EMERGENCY TELEMEDICINE SYSTEM USING MOBILE NETWORKS

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Abstract: This paper introduces a prototype of mobile emergency telemedicine system over the mobile networks. The system provides the video conference with the transmission of vital bio-signals and still images of patient from the emergency site to hospital site by using GSM/GPRS mobile telephony network. To alleviate the bandwidth limitation, a data transmission management is built-in the proposed system to improve the quality of data transmission. It controls the data transmission through the protocol selection, content prioritization, and packet queuing. Based on the system, ambulance is able to communicate directly with the hospital. The physicians can provide the healthcare services before the arrival of the ambulance, arrange the medical resources for the specific patient, or coordinate other hospital to take over this patient. As a result, pre-hospital care purpose would be achieved.

Introduction

As the heavy traffic is gradually serious, the time spent on the transportation is getting longer. When the car accident happened, the traffic usually became worse. However, the patients in the ambulance are in urgent need of the healthcare. Therefore, the pre-hospital care is particularly important in this situation.

There are many studies that have proved the feasibility and usefulness of telemedicine systems. However, most of the telemedicine systems are focus on the in-hospital care. The pre-hospital care is also important due to the bad traffic. Early diagnosis by a specialist in an ambulance is particularly important for emergency care [1]-[5]. According to the research of Marian LaMonte, M.D., M.S.N., director of the Brain Attack Team at the University of Maryland Medical Center, if we can save time and get a head start in evaluating patients even before they arrive at the hospital, we may be able to prevent more death and disability. This is very important since the clot-busting drug tPA can only be given within three hours after stroke symptoms begin [6], [7]. Therefore, if adequate pre-hospital care existed, the death toll can be reduced definitely.

The proposed system is to provide the video conference with the transmission of vital bio-signals and still images of patient from the emergency site to hospital site by using GSM/GPRS mobile telephony network. Based on the system, ambulance is able to communicate directly with the hospital. The physicians can provide the healthcare services before the arrival of the ambulance, arrange the medical resources for the specific patient, or coordinate other hospital to take over this patient. As a result, pre-hospital care purpose would be achieved.

Due to the transmission crossing the GSM/GPRS and Internet networks, interworking between heterogeneous networks is essential in this project. There are many different properties between these two networks, such as bandwidth, delay, packet loss rare, etc. To ensure the system work smoothly, the multimedia transmission over the heterogeneous networks plays an important role in this system. A data transmission management mechanism is imposed to maintain the system to operate smoothly. It controls the data transmission through the protocol selection, content prioritization, and packet queuing.

Materials and Methods

The objective of the mobile emergency telemedicine system is to provide the functionality of the video, voice, still images, and bio-signals transmission between the emergency site and the hospital site over the mobile networks. The system consists of two units: the mobile unit and the hospital unit. The mobile unit is responsible for transmitting the bio-signals of patient to the hospital, communicating with the physician, and accepting the orders from the physician. The hospital unit is responsible for providing the medical services to the emergency site and contact with the corresponding physician by the phone calls, sending SMS (Short Message Service), or MMS (Multimedia Messaging Service) messages.

A data transmission management module is involved in the system to utilize the resource of network efficiently and to avoid the influence of network, which including two basic functions: the messages classification and the prioritization. The classification function is used to classify the data into the suitable protocols according their tolerance to packet loss. UDP is usually used to transmit the un-urgent data, such as video and voice while the TCP messages include still medical images, bio-signals, patient data, and control messages. A multilevel priority pending queue is used to classify the data into three kinds with different priorities (high, medium, and low) according to the urgent level of the data. Beides, a packetization outgoing queue contains the data which is ready for

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sending out, and packetizes the data to suit to the GPRS packet size [2]. The data is selected from priority pending queue according to the priority from high to low.

The proposed system is designed to deliver the healthcare services to anywhere. It provides the tele-consultation function between the hospital and the remote mobile sites. Take into account the mobility of the remote mobile sites, for example, the ambulances, the GSM/GPRS is adopted as the communication medium for the remote sites. However, the network environment of the hospital is broadband network, i.e. Internet. The data transmission over the heterogeneous networks is also considered in the proposed system.

