TCP/IP Based Networking for Telemedicine

Muhammad I. Ibrahimy and S. M. A. Motakabber

***Abstract*—A prototype customized network based chat and different type of files transfer system have been developed for telemedicine. In brief, this project comprises of two parts: one is chat section and the other is file transfer section. The main function of the chat section is to establish a connection between collar (client) and called parties (server), so they can conversant to each other on real time. On the other hand, the file transfer section establishes a network connection using TCP/IP protocol, so that the client can transfer any type and any size of data files to the server terminal.**

***Index Terms*—Networking, TCP/IP protocal, telemedicine, client server application.**

I. Introduction

During the 1920s, radio was used to link physicians and stations situated on-shore to assist ships at sea that had medical emergencies. Desktop telemedicine began as experiments linking television and telephone by AT&T's Bell Laboratory in the 1920s and 1930s. Then, during the 1960s, the National Aeronautics and Space Administration played an important role in introducing telemedicine when humans first went into outer space - the astronauts had their pulse rates and blood pressure monitored remotely. By the 1970s, telemedicine had evolved to take advantage of satellite technology [1]. For example, paramedics in remote Alaskan and Canadian villages linked with hospitals in distant towns or cities. Subsequently, in December 1988, telemedicine was used to provide consultations from medical centers in the USA to the earthquake-hit Armenia in the erstwhile USSR. Satellite technology had transcended political, cultural, economic and social barriers to provide medical consultation [1]. The University of Kansas medical center runs one of the largest telemedicine programs in the USA. Several hundreds of local networks link hospitals, clinics, HMOs, schools and correction facilities in the state. This program sits as an example of both increasing breadth and depth of medical telecommunications. In 1994, this medical centre conducted 189 video consultations, including oncology referral, pediatric and cardiac consultations. Interest in telemedicine has increased substantially in the 1990s with the development of medical devices suited to capturing images and other data in digital electronic form, and the development and installation of high speed, high bandwidth telecommunication systems around the world.

In developed countries, telemedicine is flourishing as an important and popular health support system for the citizen. Clinical applications of telemedicine are at present found in virtually every specialty although the technological basis and practical issues of implementation are highly variable from one clinical application to another.

In developing countries like Malaysia, telemedicine is still a new concept to majority of the citizen. One of the major parts of the telemedicine system is to build up a network between data acquisition points and a central control point. In the data acquisition point, a patient's data is captured with the help of a computer interfaced monitoring system. Either this data is stored in the local interfaced computer or directly sent to the central control system so that it can be used for further applications [2]. The success of the telemedicine mostly depends on the networking and its associated communication software.

The goal of the project is to rapidly transmit patient's data to participating physicians so as to improve patient care and conserve healthcare resources in the managed care environment, while upholding patient confidentiality. In realizing this concept, a data communication system with networking features incorporated is to be developed. The system is capable to sending locally stored data (such as PPG recorded data) or to make conversation to its counterpart, which is separated by a geographical distance, via Internet (TCP/IP).

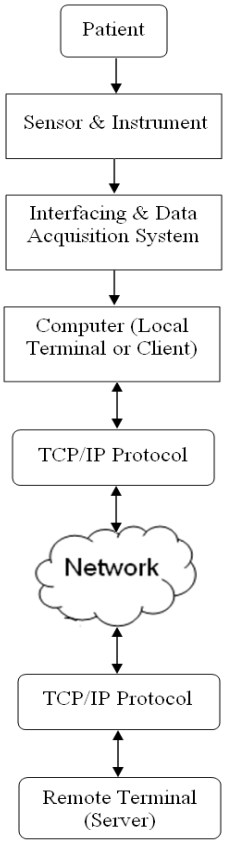

Fig. 1. Project flow chart.

