An Efficient Emergency, Healthcare, and Medical Information System

SHIHAB A. HAMEED shihab@iiu.edu.my
Faculty of Engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

AISHA-HASSAN A. HASHIM aisha@iiu.edu.my
Faculty of Engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

SHAHINA SHABNAM M. SHARIFUDEEN shahina_shabnam@yahoo.com
Faculty of Engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

VLADIMIR MEHO vladimir.miho@gmail.com
Faculty of engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

OTHMAN KHALIFA khalifa@iiu.edu.my
Faculty of engineering/ Electrical and Computer Department
International Islamic University Malaysia
Kuala Lumpur, 53100, Malaysia

Abstract

Many of the current Malaysian medical information and emergency systems are still paper-based and stand alone systems that do not fully utilize the Internet, multimedia, wireless and real time technologies. This research work focuses on developing an integrated Emergency, Healthcare, and Medical Information System (IEHMS) that can overcome many of the problems in the current systems. The main aim of this work is to incorporate the real-time and mobility technologies with medical emergency systems. Our proposed system can offer: SMS, MMS, live audio and video coverage. A prototype for the proposed system is implemented using open source tools.

1. INTRODUCTION

Nowadays, Internet plays a significant role in connecting all the participants in the health community. It is used to control remote medical equipments, communication between parties such as patients and doctors, search for needed information, transferring text, graphics, audio and video files as well as supporting collaboration in real-time [1].

In the web-based multimedia environment, the images for medical system can be categorized into different types: magnetic resonance (MR), computerized topography (CT), X-ray, electrocardiograms (ECG) among others as well as medical information in forms of charts, graphs and others. These images could be loaded electronically with digital devices into the patient medical information. Thus, this would prevent the patient's medical images from damage or lost. Besides, it would be much comfortable for both patient and doctor, where, a patient may go for treatment in other medical center without carrying the medical report. The doctors could also view the patient health related images for further clarification without re-examine the patient [2].

A mobile phone, PDA and other mobility devices can be used to link to the system. The wireless application protocol (WAP) is used to standardize the way mobility devices associated for Internet access, including e-mail and the World Wide Web. [3]
Many of the current Malaysian healthcare, medical information and emergency systems are still paper-based and stand alone systems that do not fully utilize the Internet, multimedia, wireless and real time technologies. We can summarize the drawbacks for such systems [4][5][6][7][8] as:

- Lack of global shared system that is being used by all the emergency and healthcare centers
- Several of the medical centers that use electronic medical storage system for storing patients' information are window-based.
- Lack of utilizing open source software, which results in expensive to maintain systems.
- Lack of supporting multimedia environment, real-time and mobility technology
- Lack of integration between medical and emergency systems
- Lack of automatic generation for Plan of Care (the P*lan of Care* is a document created to finalize the treatment order)

An emergency system reduces the risk of an emergency case to the health and safety of persons and valuables by providing an effective means of communication with relevant authorities, safety guidelines and measures to be taken in an emergency situation [9]. Several of these systems are normally rely on the existing telephone and other communications infrastructure via operators and service personnel; therefore they suffer from several drawbacks: [10]

- Require prior knowledge on how to behave under each situation.
- Require effective description for the emergency case and location to the emergency personnel on duty.
- The person reporting the emergency has to wait for a response before passing on the message.
- Lack of usage for advanced capabilities of multimedia technology such as video, graphs and pictures.
- Lack of integration with medical information systems.

Many hospitals' emergency centers are not efficient enough because the big number of emergency cases, which is not easy to be handled. In an emergency department, most likely a nurse will determine the severity of the wound and check patient's vital signs such as temperature, blood pressure and heart rate. Additional personal information and medical history have to be obtained. In case patient's information is stored in another clinic or hospital they have to be obtained. Unless the patient has brought the personal file along, getting the required information will slow down the process. An emergency physician will have to examine the patient. In some cases, the patient needs great attention and sometimes the surgery room or other devices will be needed. All these will have to be arranged in timely manner, which in general is not the case.
The lack or misunderstanding of ethical principles for people related to medical environment is another important problem that is reflected in the behavior of people as client or medical related staff, which affect the whole process.

2. EXISTING MEDICAL RELATED APPLICATIONS

Telemedicine can be defined as the use of audio, video, and other telecommunications and electronic information processing technologies to provide health services or assist health care personnel at distant sites [11]. Nowadays the evolution of wireless communication means enables telemedicine systems to operate across the world, increasing telemedicine benefits, applications, and services. The following are sample of projects that have been developed in the field of telemedicine and communication.

