Web-Based Database and SMS to Facilitate Healthcare Medical Emergency

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Abstract

Healthcare and medical emergency are essential systems in human life; so that many countries work toward having it. Investigation of Malaysian case shows that it suffer from locality, missing of unified electronic medical record EMR and lack of utilizing Internet, multimedia, wireless and real time technologies. Other drawbacks include: Difficulty in searching and viewing up to date records for patient, doctor, hospital, and drug, since many of such records are still kept in filing cabinet. This leads to difficulty in communication, hard to manage and exchange patient data between various medical units. The fully computerizing and combining of such medical systems will lead to produce a Novel Integrated Healthcare Medical Emergency Model (IHMEM). IHMEM includes three main parts: The web based database, the intelligent agent, and the mobility. This paper focuses on developing an interactive web-based database with unified EMR as well as using SMS facilities, where all hospitals, healthcare and emergency centers can view the patient record simultaneously, exchanging, managing and collaborate on sharing resources between medical units. A prototype for this work is build and sample of implementation results for interactive database and SMS facilities are shown. IHMEM can be easily customized to be suitable for other countries.

Keywords: web-based database; healthcare; medical emergency; intelligent agent; SMS

1. Introduction

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 model 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 and other mobility devices can be used to link to the model. 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].

Survey study for the current Malaysian healthcare, medical and emergency systems are still suffer from locality, paper-based and lack of utilizing Internet, multimedia, wireless and real time technologies. More details on drawbacks are shown in many related publications [4][5][6][7][8].

On other hand; 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].

Many hospitals and 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.
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.

2.1 Momeda (Mobile Medical Data): 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]

2.2 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 bio-signals as well as still images of the patients using GSM link. [14]

2.3 Emergency-112: is an extension of the ambulance project. It 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 bio-signals (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. 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].

2.4 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]

2.5 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 Healthcare Medical Emergency Model

L.R study and Investigation of the current situation of healthcare and medical related systems in Malaysia have several weaknesses. To overcome it we have to develop an Integrated Healthcare Medical Emergency Model. Based on requirements’ elicitation, analysis and specifications; IHMEM developed with interactive web-based multimedia environment and mobility technology. The model provides an integrated healthcare and 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 model have the capabilities for finding the patient location based 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. “Fig.1” shows the IHMEM architecture.

![IHMEM Architecture](image-url)
The model 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 model is PHP and MySQL database. 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]. The main components of the IHMEM include:

3.1 **Database:** this is a fundamental part of the system. It stores all important and detailed information about general users, emergency authorities, doctors, patients, hospitals and emergency centers, places or locations and events within the area of implementation, set of prerecorded SMS and MMS, which are suitable for different emergency and guidance cases. In addition, the database supports real-time multimedia [19] [20].

3.2 **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.

3.3 **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

3.4 **Telephony Server:** will act as a Private Branch Exchange using the open source Asterisk PBX [21]. Users are able to call the PBX number and will be prompted with an interactive voice response (IVR).

3.5 **The SMS server:** will continually listen for incoming SMS, process and pass them to the Agent. The agent will respond accordingly and the SMS server will deliver the response back to the user.

3.6 **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].

For the database part, the IHMEM utilized the 3-tier architecture including browser, web server and MySQL database server as shown in “Fig.2”. The client sides of the model are the system administrator application, medical center (MC) administrator application, doctor and nurse application, or any server client.

The database stores all the medical center information, doctors’ record and patient records. The database records are mapped in the IHMEM system application server.

4. **IHMEM Implementation (Interface and Database Design Module)**

A prototype for IHMEM is developed and sample of the implementation of the main interface and database architecture are shown in this section. A prototype of the suggested model with 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 a way for the user to go through the system. “Fig.3” shows the architecture of the client application. Database modification is done through the Data Manager layer. User login is done on the same page, but from different table in the database. The data is retrieve from the database to be send to the interface (back to user). All the data of the users are stored in the database. The communication is done at the Data Manager layer.

Administrator application; Administrator has the authority to modify all the data and the system. Admin page is important to manage data and authentication of the patients and also doctor. The responsibilities of the administrator page functions are facilitate: addition and updating of patients and medical centre with its staff, add/update the working schedules of the staff/doctor.
Staff / doctor application: The responsibilities of the Staff page functions are: Accessed past medical report of the patient; the summary of the patient report which is very important for better treatment is available. The staff could record the disease and the appropriate medicine after the consulting or treat the patient; this will be recorded in patient’s database for future references. Staff could record any new disease information and the suitable treatment plan. All the records are update after patient’s visit.

Patient Application: It is responsible for: Viewing personal and contact information, having the information of the patient next treatment or checkup, searching function for the medicine information, doctor and medical centre.