The objective of the mobile emergency telemedicine system is to provide the functionality of the video, voice, still images, and bio-signals transmission between the emergency site and the hospital site over the heterogeneous networks. The system architecture consists of two units: the mobile unit and the hospital unit.

Mobile Unit: The mobile unit is responsible for transmitting the bio-signals of patient to the hospital, communicating with the physician, and accepting the orders from the physician. There are three modules contained in the unit, as shown in Fig. 1.

Signal grabber module: This module is used for grabbing the bio-signal, voice, video, still image from the patients. The grabbed data can be displayed in the tele-consultation module and transmitted to the server located in the hospital site through the data transmission manager module.

Tele-consultation module: This module is responsible for communicating the people between the emergency site and the hospital site. The video conferencing, whiteboard, and telepointer are integrated in the module for providing the face-to-face conversation and image discussion.

Data transmission manager module: Due to the communication network used in the emergency site is GSM/GPRS mobile network, but the hospital site is Internet, the network properties are definitely different, such as bandwidth, delay, packet loss rare, etc. The module is responsible for coordinating the data transmission between the emergency site and the hospital site.

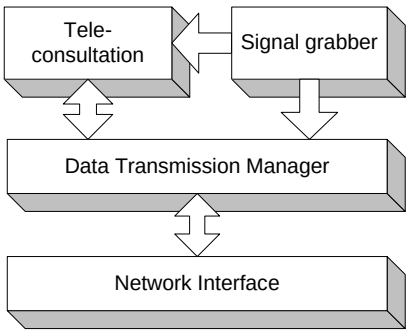

Figure 1: Functional modules of the mobile unit.

Hospital Unit: The hospital unit is responsible for providing the medical services to the emergency site. It consists of two sub-systems including the hospital server and the physician client. The hospital server represents the communication window for all mobile unit s. All mobile units connect to the hospital server first. Then, according to the condition of an injury, the operator of the hospital server will contact with the corresponding physician by the phone calls, sending SMS (Short Message Service), or MMS (Multimedia Messaging Service) messages. The physician uses the physician client to connect to the emergency site through the hospital server to provide the medical services. Meanwhile, the hospital server will log the consultation records to provide the further analysis and improve the system performance. Under the architecture, the system can support multiple emergency sites. The detail of the hospital server and the physician client is described as following.

Hospital server: The hospital server accepts the connection from the mobile unit, and retrieves the patient data from the HIS (Hospital Information System) according to the patient's identification. The operator of the hospital server will contact with the corresponding physician according to the condition of an injury. It includes five modules, as shown in Fig. 2.

Signal receiver: It is responsible for receiving the data from the mobile unit and forwarding to the signal recorder and signal monitor modules.

Signal recorder: It is used to connect to database and record the data from the mobile unit, such as bio-signal, voice, video, still image.

Signal monitor: This module is used to monitor the patient status. It will contact with the physicians when the patient status is dangerous.

HL7 gateway: It is used to connect to the HIS to retrieve the patient's medical record.

Physician dispatcher: It is responsible for contact with the corresponding physician according to the condition of an injury. In the proposed system, the operator of the server can communicate with the physician via phone calls, SMS messages, or MMS messages contained the still images of the injury region of the patient.

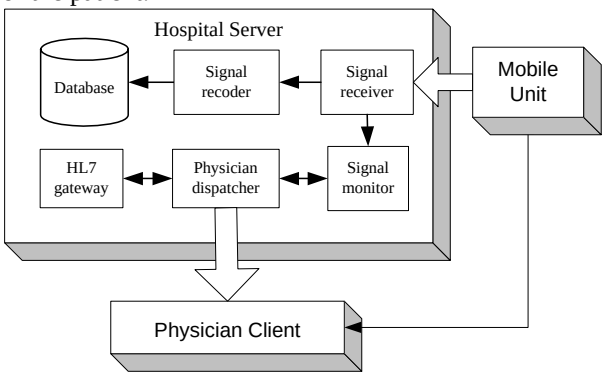

Figure 2: Functional modules of the hospital unit.

Physician client: When the physician accepted the call from the hospital server, he/she can communicate to the mobile unit by using the physician client. The

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functional modules are consists of tele-consultation, signal monitor, and data transmission manager modules.

