A SIM Card-Based Ubiquitous Medical Record Bracelet/Pendant System - A Pilot Study

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Abstract—Accidents and environmental disasters constitute emergency situations whereby paramedics require the largest obtainable amount of medical information on a particular individual in as short a time period as possible. Moreover, patients suffering from medical disorders/conditions, such as dementia, epilepsy, stroke, and cardiac arrest often find themselves in situations requiring immediate intervention from medical personnel who need prompt access to personal medical records. Given the urgency of such situations, access to the required patient's information in a medical database can be tedious and may deplete critical, life-saving, time; thus, a more adaptable, interoperable, and efficient means of obtaining personal medical information becomes a necessity. As such, this study presents the design and development of a SIM card-based personal medical record bracelet/pendant system, tagged with a 'Medirec' logo for ease of member recognition, and which is readable on Nokia Symbian mobile phones. The system consists of either a silicon-gel wristband or an army-style pendant that houses the SIM-card, encoded with the individual's medical record that is then displayed on the phone by a custom-developed 'Medirec' software application. The developed system is cost-effective, un-encumbering, and ubiquitous; and is considered to be interoperable with existing database systems. It also takes into account the holder's right to privacy inherent in the procedural manner in which the information is handled. At the same time, the system is considered to be interoperable with existing database systems.

Keywords- Personal Health Systems; Personal Health Records; Personalized Health; Mobile Health; Electronic Health Records.

I. INTRODUCTION

Medical Informatics is a subdivision of Biomedical Engineering defined as “the scientific field that deals with biomedical information, data, and knowledge - their storage, retrieval, and optimal use for problem solving and decision making” [1]. An enormous leap has been witnessed in this field with the advent of the computer age and the booming era of computer science around the end of the twentieth century. Thus, to serve its needs, Medical Informatics has leapfrogged towards employing complex methods such as systems engineering, expert systems, artificial intelligence, neural networks, database design, and applied mathematics and statistics.

On the other hand, the advances in digital technologies have permitted the storage of massive amount of information on small electronic surfaces - relieving large areas within hospitals that were used as repositories to these medical records; hence, leading to the growing shift of medical records from being paper-based to electronic databases. Within the same context, the advancement and proliferation in healthcare, subsequent to the Second World War period, and the growing influx of patients requiring healthcare, particularly with the booming population, have acted as a hindrance to the management of such enormous medical records.

Examples of the contemporary Medical Informatics nomenclatures and systems, whether generic or proprietary, include: Hospital Information systems (HIS), Clinical Information Systems (CIS), Electronic Health Records (EHR), Electronic Medical Records (EMR), Picture Archiving and Communication Systems (PACS), OpenMRS (OpenMRS LLC, Indianapolis, IN, USA) - a community-developed, open source, enterprise electronic medical record system platform, Google Health (Google, Inc., Mountain View, CA, USA), and MSN HealthVault (Microsoft Corp., Redmond, WA, USA).

At the individual level, a personal interoperable electronic medical record would provide a complementary means to the existing large-scale medical systems. As such, this paper presents the design and development of a SIM card-based personal medical record bracelet/pendant system that is readable on mobile phones. The developed system is cost-effective, un-encumbering, and ubiquitous; and is considered to be interoperable with existing database systems. It also takes
into account the holder's right to privacy [2]. Moreover, the system lends itself vital in paramedic emergency situations, ranging from large-scale disasters, such as earthquakes, hurricanes, tsunamis, and air crashes, to individual accidents and medical disorders, such as dementia, epilepsy, stroke, cardiac arrest, among others.

II. LITERATURE REVIEW

There is substantial literature pertaining to portable medical records. The following were selected for this paper:

A. Medical Records and Interoperability

In 1979, Sherman and Libow studied the feasibility of a portable medical record system in an elderly population [3]. Meingast et al. have worked on security and privacy issues related to patient healthcare information technology; the study explored the implications of the next-generation health management technologies, in terms of privacy and security, in order to minimize routine problems, such as the difficulties that face physicians when accessing patients' information, as well as the limitations of time, space, and personnel for monitoring patients [4]. Miadowink et al. studied the development and implementation of a biomedical information network in a hospital, stressing the importance of design considerations in creating a robust network with increased levels of functionality [5].