Database is created using MySQL codes. The database will store all the information of patients, staff and medical centre. Patient is relate with staff in terms of staff manages data for patients. For staff and medical centre, the staff relate with medical centre as a worker in that medical center. “Fig. 4” shows the entity relationship for the medical emergency model.

Medical Emergency model can be accessed either through the server in network system or local-host in personal computer. The model is divided into two main parts. The first part is called administration page; only authorize user have permission to access this page by entering username and password. The second part called main page so all users can access it. When user accesses the second part; there are several options for user to choose which one they want the model to do it first. The main page will displayed home, about us, health care centre and search as shown in “Fig.5”.

Searching function can be used by user to find list of: doctors, medicines, diseases, medical centre, and health tips by inserting the criteria needed. The flow of the model is shown in “Fig.5”.

5. Database Implementation Results

In this section we will present sample results for implementing IHMEM model. IHMEM model provides the registration interface for different class of users to register then view different data in database. Administrator will register the staff and their username and password will be given by the admin. The following example is for registration of new patient as shown in “Fig.6”. But, admin can only register new staff and new medical centre and only staff can register new patient.

Registered user can use the graphical user interface to log into the IHMEM by entering username and password; user needs to choose in which group they belong to, staff, patient or admin. “Fig.7” shows the login interface. Each user will be differentiating by the group and during the login after validation step; each user will be directed to the corresponding page based on their group.
After login validation user in group patient will be directed to the patient page. In this page, patient can view their own personal and contact detail information. “Fig.8” shows details for patient personal information.

Staff has the authority to view patient’s detail. In staff page, we can view the patient’s detail as shown in “Fig.9” for a list of patients. If we click on the patient name; the full detail of that patient will be displayed.

Or, for specific patient, staff can do searching by inserting patient’s IC number and click Submit. Then the server will sent the input to the database and search for patient with the given input. Sample searching result is shown in “Fig.10”.

The model offers searching the availability of the emergency unit. With this information, user can know whether the medical centre has emergency unit or not, the number of
available room, bed and ambulance. “Fig.11” shows available medical center and emergency units.

The doctors work schedules is very important to identify the availability of doctor. The system has the capability to add/update and delete the work schedule. The administrator is responsible for add/update their own respective doctors’ work schedules. “Fig.12” shows the list of staff with their work schedule.

6. SMS Module

One of the main facilities of the mobility is the using of SMS and MMS. In this paper we will focus on using the SMS facility within IHMEM. SMS module provides three main features: locate nearest healthcare center, healthcare center search and SMS broadcasting. Non-functional requirements related to this module include the following:

- The features of this module must be available only to devices that can send or receive SMS messages
- No authentication is required for:
  - locating nearest health care center requests
  - healthcare center search requests
  - SMS user registration for SMS broadcast feature

SMS module consists of two actors and three use cases. User initiates ‘locate nearest health care center’ and ‘health care center search’ use cases, while staff initiates ‘SMS broadcast’ use case.

6.1 Locate Nearest Healthcare Center by SMS

Locating the nearest health care center by using SMS is an essential feature of the system. This feature comes in handy when a patient is in need of medical attention but is not aware of the nearest health care center. Responsibilities of this module unit include:

- Handling receiving of SMS requests for nearest healthcare center
- Locating nearest healthcare center based on the provided input
- Sending SMS for nearest healthcare center information to requester

As seen in “Fig. 13” the module needs to communicate with Google Geocoding service and local hospital database. In our model all the SMS requests are received by the GSM modem. In the telephony server, a daemon continuously running in the background listens for incoming SMS requests. Once a request is received by the GSM modem, it is placed by the daemon to a queue for processing.

Once the nearest healthcare center is found, its name, address and contact information are retrieved and send by SMS to the requester.

![Figure 12 list of staff with their work schedule](image)

Figure 13: Locating nearest healthcare center

![Figure 14: Activity diagram for Locate nearest healthcare center](image)
differentiate between different user requests. To search for the nearest health care center the keyword **SNH** is used. The message format to request for the nearest health care center is:

**SNH <current_location_address>**

The SMS module will reply back to the requester with an SMS message containing the nearest health care center relevant information. “Fig.15a” shows SMS message request for the nearest health care center. The SMS module will locate the nearest health care center and return the SMS message shown in “Fig.15b”, which contains the relevant search results.

![Figure 15: Finding nearest healthcare center by SMS](image)

(a) Request SMS message  
(b) Received SMS message

### 6.2 Healthcare Center Search by SMS

SMS search module allows users to search for health care centers using short message service (SMS) platform. Users send queries to a provided universal short code (which in our model is a mobile phone number) and receive results on their phones. As shown in “Fig.16”, this module requires a single input and provides the output based on the search string.

The following is the list of input and output:

- **Input:** Health care center partial or full name (mandatory)
- **Output:** SMS requester top two search results.
- **Results:** include healthcare center name, address and contact information.

