the activities of the nursing and clinical staff. When both systems are coupled together, a revolutionary system would emerge into the area of automation of patient history systems, which would assure the guaranteed quality health care and cost effectiveness. The prototype to be implemented would comprise few PDAs, laptops, and PCs connected to centralized database server, via wireless station along with all

supporting software.

The Ministry of Health, KSA, has been very keen on employing the modern technologies into the health sector, especially the armed services hospitals. But general hospitals and health centers, which come under the public domain, have been largely devoid of applications of modern technologies.

Since our proposed system would be a result of sophisticated, and cutting edge information and communication technologies, it could be considered as very viable, scalable, sustainable and affordable to the hospitals. The anticipated achievements and objectives of this research work are:

- With computerization of the patient medical record, there is the potential of having a complete patient medical record.
- Legibility of information is guaranteed.
- Ordering tests can be done much more quickly than with a physician order sheet that is on paper. Orders and results would be automatically and immediately recorded in the patient medical record.
- “*Clinical checking*” of medication orders can be done by the computerized system including checking for wrong doses, wrong choices, wrong techniques, delays, known allergies, missed doses, wrong drugs, drug-drug interactions, etc.
- The system would inform a doctor of trends in the patient's health based upon measurements taken over a period of time (e.g., increase in blood pressure).
- The computerized patient medical record system would record actual outcomes of treatments.
- Storage of diagnostic images digitally would save lots of money.
- Patient could be given a printed document which would be

reviewed by a nurse, explaining the diagnosis, what the patient needs to do to get or keep healthy, and what medications have been prescribed or tests have been ordered.

- Patient could check for the accuracy of information in the patient record and correct any inaccuracies.
- Use of PDAs by nursing and other supporting staff would reduce time, redundant paperwork, and consequently it would enable nursing staff to give more time to patients and to provide *'hand on'* care.
- Transcription time and associated costs would be saved. Time and costs to do ordering could be cut, as well as costs of transporting paper orders and paper returned results.
- Communication between doctors would be speeded, and the process of oversight of nurse practitioners and physician assistants by supervising physicians could be facilitated.
- Money can be saved by electronic billing and electronic commerce supported by the computerized patient medical record. Billing information can be captured by the computerized patient medical record system, including diseases, procedures, providers, supplies and medications for a patient.

CONCLUSION

Indeed, the healthcare industry has a pivotal role in the economic health. KSA has long been the recognized leader in providing high quality innovative care in the Gulf region. Medical technology is the fastest growing sector. The healthcare industry is not integrated in its information management. Patient information is often inaccessible at the time healthcare decisions are made. Healthcare professionals spend valuable time looking for records,

calling each other for basic information, or repeating tests because previous test results could not be found or obtained quickly. It has been estimated by the Parkview Episcopal Medical Center, Parkview, Colorado (July 1994) that physicians spend 35 % of their time and nurses spend 50 % of their time on paperwork (**Advanced Technology Program, 2009**).

This project would bear a great commercial value since it would guarantee quality medical care to the people of KSA with comparatively less cost and efforts spent. Valuable and critical information pertaining to patients would be available in no time at the finger tips of the hospital staff, including doctors, nursing/clinical staff and the hospital management.

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