Using Digital Access To Medication (D-ATM, Substance Abuse and Mental Health Services Administration, Rockville, MD, USA) as a model, DeClaris examined issues encountered with interoperability as well as success achieved during its development [6]. The objective of the study was to present a roadmap for clinical interoperability of patient management data within private industry. In another paper and based on the campaign carried out by the Chinese government, over the latter years, aiming at medical reform with the objective that every and each of the 1.33 billion Chinese citizens could have access to basic medical health services, Junping et al. explored the application of e-Health in China and its challenges [7].

In their paper entitled “Multidimensional Medical Decision Making”, Hudson and Cohen stated that the physician of the 21st Century is “faced with multi-parameter analyses that include sophisticated imaging, advanced cardiovascular studies, extensive laboratory tests, and genetic information, all of which impact diagnosis, treatment, and prognosis” [8]. Accordingly, the authors proposed that in order to assist the physician in clinical decision making, new informatics tools that are conformable to new methods of diagnosis and to advancement in information technology are to be sought. Quantin et al. proposed the creation of a secured European Patient Identifier (EPI), encoded on individualized smart cards that are interoperable and permit linkage of the major databases at all levels [9]. As such, “the medical records of all Europeans would be available and accessible to the entire European health workforce”.

Kalogriopoulos et al. highlighted the leading role of developed countries in the modernization of medical records and the way the developing countries are progressing from paper-based medical records to e-records [10]. The authors stressed the existing difference in systems’ requirements between these countries. The authors continued with a brief delineation of the benefits of Electronic Medical Records in developing countries and which systems would be best fit in a particular situation. Vivas et al. investigated various security mechanisms based on digital certificates implemented in a novel telemedicine network interconnecting hospitals, over the Internet, within different regions of Venezuela [11]. The developed network “guarantees the confidentiality, integrity and availability of the medical information of the patients for the hospitable centers involved.”

B. Smartcards

Leehan and Leralut compared the JPEG2000 standard compression method to that of a full-frame wavelet packet in the context of storage of electronic medical records on the newer versions of smart cards [12]. Xiao and Yu have proposed a method for developing a personal portable medical record smart card, together with a simplified framework for maintenance and transfer of patient records [13]. The aim behind such a proposal is to secure a feasible and cost-effective stepping stone towards a nation-wide electronic records system. Under the name MyCare Card, Rybynok et al. presented the design, development, and evaluation of a prototype patient electronic health record portable card to be implemented in the United Kingdom [14].

C. Mobile Phones

In an attempt to assess the effects of recent research in e-healthcare on the next generation of mobile health systems, Prentza et al. presented a study on the use of e-Vital and CHS in the delivery of healthcare services over mobile phones [15]. These two projects were developed under the IST and eTen Programs of the European Commission.

III. MATERIALS AND METHODS

The personal medical record bracelet/pendant system developed in this study consists of either a silicon-gel wristband or an army-style pendant that houses an ACOS3-24-SIM (Advanced Card Systems, Ltd., Kowloon Bay, Hong Kong) smart-card. The bracelet/pendant is tagged with a customized ‘Medirec’ logo for ease of member recognition in an emergency situation. The material used for the SIM-Card housing was selected based on its durability, water-resistance, hypoallergenic, and light-weight characteristics. The SIM-card receptacle has a mechanical component (a push-and-slide mechanism) to hold the SIM-card in place and protect it from the elements as well as unintentional release. The 16-kByte SIM-card, Figure 1, is programmed via an ACR38 SDK.
The system is driven by an Acer (Xizhi, Taipei City, Taiwan, ROC) Aspire 5738 laptop, with an Intel Core 2 Duo 2.2 GHz processor (Intel Corp., Santa Clara, CA, USA) and 2 GB of RAM, running on a Windows XP (Microsoft Corp., Redmond, WA, USA) platform. The programmed SIM-card is then mounted on a Nokia 5630 XpressMusic Symbian (Nokia Corp., Espoo, Finland) mobile phone to display the individual's medical record through a custom-developed 'Medirec' software application, shown in Figure 2.