- **Momeda** that stands for **Mo**bile **Me**dical **Da**ta is a demonstrator that can be used from a PDA (Personal Digital Assistant) to access electronic patient record data and provide it to the consulting physician. Diagnostic information such as radiological images as well as text and laboratory data is transmitted to a wireless pocket-size terminal in a user-friendly multimedia format using Web-approach.[12] It allows patients to access customized disease-specific information material that enables them to fully understand in a simple and constructive form what their medical problem is, what the planned procedures are, what lifestyle they should follow during and after their hospitalization, thus becoming more qualified partners in the recovery process.[13]
- **The Ambulance** project was developed by the national university of Athens. They develop a portable emergency telemedicine device that supports real time transmission of critical biosignals as well as still images of the patients using GSM link. [14]
- **Emergency-112** is an extension of the ambulance project. They targeted to: reduces treatment times, improve medical diagnosis, and reduce costs by developing an integrated portable medical device for Emergency Telemedicine. The transmission of critical biosignals (ECG, BP, HR, SpO2, and Temperature) and images to an Emergency call centre enables physicians to direct pre-hospital care more effectively, improving patient outcomes

and reducing mortality. The device allows numerous communication links, both fixed and wireless which maximize the potential use in different emergency situations. Networking links to medical information databases, Hospital Information Systems, and Inter-hospital links are also provided to maximize information available to consulting physicians. The Emergency-112 system has been used successfully since 1998 in three European Countries (Greece, Italy, and Cyprus). Nevertheless, as the above projects mainly use a slow GSM link (9.6kbps), it cannot incorporate video along its transmission nor can it support high resolution imaging [15].

- **Multimedia telemedicine system** (**MTS**) is a client/server architecture that uses TCP/IP over the Internet. Doctor with patient and doctor can communicate each other by exchanging real-time data including audio, video and instant message (IM), and non-real-time data, including vital sign signals, radiological images with DICOM 3.0, file, bio-signal, bio-data etc. [16]
- Project **E-vita** is a commercial browser based electronic health record system with a low bandwidth requirement. Patient clinical encounter history with nurses, doctors and other healthcare professionals from multiple agencies can all be recorded in one easy to use browser based patient record. [17].

3. INTEGRATED EMERGENCY, HEALTHCARE AND MEDICAL INFORMATION SYSTEM (IEHMS)

To overcome the weakness of the current Malaysian medical related system; we propose this project, which is an Integrated Emergency, Healthcare and Medical Information System (IEHMS). It provides an easy to use, efficient and cost-effective web based system while making use of multimedia environment, real time and mobility technology. The main features of this system can be summarized as:

- Creating a virtual global community
- Investigating and overcoming the weaknesses of the current medical emergency systems
- Offering real time communication between the client/patient and the emergency officer through:
  - SMS (Short Message Service)
  - MMS (Multimedia Messaging Service)
  - Live chat (web based)
  - IVR (Integrated Voice Response)
  - email
- Developing a real time agent based medical emergency system by using multimedia, web 2.0 and mobility technology
- Offering User friendly web interface application:
  - For the emergency center/hospital staff to interact with the client/patient.
  - To provide doctors with up to date medical records for the patient(s)
  - To provide patients with up to date personal medical related data as well as customized disease-related information.
- Offering guidance and address to the nearest emergency center or hospital.
- Arrange all the required equipments needed in emergency cases (emergency room, surgery room, special tools needed, assign a doctor to the case, automatically inform and call the doctor, etc.)
- Offer multiple language web interfaces.
- Offering ethical principles for people related to medical environment.

The Integrated Emergency, Healthcare, and Medical Information System (IEHMS) will be developed in the web-based multimedia environment, mobility and real-time technology. The system provides an integrated medical database, which can provide stakeholders with related medical information. The registered users can log into the system to access or provide medical information based on their accessing privilege. The medical information can be stored in a variety of multimedia forms such as video, audio, pictures and text. For example, in addition to text description of patients' historical medical information, graphic images such as X-rays or video files of doctors' discussion about the disease can also be saved in patients' record.

The system will have the capabilities for finding the patient location based (in case of an emergency call) and suggest the nearest emergency center, arrange all necessary related patient information to be ready for the physician when the patient arrives, assigning a doctor to the patient based on the availability of the doctors and list all necessary requirements (if any) such as special devices or surgery room.

