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# Development of a Centralized Telemedicine System and its Application to Rural Areas

Daoud I. Zatari
Department of Electrical and Computer Engineering,
Palestine Polytechnic University, Hebron, P.O. Box 198, West Bank

**Abstract:** This study describes the design and development of a simple and low cost centralized telemedicine system in Palestine CTS. The proposed system overcomes existing isolation problems of Palestinian cities and villages and facilitates access to telemedicine services. The system servers communicate with remote locations through a dial-up technology, the internet, or using 128 kbps ISDN lines. The software protocol is capable to establish connection with more than one remote site, sort requests according to priority, identify the specialist through its database and respond automatically to the end user. A successful experiment shows that two communication links (the internet, wireless mobile phone) enables the transmission of a Chest-X Ray image from a rural clinic to the CTS. The transmission time and resolution were acceptable to physicians at both ends. The study is still in progress to test the remaining parts of the system.

**Key words:** Telemedicine, centralized, rural clinics, communication technologies, wireless GSM

## INTRODUCTION

Although the new technologies in mobile telecommunication emerged recently, its advantages to send the multimedia information in large amounts are quickly realized by the health-care sector. The movement of telemedicine from desktop platforms to wireless and mobile configurations may have a significant impact on future health care[1]. Mobile telemedicine is a new and evolving area for health service providers. It was suggested that the next step in the evolution of telemedicine will be mobile telemedicine systems[2]. However, some commercial products have come into everyday use.

The new technologies can make the remote medical monitoring, consulting and health care more flexible and convenient. There are many challenges for successful wireless telemedicine that requires special attention and considerations. However, those challenges will be addressed in future work by the author.

Tele-medicine uses computer-based telecommunications technology to transmit medical data and images from one site to another. It is common to transfer information from one site with limited specialist resources to a specialist site with greater resources. Any Telemedicine system must be fast, reliable, easy to use and provide excellent quality, this challenge can be achieved by improving the existing protocols and make efficient use of the features provided by transmission media and the networking architecture. The main benefits of Telemedicine services are to improve access, reduce cost, overcome isolation and improve quality of health care[3].

Successful implementation of telemedicine services depends on an adequate telecommunications infrastructure[4]. At present the main infrastructure in Palestine consists of analogue telephone lines, fiber optic lines, ISDN lines in some cities, the Internet and mobile phones. These are sufficient to provide adequate bandwidth for the transmission of real-time teleconsultations for major cities in the country. Rural areas can communicate with the CTS through wireless connection using Global Systems for Mobile Communications (GSM) mobile phones (second generation technology 2G) and through the Internet. This 2G technology will be described in later section of this paper. The aim is maintain an interactive medical consultation and communication links of medical images and video data such as the videophones over Internet links in complete mobility and in global coverage and connectivity. The Internet is already being used for some medical applications[5]. This might need more than just mobile phones whose transmission bandwidth is likely to be limited and the large amounts of images and data require some of the characteristics of fixed link installation using black fiber links[6].

The system operator usually expectsseveral problems during service delivery. Among those problems are:

**Corresponding Author:** Daoud I. Zatari, Electrical and Computer Engineering Department,
Palestine Polytechnic University, Hebron, P.O. Box 198, West Bank
Tel: 00972 2 2224978 Fax: 00972 2 2217248

- Bandwidth limitation in certain parts of the country.
- Lack of awareness by health service providers of the use of information technology applications in medicine such as telemedicine.
- Lack of financial resources.
- Privacy issues and confidentiality of patient data records.
- The lack of standards and interfaces for both health care data acquisition and for the effective use of such information.
- Physician's concerns regarding the compressed data (transmitted images) and the adequacy or completeness of information for computer-based patient record.
- The legal issues.

During the implementation of services, the system operator tries to overcome the above-mentioned problems in order to achieve a considerable success. With the suitable devices, it also has to make sure the seamless data flow (images, data, text, voice) to and from mobile terminals through the mobile and fixed network to the hospital and health care communication infrastructure[7].

In this study, the author emphasis on the mechanism of delivering telemedicine services using different communication technologies. However, it is clear that the paper focuses on delivering telemedicine services to rural areas of the Palestinian villages through CTS by means of a wireless technology. It is worth to mention that during this research work, two different case studies are implemented. The first case demonstrates the teleconsulation activities between two hospitals in the city of Hebron in Palestine. The second case demonstrates a successful teleconsultation between a rural clinic and the hospital through the CTS system.

**Second Generation 2G Wireless Technology:** The 2G wireless networks are digital and expand the range of applications to more advanced voice services, such as Called Line Identification. The (2G) of the wireless mobile network is based on low-band digital data signaling. Most of the networks are based on circuit-switched technologies developed in different parts of the world. GSM system is the most popular, which operates in the 900-MHz and 1.8-GHz bands throughout the world with the exception of the Americas where they operate in the 1.9-GHz band. The 2G wireless technology can handle some data capabilities such as fax and short message service at the data rate of up to 9.6 kbps, but it is not suitable for web browsing and multimedia applications. The data rate of 2G circuit-switched wireless systems is very slow for today's Internet usage. As a result, GSM as a TDMA-based mobile system provider has developed 2G+ technology, which is packet-based. It increases the data communication speeds to as high as 384 kbps. This development will be used in the future and will enable better image and video services in Telemedicine applications.