The Nokia phone was selected based on: i) its leading rank in worldwide sales of mobile phones (28.9% of 1.596 billion mobile phones sold in 2010 [16]), ii) the widespread use of its Symbian operating system, and iii) its ease of programming using JAVA Mobility Edition (Oracle Corp., Redwood Shores, CA, USA).

The SIM-card contains four clusters: i) General Information, ii) Medical History, iii) Medical Encounters, and iv) Others. The clusters contain the following properties:

**General Information**: Name, Gender, Marital Status, DOB, Blood Type, Telephone, Address, and Alternative Contact.

**Medical History**: Surgical History, Obstetric History (for females), Allergies and Medication, Family History, Social History, Habits, Immunization History, and Developmental History.

**Medical Encounters**: Chief Complaint(s), Present Illness, Physical Examination, and Assessment and Plan.

**Others**: Orders and Prescriptions, Progress Notes, Test Results, Medical Images, and Other Information.

This information is encoded onto the SIM-card via a USB-interface SIM-card reader/writer, as an Extensible Markup Language (XML) file. On the other hand, the 'Medirec' software application was developed using NetBeans IDE (Oracle Corp., Redwood Shores, CA, USA) with Java™ Mobility Edition (J2ME) programming language.

A Nokia Symbian mobile phone emulator, provided in the Nokia Symbian SDK, was used to test-drive the application and to refine the developed system's design. Subsequently, the application was deployed on the actual mobile phone.

IV. RESULTS

In a medical emergency situation, paramedics can easily identify and provide the appropriate medical treatment to an individual wearing the SIM card-based medical record bracelet/pendant system developed in this study. This can be accomplished by dislodging the SIM-card from the receptacle on the bracelet/pendant and inserting it into a Nokia Symbian mobile phone running the 'Medirec' application. Figure 3 shows the system's output, revealing the personal medical record stored within the SIM-card in terms of the aforementioned clusters and their constituent properties.

V. DISCUSSION AND CONCLUSIONS

A SIM card-based personal medical record bracelet/pendant system that is readable on Nokia Symbian mobile phones has been designed and developed in this study. The choice between a bracelet and a pendant is based on personal comfort and ease of accessibility in the event of an emergency situation. The developed system has been initially intended to be used as a stand-alone means to encode personal interoperable electronic medical records; it is also envisioned to complement the existing large-scale medical information systems.
To make it a standard procedure, the encoded information on the SIM-card would be updated at the hospital or the outpatient clinic, subsequent to a medical encounter, through a pre-installed USB-interface SIM-card reader/writer. Moreover, the holder's right to privacy is safeguarded in the inherent procedure in which the information is handled, as well as the controlled distribution of the ‘Medirec’ software application.

This system has also been designed with the intention to hold medical images in a compressed format; however, limitations posed by current smart-card technologies, which offer limited storage capacity, precluded such implementation. Yet, the authors of this paper believe that according to Moore’s Law, such a limitation could be overcome within the next few years [17-18].

The system developed in this study is compatible with the work done by Quantin et al. [9], Xiao and Yu [13], and Rybynok et al. [14], yet its own originality lies in its simple design, user friendliness, adaptability, durability, low cost, and potential of proliferation, thus making it ubiquitous.

It is imperative to note that the Nokia mobile and Symbian technologies were used in this study as a proof of concept. Having in mind that the life-span of existing technologies is limited and contingent upon the ever evolving technology, the developed system has been designed to be implemented, with the necessary modifications and within a short time frame, in other compatible or advanced technologies, such as contemporary Android platforms (~100 Million activated devices in 2011).

In the same context, the feasibility of the use of RFID tags, although they offer unhindered access to data, they are vulnerable to unauthorized access and information theft, thus, requiring further security encoding measures. Therefore, the SIM-card is the preferred choice for now.

Future plans include field testing of the feasibility of the application in various simulated emergency settings, including the ease and time of accessing the data from test subjects.

ACKNOWLEDGMENT
This work was supported by funds from the Research Council of the American University of Science & Technology (AUST, Beirut, Lebanon).

Prof. Ziad Abu-Faraj and co-authors thank Mrs. Henriette Skaff in the Department of Languages and Translation at AUST for her invaluable help in editing this article.

REFERENCES


‡ All Uniform Resource Locators used in this paper were accessed on March 30, 2011.