The system is an open cross-platform web-based real-time client-server environment with multiple language capabilities. The client system is loaded with multi-form interfaces, database access functionalities, and multimedia information processing and manipulation tools. The system provides mechanisms for exchange of image files, shared discussion lists, textual information exchange, access to images and data exported from local data bases, voice and video transmission.

The scripting language used to build the system is PHP and the database utilized is MySQL. MySQL is a true multi-user, multi-threaded SQL database server. PHP is an HTML-embedded scripting language. The goal of PHP is to allow web developers to write dynamically generated pages. By implementing MySQL and PHP together, one can design a functional web-based database quickly [18].

4. IEHMS SYSTEM DESIGN

Figure 1 shows the architecture of the overall system that consists of the following components:

- Web Server: will listens for requests from Web browsers and upon receiving a request for a file sends it back to the browser. It will host the program and control information for the system
- Database: this is a fundamental part of the system. It stores all important and detailed information about the system stakeholder such as general users, emergency authorities, doctors, patients, hospitals and emergency centers, places or locations and events within the area of implementation. .Beside that there is detail set of prerecorded SMS and MMS, which are suitable for different emergency and guidance cases. In addition, the database supports real-time multimedia. Hence it has both temporal validity and precise timing constrains [19] [20], which allow it to store the most recent data and effect instant changes as soon as they occur.
- Telephony Server: will act as a Private Branch Exchange (i.e. a private telephone network used within an enterprise). The system will use the open source Asterisk PBX [21]. Users are able to call the PBX number and will be prompted with an interactive voice response (IVR). The IVR options will be generated by the Agent according to the selections made by the caller. The telephony server will also host a SMS server that will be responsible for communication between the patient/user and the Agent.
- The SMS server will continually listen for incoming SMS messages, process and pass them to the Agent. The agent will respond accordingly and the SMS server will deliver the response back to the user.
- Streaming Media Server: this is a dedicated Streaming Server for streaming multimedia to the stakeholders. It provides high quality media, effective bandwidth utilization, and supports detailed reporting and multi-stream multimedia for larger numbers of users [22].

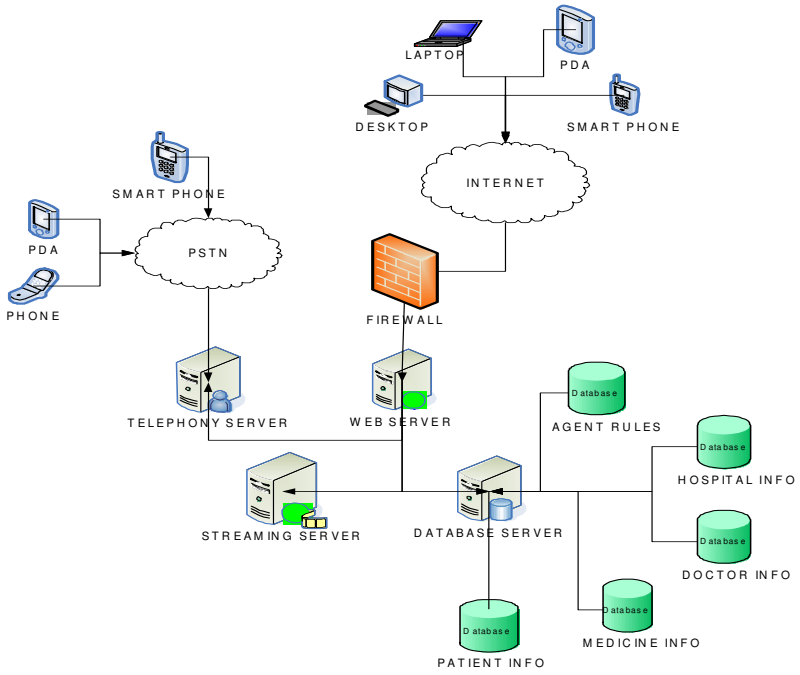

Figure1: Overall IEHMS architecture

Web Interface: the interface is simple, user friendly and requires little input from the user, mostly in the form of choices. It is based on Web 2.0 technology and has multiple language features.

5. PRELIMINARY RESULTS ANALYSIS

This research paper is work toward defining preliminary version of IEHMS system. A prototype as part of the suggested system has been build and some of the above mentioned features have been implemented. They include client application, administrator application, doctor application and mobility access system application.
Client application is the interface between the user and the system. Figure 2 shows a simple diagram of the client application architecture. It uses the Data-Manager layer to access and modify the database. The users have to be authenticated before they start using the system. The authorization function is global for all types of users, however the interface from where the users login is separated.