Unlike locating nearest health care center module, the search module doesn’t require a communication session with the Google Geocode service. It only queries the local health care center database.

![Figure 16: Input and output for SMS search module](image)

The SMS search module consists of a daemon running constantly in the background listening for incoming SMS search requests. Once the search requests are received by the GSM modem, they are placed into a queue by the daemon for processing. “Fig.17” shows the flow and components of the healthcare / emergency center SMS search.

![Figure 17: Health care center SMS search](image)

In fact the search may return more than one result. Thus, in our model only top two results are sent to the user. However, this can be easily changed by editing the module configuration file. Since the length of the text of an SMS is limited to 160 characters, each result is send as a separate message. Each SMS message contains health care center name, address and contact information. “Fig.18” displays the UML activity diagram for a single SMS request.

![Figure 18: Activity diagram for the Health care center search](image)

The SMS module allows the user to search for hospitals by using their mobile phones. Users send SMS search queries to the provided short code (GSM Modem number) and the SMS module will return the search results. When searching for a hospital, the search might return more than one result. Only the top two search results will be send to the user each in different SMS messages. The request SMS format is:

**SH <hospital_name>**

![Figure 19: Hospital search by SMS](image)

(a) Request SMS message  
(b) Received message

“Fig.19a” shows a hospital search request SMS message. The user is searching for a hospital that contains the keyword **Gleneagles** in the name. After the SMS is received by the SMS module, it will find and SMS back the top two search results. In this case there is only one search result returned that is sent back to the user as shown in “Fig.19b”.

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**Search string**  
**SMS Search Module**  
**Search Results:** Health Care Center name, address & contact information
Locating the nearest health care center using SMS is a very useful feature. It offers to the user great flexibility. However, SMS cannot be considered as a real time communication medium. The time that the SMS message reaches the server or the user will depend on the condition of the telephony network. However, telecommunication companies offer a faster SMS service for a certain fee. This will speed up the SMS communication between the user and the system.

6.3 SMS broadcast

SMS is a very efficient way to communicate short important information to the public. It can be efficiently used to send advices, preventions and treatment messages to patients related to different diseases. The following is a list of input and expected output of the SMS notification module:

**Input:**
- message content (mandatory)
- destination mobile numbers (mandatory)
- date and time when the message is to be send (mandatory)

**Expected output:**
- SMS broadcast the specified content to the provided destination numbers at the specified time.

Destination mobile number is one of the input requirements of the module. There are two ways to get the destination mobile numbers. The flow of activities involved in the sending of SMS notification is revealed in “Fig.20”. The module carries out the following activities:
- get SMS content
- get destination mobile numbers
- send SMS to the destination numbers

As seen in “Fig.20” all activities are carried out by the module. The module consists of a daemon continuously running on the background checking if there is any scheduled message to be sent by SMS. If a message is found the module initiates a connection to the database and gets the content of the message. Subsequently, the list of the destination mobile numbers is pulled out from the database and placed in an array. After that the module will connect to the GSM modem and send the message to all the destination mobile numbers.

**Figure 21:** (a) Registration SMS message (b) Sample SMS message received by the system

SMS is a very efficient way to communicate short important information to the public. SMS can be efficiently used to send advices, preventions and treatment messages to patients related to different diseases. SMS can be used to send prevention messages, which in return can help the spreading of the disease. “Fig.21a” and “Fig. 21b” show how it works:
- User registers to receive SMS messages by sending an SMS message to the provided short code (in our model the phone number of our GMS modem) with the message: REG SWINEFLU.
- The system will send to the user SMS messages containing prevention or other useful information. These SMS messages can be sent by the administrator by simply filling a form and the system will automatically send the SMS message to all registered users.

7. Conclusion

Locality, lack of: mobility and multimedia as well as missing of unified database and electronic medical record are main drawbacks for current medical related systems in Malaysia. We develop an Integrated Healthcare Medical Emergency Model (IHMEM) to overcome such problems.

This paper focuses on developing and implementing a prototype for an interactive web-based database with unified EMR as well as using SMS facilities, where all hospitals, healthcare and emergency centers can view the patient record simultaneously, exchanging, managing and collaborate on sharing resources between medical units. Sample of the results are shown in this paper which reflect some of the capability of this model in offering insertion, deletion, updating and searching for different related data.

The results show the important of this model in serving different stakeholders such as doctor, nurse, patients in their daily activity. IHMEM is a very helpful user friendly tool for patients and other users especially in emergency cases since it offers information about medical centers and available emergency units so the patient can go directly to the suitable and nearest one.
Results of implementing SMS module shows sample SMS facilities in searching and locating for a suitable hospital as well as finding the nearest hospital.

Although this study and model build based on the Malaysia case but it is also suitable to be used for other countries with little adjustment on data and functional description.

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8. References