Study of Mobile Emergency Monitoring Prototype System

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Abstract

In 2004, accidents remained the top 5th reason of death in Taiwan. How to promptly provide emergency medical technicians (EMTs) with usable information became an important issue in promoting emergency health care efficiency.

We try to construct a mobile emergency monitoring system to assist EMTs to access the historical medical records related to the patient and transmit the patient's bio-signal information back to the emergency department to provide the physician with sufficient information so that he may instruct and assist EMTs to handle some complex situations.

The system integrates information technology, wireless network and emergency health information, and transmits patients' information between the client site and server site through WLAN. With the synchronization control server we can still handle and store patients' data at the client site when the wireless network is not available in order to synchronize patient's data when the system is reconnected to the wireless network.

1. Introductions

With the improvement of information technology, each industry could take advantage of the efficiency and convenience that information technology has brought us nowadays. The introduction of inventions such as mobile devices and Wireless Local Area Network (WLAN), have created a mobile working environment, dramatically changing and expanding both the originally restricted working area and limited utility functions. Mobility could save time and increase efficiency and wireless technology could be unchained from the wire internet system. The characteristics of mobility and wireless complement each other.

Accident remained the top 5th reason of death last year, according to "The Main Causes of Death for Taiwan Region in 2004", which was proclaimed by the Department of Health earlier this year. It was also the Top 6th reason of death for the Taipei region in 2004. No matter in which part of Taiwan, accidents have always ranked in the top 10 reasons for premature death on various death lists. We know that emergency medical care often has the need to communicate and exchange information with the hospital concerning the patient's situation at present. There may be a long distance from the hospital to the place where the emergency medical care is given. Determining how best to provide prompt information to assist EMTs is a key issue in promoting emergency health care efficiency.

Taipei city drew up plans to develop a wireless environment city seven years ago. This plan can be divided into two stages: the first stage is to develop infrastructure like e-government, free on-line training and free e-mail account. The second stage is to arrange and set up wireless access points. The second stage started in 2003 and the hot spots were mainly distributed around hospitals, MRT stations and government office. In December 2005, the wireless service covered an area of about 28 myriare, with 2300 access points and 50,000 residents within that area. By July 2006, there will be 4000 access points around Taipei city, with a wireless service coverage area of about 130 myriare to provide service to 90% of the agglomerate population area in Taipei.[1]

We construct a system with which to provide information for emergency medical service based on the advantages of the wireless environment of Taipei city.

2. Motivations

The 60 minutes after an accident occurs or an illness is diagnosed are known as the "golden hour," the time when the right or wrong decisions have the greatest impact on a patient's condition.[2] Many studies worldwide have proven that a rapid response time in pre-hospital settings resulting from treatment of acute cardiac events decreases mortality and improves patient outcomes dramatically.[3, 4]

Many studies have already tried to improve the response time of Emergency Medical Service (EMS) by the use of technology like mobility and wireless. Sotiris Pavlopoulos et al. have developed a portable medical device that allows telediagnosis, long distance support, and teleconsultation of mobile healthcare providers by expert physicians and transmission of vital bio-signals and still images of the patient from the emergency site to the consultation site using the GSM mobile telephony network.[5]

Nada Hashmi et al. have described a scalable emergency medical response system that couples the efficient data collection of sensor networks with the flexibility and interoperability of a web services

architecture. This system integrates cellular/satellite wireless links for real time communication between local and remote sites and uses wireless infrastructure for real-time data transport between motes and local PDAs and tablet PCs.[6]

In Taiwan, two recent researches mainly focused on a wireless system using tablet PC to assist EMTs' tasks outside of the hospital. One is the "Activity Emergency Medicine System by Handwriting". It provides a more flexible way for EMTs to entry data, and synchronizes data through GPRS. The system will first store data at the client database and then transmit to the server site to avoid data loss caused by an unstable wireless link.[7] It uses web service to provide information to a health department or hospital to assist in triage and medical resource arrangements. The system's primary purpose is to provide fast information for the Health unit and hospital unit, but does not provide information for the EMTs' tasks. It only performs a one-way synchronization with the server.