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II. Flow of Project

Fig. 1 shows the overall functional flow of the telemedicine. First, electrodes or sensors are placed on the human body to capture the small signal in the form of electrical voltage. This signal then fed into an instrumentation amplifier with the associated low pass and high pass filter. This is to provide amplification and filtering to obtain a noise free signal. Then, the amplified signal is fed into the ADC circuit for analog to digital conversion. The digital output of ADC circuit is sent to local terminal (patient's terminal) via interface circuit. Then, the data are transferred to a remote terminal (server) via network using TCP/IP protocol.

The networking part is in the form of a Visual Basic based client/server pair application. The client and server application is installed in local and remote terminal respectively. The networking program is to establish a connection between local and remote terminal via TCP/IP protocol to provide transfer of data and enable chat session.

TCP provides a reliable, point-to-point communication channel that client-server application on the Internet use to communicate with each other [3]. To communicate over TCP, a client program and a server program are developed to establish a connection to one another [4].

III. Networking

A. Software of Networking Application

The networking program is manifested in the form of a client/server pair application. The client application is known as Local Patient Monitoring System (LPMS), which is installed in the local terminal. On the other hand, the server application, which is known as Remote Patient Monitoring System (RPMS), is installed in the remote terminal. Here, the terms of local terminal refers to the PC or workstation resides in the patient's residential area. Remote terminal refers to the PC or workstation resides in hospital that is separated with a geographical distance from the patient.

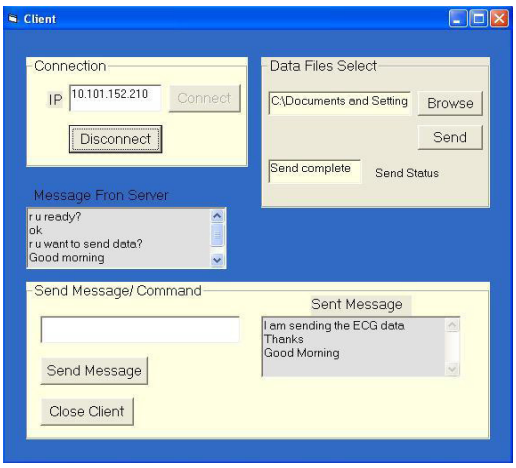

Fig. 2. Local patient monitoring system (LPMS).

The most fundamental feature of the networking program is the ability to set up a connection between local and remote terminal via TCP/IP. Fig. 2 and Fig. 3 are shown the screenshot of LPMS and RPMS respectively.

Local Patient Monitoring System (LPMS) provides: Dial up to predefined hospital or clinic terminal and hence set up full duplex communication with RPMS.

- Simple chat/dialog session with RPMS
- Transmission of PPG data via established connection

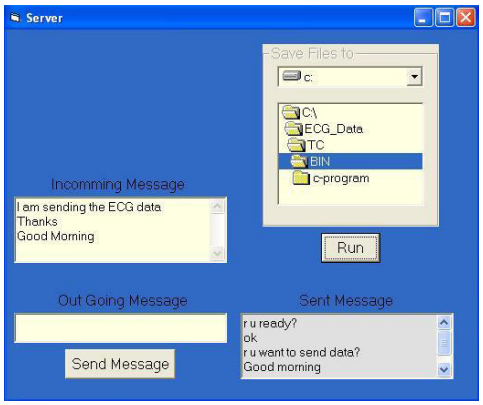

Fig. 3. Remote patient monitoring system (RPMS).

- Remote Patient Monitoring System (RPMS) provides:
- Set up networking with LPMS
- Simple chat session between the two parties
- Receiving of PPG data via TCP/IP

B. System Design Architecture

Since both LPMS and RPMS comprise of a few functional component (or feature), the process of algorithm design and code writing is based on a modular architecture. Fig. 4 and Fig. 5 are shown the system architecture for LPMS and RPMS respectively.

Each of the functional components such as plot graph, sending of PPG data are treated as module. The Graphical User Interface (GUI) is analogous to operating system (OS) or kernel that manages and coordinates the activity of these modules. In the first stage, all the modules are designed separately. The codes are compiled and run using a standard Visual Basic 6 compiler. On the other hand, the operating system or GUI is developed using an IDE tool called JBUILDER. The final step is to incorporate all the modules into the kernel or GUI. The detailed feature of each module and the process of development are given in the following sections.