**A Centralized Telemedicine System Architecture:** Figure1 shows the overall system architecture. The main modules of the system consist of:

- A communication unit.
- A communication Interface unit.
- Communication technologies.
- Connection sites or nodes.

The main CTS network consists of a main server, A WEB server, a high quality Telemedicine workstation, monitoring stations, communication interface unit, high-resolution scanner, a digital camera and a printer[8]. The workstation must be able to perform different functions such as image compression and decompression and also to be able to handle data in different format since a medical record may contain data, characters, audio signals, ECG signals, medical images and video.

## MATERIALS AND MATHODS

**Case Study 1:** In this part, a point-to-point link between two different hospitals in the city of Hebron is established. Figure 2 shows the network topology. A real time- teleconsultation for a patient record (include a CT image with size 512X512X8, voice, other medical parameters such as blood pressure, temperature) is discussed between two physicians at the two hospitals (A and B) that are separated with an approximate distance of 3 km. The communication channel was through a 128 kbps ISDN line. The image resolution was acceptable. However, a better resolution for medical image transmission is possible if a 384 kbps rate is used. The two physicians spent approximately 30 minutes session on real-time and there assessment for this experiment was very satisfactory. You can find more details for this successful case study in a previous study of cooud *et al.*[3] and schwai bold *et al.*[9].

## COMMUNICATION BETWEEN THE SYSTEM AND THE RURAL CLINIC

**Case Study 2:** Figure 3 demonstrates the operation of the system between a rural clinic and one of the hospitals in the city of Hebron in Palestine. In this experiment, two

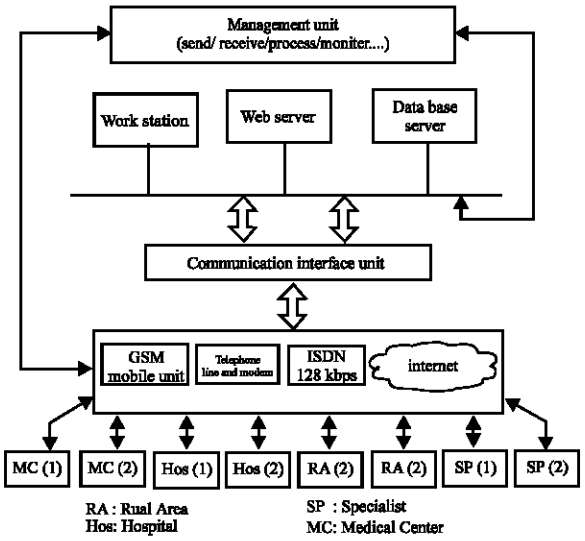


Fig. 1: A model for a centralized telemedicine system

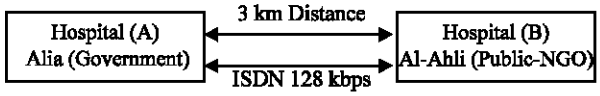


Fig. 2: Connecting two hospitals in Hebron city with an ISDN line to transmit a patient medical record

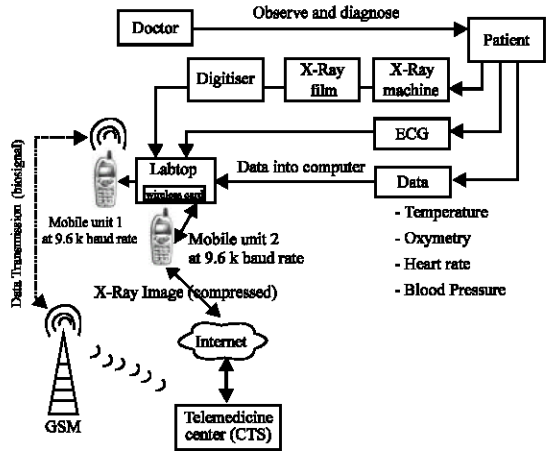


Fig. 3: Rural clinic site communicates with CTS

different data types are transmitted from the rural clinic to the hospital using two different communication technologies for testing purposes. The author is aware that the patient record can be transmitted using one type of communication link only. The wireless signals are transmitted to a CTS server at the city of Hebron. These are forwarded to the computer monitor of any selected specialist connected to the system. One of the communication links was the use of Internet to transmit a chest X-ray image of size 256x256 with an 8 bit resolution. The image transmission was completed when the computer at the clinic (laptop with a wireless modem) was connected to internet through the GSM mobile phone. The image was sent to the CTS in a compressed file by as an electronic mail. The CTS system operator directs the image to a radiologist and the later reviewed the case and retransmits a report to system operator. The system operator then responded to the rural clinic by emailing a radiologist report. This process is performed under the management of system operator in less than 10 min. It is important to realize that the application of compression techniques for medical images is of great concern to physicians. This is because any loss of information may cause false diagnoses to patient. Therefore, a lossless compression technique with low compression ratio CR (e.g. CR of less than 10) is preferable during image transmission.