The other research develops the prototype emergency information system for the Hualien Fire Department to assist EMTs' work. The system has two major features: 1. using a big press button to replace the check box, 2. flexible system interface layout to enable EMTs to choose the layout with which they are more comfortable.[8] It emphasizes improved data entry efficiency but doesn't connect with any other system. The information collected by EMTs is stored in the tablet pc and printed out for information exchange with the hospital.

3. System Design

The main design purpose of our system architecture is to assist EMTs to access the medical records and allergy history related to the patient through wireless link. At the same time the system also transmits the patient's bio-signals and physical symptoms information to the emergency department in the hospital to enable the physician on duty with sufficient information to instruct EMTs on how best to handle some complex situations.

The data collected by EMTs at the emergency scene will be first stored in the client DB in the ambulance then transmitted to the server site through the synchronization process, to avoid data loss during transmission between the client site and the server site caused by the wireless network environment.

While we usually need to consider the concurrency control problem of the DB system design, in this system we assume that the physician at the server site only reads the patient's data without changing the data, and also we assume that the use of a different client site won't demand the same patient's data because the patient can only appear at one place at one time. The brief system architecture design is shows in Figure 1.

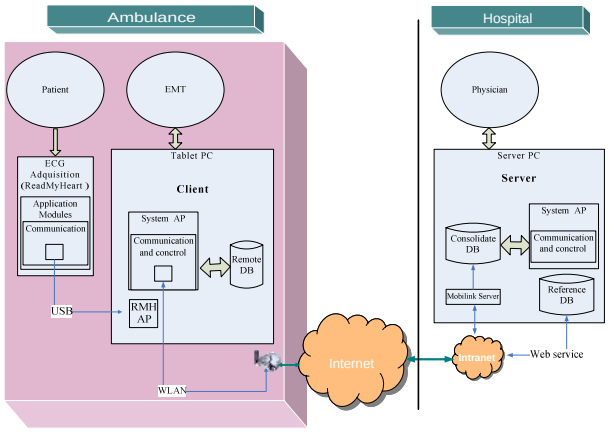

Figure 1 System Architecture

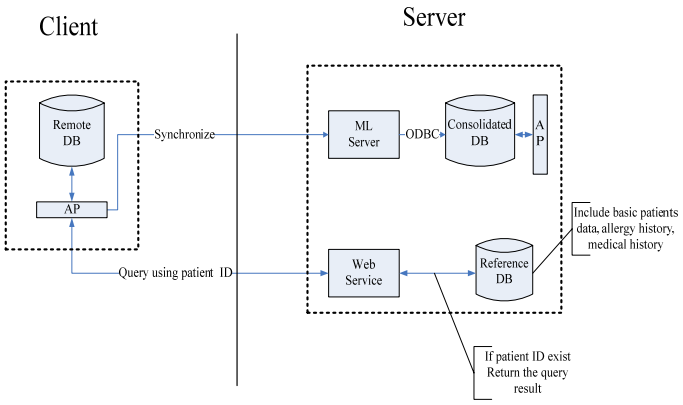

Figure 2 System Design

Because we need to make data insertion and queries to the DB in the hospital, using a client/server system design can satisfy our needs unhampered by the wireless network condition. Data could be first stored in the client's DB and then synchronized to the server DB when the wireless network link is okay. With this kind of process, we don't have to deal with the problem of missing data. The system design is shown in Figure 2.

3.1 Server Site

At the server site we set up two different DB's. We assume that reference DB is used as the HIS DB in the hospital. We can query the reference DB for patients' historical medical data using patients' ID numbers. The consolidated DB is used as the target DB for synchronicity with the client's site. We make that assumption of the view that EMTs are not members of the hospital staff, so the data entry by EMTs would be separated from the reference DB. Besides, we use medical numbers instead of patient ID as the unique identification for different emergency cases so that we can avoid data synchronization conflict.

For the synchronization control, we set up the MobiLink server to deal with the data consistence problem if the wireless link broke while the synchronization process was proceeding. Because MobiLink server controls the synchronization process with store procedures, we can't pass along the specific

patient ID number to query the DB. We use application wizard in Adaptive Server Anywhere to set up the web service for the query need.

3.2 Client Site

We use a tablet PC as our client site that consists of the system program and a remote DB (client DB).