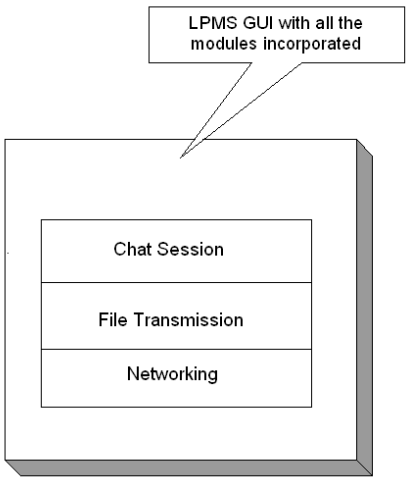

Fig. 4. LPMS modular architecture.

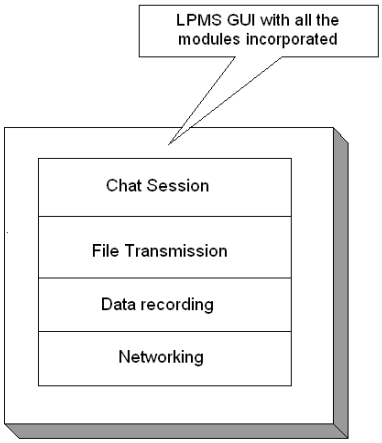

Fig. 5. RPMS modular architecture.

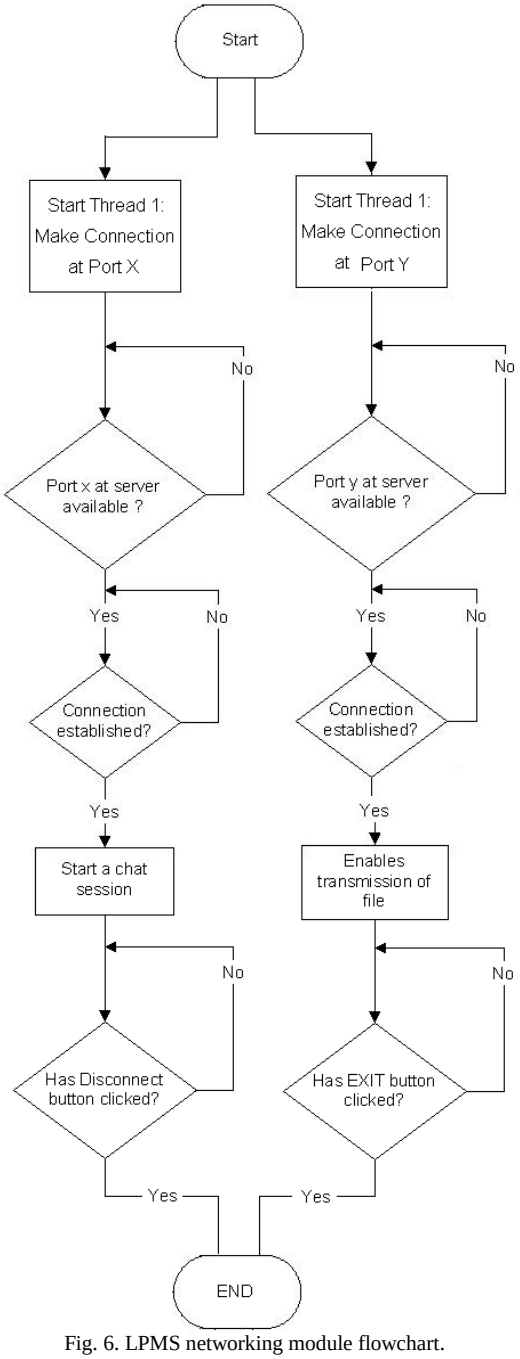

Fig. 6. LPMS networking module flowchart.