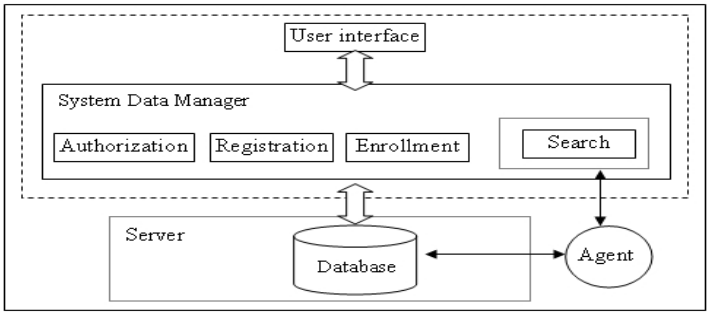

Figure 2: Client application architecture

Figure 3 shows the login interface for administrators and doctors. Each user will have different privileges that will be assigned accordingly by the system administrators.

Figure 3: Login interface

Administrator application is responsible for managing the system configuration, management of the system users, medical information, patients, doctors, hospital staff, etc. Figure 4 shows the interface for adding new doctor work schedule. Administration system is component based designed so that different components can be easily added at any time to extent the functionality of the system.

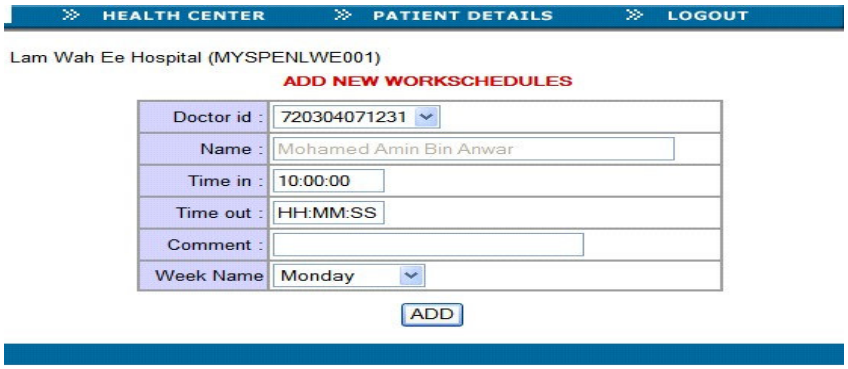

Figure 4: Add doctor work schedule

Doctor application allows doctors to access past medical reports on patients as shown in Figure 5, summary of patient's records, record diseases and appropriate medicine after consulting a patient, record diseases and any related treatment, etc.

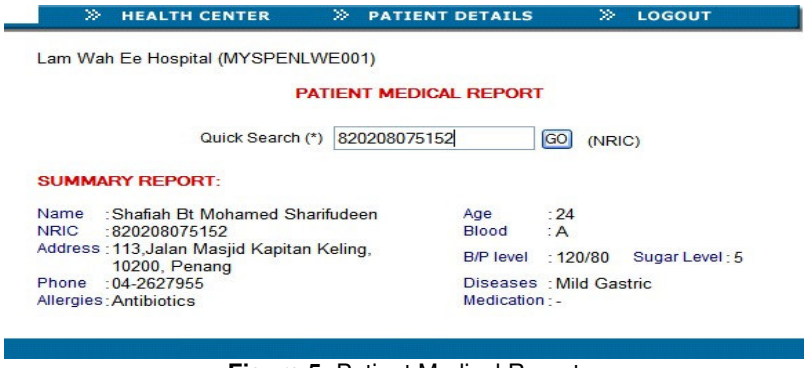

Figure 5: Patient Medical Report

Clients are able to use phone to access The Mobility Access System Application can be accessed by clients using WAP enabled phones. Figure 6(a) shows system's interface when accessed through a phone. The user can invoke the system from a mobile device to search for nearest HCC and availability of doctor as shown in Figure 6(b).

(a) (b)

Figure 6: (a) Welcome screen. (b) Search interface

Once user generates a search request, the web server transfers further requests to the Servlet engine. The Servlet communicates with the database to obtain the required data. The request is forwarded to a Java Server Page, which then reads the data and forms the response HTML document. This document is sent to the client by the Servlet engine through the web server. Figure 7 shows the architecture of the mobility access system.