The client DB schema is basically designed according to the emergency medical record sheet of Taipei City Fire Department. The reason for using this sheet as data input foundation is that it's in common use in ambulances. This record sheet is designed to record not only the medical care information, like symptoms or allergy history, but also the other information used to record the management needs like time interval between receipt of the call and arrival the scene. Client DB schema handles both kinds of information, but medical care information is more directly linked to patient care than the other information needs for management, but the former is still useful for the study analysis.

3.3 User Interface and System Function

This study aims to help EMTs to get the patient information like patient medical history or allergies, from the consolidated site like hospital DB, and synchronize the patient information collected on scene with the server site to provide better emergency care quality. So the system user interface design focus is on easy data entry and easy reviewing of patient information. For the easy data entry concern, the design uses the check box or dropdown list box to replace keyboard data entry. To avoid missing viewing some item, the user interface uses page leaf switch and displays all items on one screen view without using the horizontal or vertical scroll bar.

The system interface view is shown in Figure 3 and Figure 4

Figure 3 System Interface of Care Reason

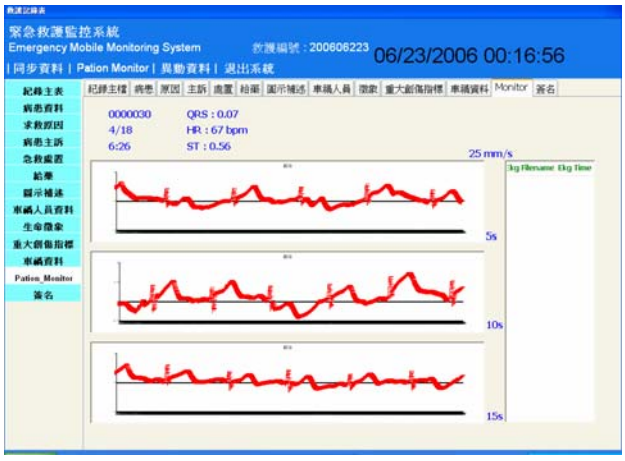

Figure 4 System Interface of ECG viewing

4. Evaluation

For the system evaluation we interviewed 5 EMTs of the Taipei City Fire Department and spent 20 minutes with each one to gain a better understanding of what they thought about this system.

We first demonstrated how to use the system and then let them try it by themselves. After they tested the system, we asked them for their opinions. The suggestions are concluded as follows:

1. Although they are satisfied with the screen size, the tablet PC is still too heavy and inconvenient to carry. 2. Using touch sensitive screen instead of digital pen to facilitate data entry speed. 3. Cooperate with the fire department mission dispatch system to reduce the data entry time. 4. The average transportation time from the emergency scene to a hospital is below 8 minutes in Taipei city, this system may be more useful in cases when the patient needs long distance transportation.

For the wireless environment testing, we tested the system in the ambulance several times, mainly around Taipei City Government building during April 12 to April 14. It is about ten minutes drive distance starting from the east square of Taipei City Government building.

At the testing scene, we placed the server site at the east square of Taipei City Government and placed the client site in the moving ambulance. Both the client site and server site were connected to WLAN, and we only inputted ECG data in the client site for the transmitting test. We also communicated with the server site using Skype to transmit the video image and voice. The scene, using ECG acquisition equipment in the ambulance is shown in Figure 5

Figure 5 System Demo on an Ambulance

Testing result:
1. Although the wireless link was interrupted in some cases, there was no ECG data lost. 2. The wireless signal was not strong enough for the moving ambulance and we needed to use an additional receiver to enhance the wireless link ability. 3. The data transmitting rate would become lower when the ambulance was crossing the area from one access point to another. 4. If the speed of the ambulance was higher then 30 km/hr, the wireless link would become unstable or interrupted. 5. The wireless signal from the SNG car would interfere with the wireless link for the client site in the ambulance.

5. Discussion

In this section we discuss medical and technical problems related to the system application.