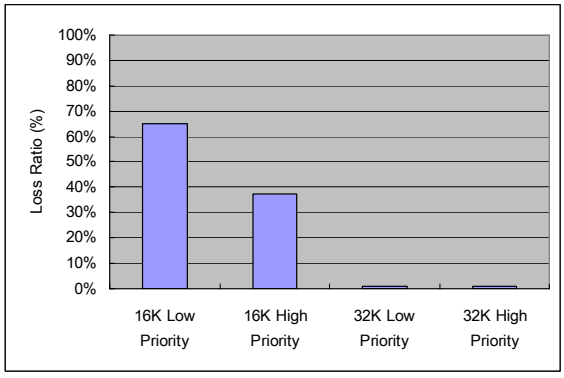
Tele-consultation module: This module is responsible for communicating the people between the emergency site and the hospital site. The video conferencing, whiteboard, and telepointer are integrated in the module for providing the face-to-face conversation and image discussion.

Signal monitor: This module is used to monitor the patient status. When the condition of the patient is stable and the physician is too busy to pay attention to this physician, this module can monitor the patient. It will alert the physician to the danger condition of the patient.

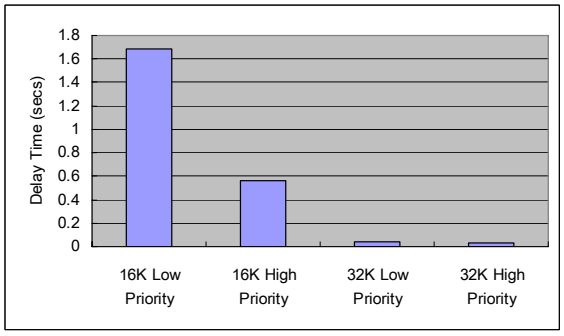
Data transmission manager module: It is responsible for coordinating the data transmission between the emergency site and the hospital site.

Results

In the system, medical images, bio-signals signal (ECG), video, and voice are transmitted during the consultation. The GSM 13 kbps voice codec is adopted in the system. The video stream is encode by the Mpeg4 codec, and transmitted at the resolution of 176x144 with a frame rate of 8 fps. The video bit-rate is around 20 kbps. To evaluate the performance of the proposed data transmission management scheme, we measured the transmission latency and the packet loss rate of the video packets over different traffic shapes. When the consultation is established and the voice/video conferencing is started, the priority of the voice transmission is fixed at the middle level. The network traffic shape is setup at the 16 kbps and 32 kbps. Both video priorities, low and high, are assigned for these two traffic shapes. The packet loss ratio and delay time are shown in the Fig. 4(a) and Fig. 4 (b), respectively. According to Fig. 4, it can be seen that when the priority of video transmission is assigned to higher than the priority of the voice, the packet loss rate and delay time of the video transmission are decreased significantly for the bandwidth of 16 kbps. Therefore, the proposed data transmission management scheme is worked very well. However, when the bandwidth is increased to 32 kbps, the affection of the priority level for the packet loss rate and delay time is not so significantly. It is because that the bandwidth is enough for the voice and video transmission.



(a)



(b)

Figure 4: Performance of the data transmission management scheme. (a) Packet loss ratio of video transmission. (b) Packet delay time of video transmission.

Discussion

This paper explored the feasibility study of information technologies to pre-hospital care. The key technologies include the multimedia processing and networking. Results from this study seem to suggest that the bandwidth requirements should be minimized as small as possible for provideing the better transmission quality. Although the biggest limitation was the bandwidth of the mobile networks, the revolution technologies can vanish the barriers. For example, the new mobile communication technologies, such as 3G and WiMAX [16], can provide the larger bandwidth than the GPRS network. The new video compression technology-H.264 can also reduce the bandwith consumption. Therefore, we can see that the applications of the mobile telemedicine will be still growing, and can provide the more functionalities and better quality in the future.

Conclusions

In this paper, we propose a mobile emergency telemedicine system over mobile networks. Based on the data transmission management, the proposed method can compensate for the insufficient bandwidth and provide a better transmission quality. The system can deliver the pre-hospital care and reduce the death rate, especially the situations where the long transport time or multiple transfers are involved.

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