C. Networking Module

This module is the most important feature in both the Local Patient Monitoring System (LPMS) and Remote Patient Monitoring System (RPMS). The networking module in LPMS works in synchronization with its counterpart in RPMS. The function of these modules is to set up a full duplex connection between the local or patient's terminal and remote or physician's terminal. Full duplex implies that users at both terminals can have a two-way communication at the same time [5]. This is analogous to the scenario where two persons talk over the conventional telephone system. Note that the term "terminal" refers to PC or workstation.

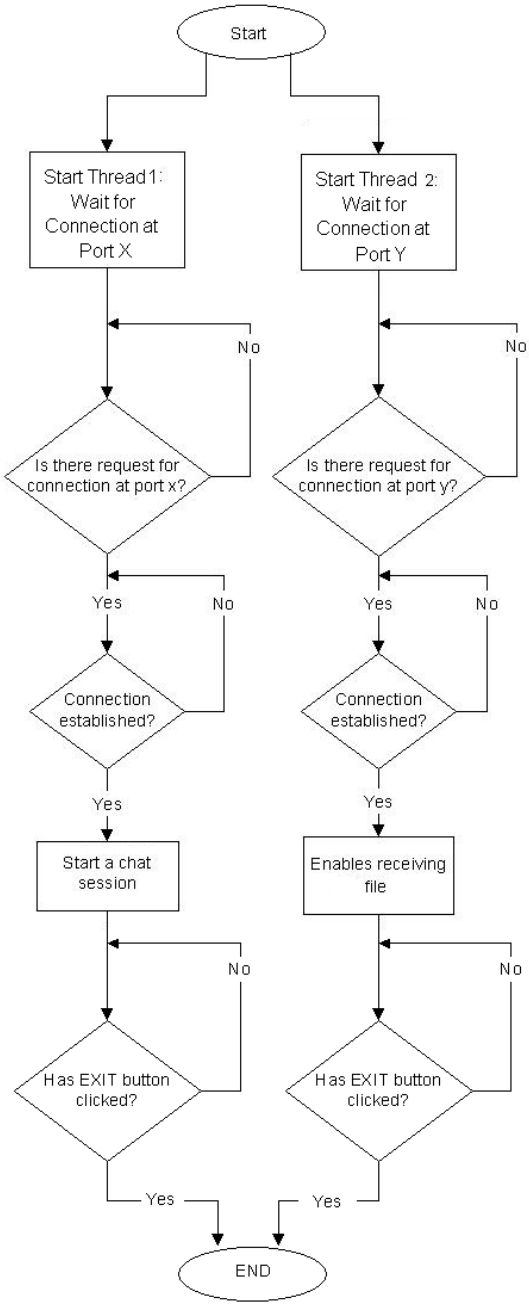

Fig. 7. RPMS networking module flowchart.

The features provided by these two modules are as summarized as below:

- Establish a connection between local and remote terminal
- Connection is to support the chat session feature
- Connection is to support the sending/receiving of PPG data file

In developing the networking module of programming, multithreading is adopted. A thread is a single sequential flow of control within a program. Multithreading as the name implies there are multiple threads in the program and hence, multiple sequential flow of control in the system. Each thread is allocated part of available resources. In a conventional or sequential program, only one task can be performed at one time. If the second task is to be carried out, it is to wait until the first task is completed. Obviously, this is inefficient.

Why multithreading concept is necessary? This is because there is a requirement for multitasking in the networking application. Multitasking simply means the system can perform more than one tasks simultaneously [6]. Recall that there are multiple connections between LPMS and RPMS. For instance, LPMS is required to hold a chat session, able to send PPG signal file at the same time. And the same goes to RPMS. Fig. 6 and Fig. 7 are shown the flowchart for the networking module of LPMS and RPMS respectively.

IV. Conclusion

The networking system enables transferring of various types of data files, online chat, updating and creating of patient's medical record through database. In brief, the software development is based on a modular architecture. The small modules, which make up the complete program, are developed first. When each of the modules is runnable, then the linking or integration process takes place. GUI is the element, which manages and coordinates the activities of the modules. It is analogous to the kernel the computer architecture.

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