For a speed of 9600 baud rate of the mobile unit, usually in practice about 80% efficiency of this speed is realized, when one wireless mobile unit was used the transmission time for the image was 1.137 min without compression. When compression is applied with a ratio of 3, the transmission time was reduced to 0.38 min. It was obvious that the quality of image and its resolution was not affected by the transmission methodology or by the compression. The physician at CTS site was satisfied with image quality and transmission time with and without applying compression.

In this experiment, it is realized that transmission of medical images from rural clinics using wireless mobile units is better through the browsing of the internet and using the simple email communication (with image compression). However, if the transmission size of bits is small (i.e. transmitting blood pressure or temperature or ECG signal which are in the order of kilobits) then a real-time transmission between the rural clinic and the CTS site through one or more mobile phones is feasible.

Since the transmission time of a medical record using a wireless GSM mobile is an important issue for real-time service delivery, then it is possible to increase the modem speed, it might be more convenient to use two or three or more mobile phones units during the transmission process. Usually this is applicable and necessary in emergency cases and in particularly when an ambulance is at the site of a road accident and the emergency team establishes telemedicine session (audio and video) with their emergency unit at the hospital.

## THE SYSTEM OPERATION MECHANISM

The operation mechanism of the proposed system is simple and works with high performance. Figure 4 shows the flow diagram of the system. It is important to acknowledge that most of the processing time at the CTS

management unit is spent on monitoring the tasks or requests received, or initiated contacts with specialists, or reports managements, or identification of priority requests for processing, or management of medical records (retrieve or store).The database management system is based on Oracle technology. The software system for control and monitoring is developed in order to achieve high performance and accuracy. The mechanism of operation of the system is described as follows:

A request of service is placed by the end-user that might be a rural clinic or a medical center as shown in Fig. 1. The end-user selects type of communication technology that is available at his site. As soon as the connection is established with the CTS, the system operator process the received request and consequently the CTS transmits the patient data to a specialist by forming an appropriate links between the system and the specialist. The system then keeps following up with the specialist until a second opinion is ready, hence the system report back to the end-user at his remote site. This processing mechanism has several benefits to both the patient and to the health service providers. Among those benefits are:

- Fast response and in most cases doctors receives replies in real-time (within few minutes).
- The system gives a higher priority of service delivery for emergency requests.
- The communication links with the system are continuously monitored by system operator, hence the system reliability is very high.
- The infrastructure requirement at the end-user site is minimal.

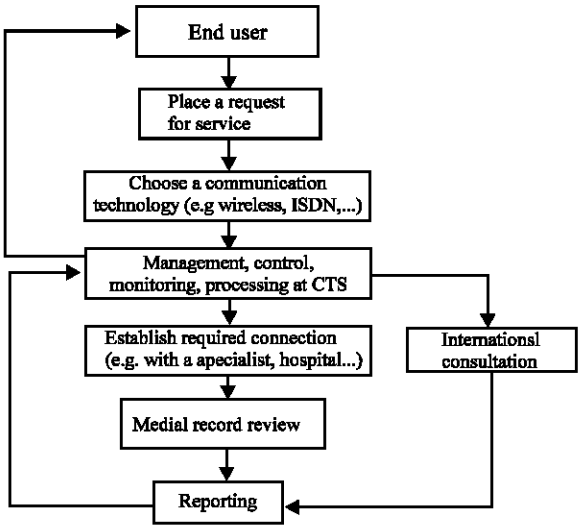


Fig. 4: A flow diagram for CTS operation

## FUTURE WORKS

Further investigation will include the use of satellite communications with rural areas and the system. Emphasis will also be given to compression technologies security issues of the transmitted data particularly for store and forward images and video images. The system integrates the existing wireless commercial technologies and the use of open-system standards. This approach simplifies the introduction of new technological developments. In the future, if more collaboration between rural sites and the central system CTS within the city itself and between cities around the country is established, then this requires the flow of data among all nodes using wireless technology and other types in order to maintain convenience and rapid treatment particularly in emergency cases. This would require micro-technological sensors to be used in mobile applications, a wireless communication network, local intelligence in the form of a powerful mobile information unit, connection to a global network and a conclusive system design for improving the efficiency of health care-related procedures[10].

## CONCLUSIONS

The proposed telemedicine model presented is a very important step to provide a telemedicine services in Palestine at low cost and with minimum communication infrastructure. Following the successful implementation and assessment of case two (a wireless connection of a rural clinic with CTS), the system will find acceptance from health service providers particularly at rural areas. A simple wireless communication technology that is dependent either on mobile phones or on WEB-based wireless connection and is part of CTS architecture will improve the quality of health services for rural areas. However, the success of this type of telemedicine services depends on the readiness of doctors at the sending and receiving sites to use this technology during there service delivery. Training at local and national level programs is necessary to attract the attention and awareness of health service providers and patients on the importance of telemedicine applications. A further development for the system includes the data security of medical health records in order to protect the privacy of patient's information.

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