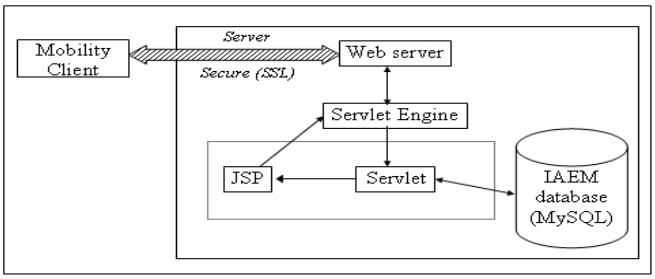

Figure 7: Mobility access system architecture

The system offers advance search capabilities on both web and mobile interfaces. Figure 8 shows the graphical user interface of the searching. Users can enter search criteria such as country, state and doctor's specialist type. In this particular example, the user is searching for "Malaysia" as country, "Selangor" as state and "Obstetrics & Gynaelogy" as doctor's specialist type.

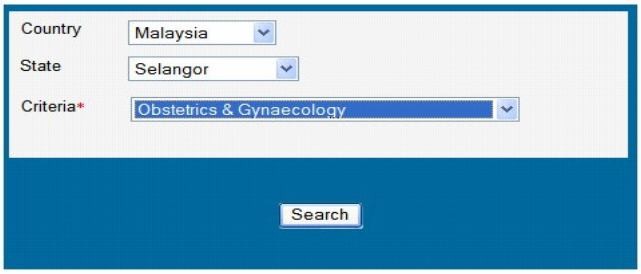

Figure 8: Search interface

The search results will be shown in friendly interface. The paging capability allows the user to easily navigate between the returned results. The user will also be able to specify the number of records that is to be displayed at a time in the screen. Figure 9 shows some sample results returned from the system.

Figure 9: Returned search results

The RDBMS used to host the data is MySQL which is open source software. The system database consists of a number of tables. A short list of tables and their description is included in the Table 1. Each of the tables consists of a certain number of related fields.

T 1: Partial list of database tables

	Description
User account	For user authentication
Patient_info	Patient personal information
Patient_medical_reco	Patient medical record
HCC_info	Health care centre (HCC) information
HCC_dept	HCC department details
HCC_staff_info	HCC Staff information which include HCC
HCC_doctor_ info	HCC doctor information

HCC_work_slot	Working slot of the doctors. This is to view
diseases_info	Diseases information and its appropriate
update_person_ info	Information about whom update the information of the patient (doctor or nurse)
country list	Country list and its 3-letter abbreviation - (for
state list	State list and its 3-letter abbreviation (filtered by country)- (for drop menu)
specialty_type	Specialization of doctor (for drop down menu)

The figure 10 shows the details for table *HCC_staff_info*.

Field	Type	Collation	Attributes	Null
StaffNumber	varchar(8)	latin1_general_ci		No
FirstName	varchar(30)	latin1_general_ci		No
LastName	varchar(30)	latin1_general_ci		No
Address	text	latin1_general_ci		No
Sex	varchar(8)	latin1_general_ci		No
Date_Of_Birth	date			Yes
Tel_No	varchar(15)	latin1_general_ci		No
IC_No	varchar(20)	latin1_general_ci		No
Position	char(40)	latin1_general_ci		No
CurrentSalary	double(10,2)			No
Hours_Week	int(3)			Yes
Permanent_Temporary	varchar(2)	latin1_general_ci		Yes
QualificationType	varchar(50)	latin1_general_ci		Yes
Date_Of_Qualification	date			Yes
Institution	varchar(50)	latin1_general_ci		Yes
PreviousPosition	varchar(40)	latin1_general_ci		Yes
Start_Date	date			Yes
Finish_Date	date			Yes
Organization	varchar(50)	latin1_general_ci		Yes

FIGURE 10: *HCC_staff_info* table details

6. CONCLUSION

The study of the current Malaysian emergency, healthcare and medical information systems shows that they have several drawbacks such as lack of sharing between hospitals, no integration between emergency, healthcare and medical information systems, lack of utilizing real-time and mobility technologies, still some parts are paper-based and stand alone systems. Thus, this paper is to develop an integrated Emergency, Healthcare, and Medical Information System (IEHMS) that can overcome many of the above problems.

The proposed system contrast with the traditional approach in which, health professionals would need to gather information from many different devices or locations in the medical center to obtain a complete picture of a patient's status.

A prototype for IEHMS using the multimedia web environment, real-time and mobility technologies has been designed and implemented. The result meets some of the objectives of developing IEHMS system. It can be used to search the nearest health center and check for the availability of the specialist doctor in that particular hospital with a minimal input from the user. The system alerts the availability doctors by sending SMS or email notification. In emergency situation SMS application is used to get assistance from the system to locate the nearest medical or healthcare centre and contacts them automatically.

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