5.1 Pre-hospital Patient Care Record

With the advancement of electronic medical records, a well-informed clinician or EMT can respond to specific patient needs in a knowledgeable fashion and may therefore avoid possible errors such as those in recording. Electronic pre-hospital patient care record with wireless transmission could provide more pre-hospital information before arrival to the emergency departments. [9, 10]

But the pre-hospital patient care record should meet the following criteria: [9] 1. Factual: what EMTs observe about the scene, what they observe on the scene, glean from their assessment, or treatments rendered to the patient. 2. Accurate: Every word and time frame should be meaningful. Inaccurate or incomplete entries, without just cause, diminish the reliability of the record. 3. Complete: The communications log should stand alone as a chronological recording of all out-of-hospital events. 4. Timely: The EMT should document as much as possible during the run.

How to control the record's quality is a problem since EMTs only have limited time to handle and respond to patients' situation while simultaneously keying in data.

5.2 Patient Information Security

About the patient information security issue, we need to distinguish two types of rights: network access rights and data access rights.

The right to access the network enables authenticated users to access the system network. We need to ensure that an EMT can only access the system network when he is on duty.

Data access rights enable the system user to consult specific patients' information. In the synchronization process, each user's rights must be strictly taken into account. It is very important that the server only sends information to the current user who is entitled access. We need to consider if the EMTs qualify the standard to look up patients' information from the server site like hospitals.

How to insure patients' information is secure and to have the information on time at the same time are problems requiring careful consideration.

5.3 Consideration of EMTs

Presently in Taiwan the first ones to respond to an emergency service are the EMTs from fire departments. Most of these EMTs are qualified EMT-II and could provide basic life-support service. But according to the research, 90% of EMTs are worried about those issues listed below which hold them back when they are providing emergency medical care.[11] 1. Providing pre-hospital care may cause unnecessary litigation. 2. Lack of manpower and funds. 3. The role and obligation of emergency medical care for fire department units and health organizations are indistinct. 4. The standard legal issues for EMTs. 5. Patients and their family members have insufficient confidence in emergency medical care provided by EMTs.

5.4 WLAN Bandwidth Allocate

According to the NCC Chairman, Dr. Su Yeong-Chin's statement, the key need for developing a ubiquitous network and successful services, is proper arrangement and the release of radio frequency. [12] Radio frequency is a rare resource and so is the bandwidth for WLAN.

Since our system aims to assist EMTs' task based on a WLAN environment, we need to consider the bandwidth allocation to ensure that the wireless connection is available for emergency situations. That is the technology 'layer' issue for WLAN.

We suggest there should be a bandwidth control mechanism to ensure that the wireless connection is available for emergency situations. For example, we may classify the information according to different categories and priorities, giving the information transmitted from government or health care institutions the highest priority. At the same time, the wireless service provider should give the government or health care institution a special log-on account to ensure they can always access the WLAN during the emergency situation.

6. Conclusion

In this study, we develop a Prototype Mobile Emergency Monitoring System that integrates information technology, wireless network and emergency health information. We use wireless internet to transmit patients' information between the client site and server site. With the synchronization control server, we can still handle and store patients' data at the client site when the wireless network is not available and synchronize patients' data as the system comes back on, to the wireless network.

6.1Technology Layer

We use non-real time synchronization technology to deal with the data consistency problem caused by wireless network link instability.

General synchronization systems do not store any data at the client site and mainly access and query the remote DB through the internet to achieve the purpose of information sharing. Because the client site does not store data, this may cause data loss or incomplete transmission when synchronizing data to the remote DB if the wireless network is unstable. So this system needs to deal with the problems caused by the broken wireless link.

Our system uses non-real time synchronization processing to avoid data loss or incomplete transmission problems caused by the wireless network. With this method, we first store data collected by the client user at the remote client site then synchronize data back to the consolidated DB at the server site. This ensures that there will be no data loss or incomplete transmission problem.

6.2 Medical Layer

Traditionally pre-hospital medical care records were only kept on paper and handed over to the emergency department staff after the patient arrived at the hospital, at the paper-based flow. Patients' information collected at the emergency scene and patients' medical records information could only be transmitted via radio cell phone which risked misunderstandings. With this system, EMTs can query patients' medical records when needed and transmit those data collected from the client site back to the consolidated DB, permitting physicians at the server site to provide the necessary instruction to assist EMTs' work.

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