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REAL-TIME ECG TRANSMISSION FROM MULTI-PATIENT TOWARD MULTI-PHYSICIAN USING WIRELESS COMMUNICATIONS TECHNOLOGIES

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ABSTRACT

This paper presents the tool system design for an application that provides Real Time Remote Monitoring for ECG signals and ensures mobility for both patients and physicians all over the world. With friendly user interface, an authenticated physician can monitor in real time the patient's ECG and retrieve older sessions in order to follow his recovery and healing. Telemedicine application is presented which allows doctor to view his patient's ECG signal remotely and dynamically in a web page in real-time, and doesn't need to have any special requirements on his PC, all he needs is an internet access. These aims are achieved using TCP protocol which is implemented in LabVIEW.

Keywords: *ECG; Real Time; Remote Monitoring; LabVIEW; G Web Server; TDMS*

1. INTRODUCTION

In recent years, the prevalence of cardiopulmonary diseases has increased, due to a very busy lifestyle and deterioration of environmental health factors. Insurers and employers are putting big pressure to reduce healthcare expenses. Spending time at a hospital could be a difficult experience, due to high costs, travel time, staying away from home and family, less freedom to move, etc. With advancements in bioinstrumentation, computers, and telecommunications technologies, it becomes feasible to design home-based vital sign telemonitoring systems to acquire, record, display, and transmit physiological signals from the human body to any location. Several studies were done in telemedicine applications in order to perform a real-time ECG telemonitoring via multiple communications networks like telephone network [1-4].

Omnipresent cellular networks may be used, in order to have patient mobility at signal acquisition. Actually, in previous studies, the GSM cellular network was used for telemedicine applications [5].
The GSM SMS was also used to deliver measurement information, alarm conditions and warnings, all in static format [6].

Using the protocol MMS -which is not enabled in full features (video buffering..) in the 2G of cellular networks- can be useful for real time telemonitoring, but it is an expensive technology especially for continuous telemonitoring [7].

A proposed solution is presented in a previous study [8] that can correct most of lost packets and provide an acceptable time delay which matches the requirements of telemedicine applications.

Using the Real-time Transport is the ideal solution for such application, Real-time Transport Protocol is an application level protocol that provides transfer of real-time data over Internet. RTP does not provide resource reservation or provide other quality-of-service guarantees, but relies on lower-layer services to do so. The data transport is augmented by a control protocol (RTCP) which provides minimal control and identification functionality.

At the same time, it is more practical and convenient for medical and paramedical staff to monitor vital signs from any computer connected to the Internet [9, 10]. The context of this paper is the continuous remote ECG monitoring of the chronically ill whether hospitalized or put under home surveillance.

We will present the design of a computer based low-cost ECG telemonitor and recorder equipped with a user-friendly graphical interface to visualize the vital signs to the medical practitioner. The vital signs and patient

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informations could be accessed through the Internet in a Web-page creating the possibility of real-time patient telemonitoring using the omnipresent World Wide Web capabilities.

2. SYTEM PRESENTATION

The Real-time ECG transmitting system schematic is shown in Fig. 1. It contains electronic and software components. The electronic component covers two aspects. The first ensures the acquisition and transmission of the signal using Acquisition Card DAQmx, or Digital Multimeter (DMM); the second shall receive the signals on the server side using LabVIEW applications.

3. METHODS

A. Real Time telemonitoring using LabVIEW

LabVIEW has been used to build CGI programs and URLs, to send and receive data using the Telnet protocol, to store and retrieve files from FTP servers, to publish Vis on the Web, and to control remotely VIs from a Web browser. LabVIEW Internet Toolkit includes the G Web Server, which is an HTTP/1.0-compatible server that we have used to run applications on the Web.

B. Using CGI VIs with the G Web Server

Servers and CGI applications inter-communicate through environmental variables, and standard inputs and outputs. When an HTTP server executes a CGI application, it sends information using environmental variables. Because LabVIEW does not work with standard HTTP input and output, a CGI VI receives the standard input data as string when receives a request and sends data that generate string, as well.

C. Publishing Front Panel Images with the G Web Server

We can use the G Web Server to publish images of front panels on the Web. You can load static or animated front panel images. The G Web Server can generate images in JPEG or PNG image formats.

Currently, only Netscape supports animated images of the front panel. Internet Explorer 5.0 or later does not support animated images, but it does periodically refresh the screen.

All above mentioned features have been used in our application. The acquisition is triggered by the physician remotely, once he decided to view the ECG of one of his patients, the request is redirected from the asp.net based web site to the GWebServer which execute remotely a LabVIEW application embedded in the patient's pc and the session is opened, then the signal is displayed dynamically in the web page at the physician side.

This requires that the patient is already prepared with the electrodes on, which means arrangement and coordination between patient and physician should have been prepared previously like emitting SMS or Bip signal. Fig. 2 Shows the emitted signal from patient side.

From the physicians side, a computer based low-cost ECG telemonitor and recorder equipped with a user-friendly graphical interface is designed in order to visualize the vital signs. They could be accessed through the Internet in a web-page creating the possibility of real-time patient telemonitoring using the omnipresent World Wide Web capabilities. Fig. 3 shows the ECG signal accessed from the physician side.

Also, the physician will retrieve all basic information about his patients that he may need while assessing their health condition, such as weight, pulse, blood pressure, etc.

D. Recording possibility

In some cases it is important while assessing the health condition of a patient, to go back to previous ECG. Each session is saved in TDMS file then uploaded at the end of session to the server, saving this file with the name and photo of the patient along with the session date, will allow the physician to retrieve the desired session by date among all recorded sessions.

In order to reduce the load on the server we divide the available storage space between the authorized patients dynamically, if a new patient is defined, the partition per patient is reduced automatically, and once the storage limit per patient is exceeded the oldest saved record is replaced with the newest.

Moreover the process can be controlled by the physician; he can put a limitation on what duration of signal to be saved.

E. User interface and Multi-Client configuration

Our goal is to design a friendly graphical user interface for the physician. In the welcome page, the user, if successfully authorized, will be redirected to the list of names of his current patients (i.e. under follow-up).

When he selects a patient he can choose either to start a new ECG session, or to view a recorded

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one. To manage simultaneous requests (deliver for each physician the ECG of his selected patient) an additional LabVIEW application is added at the server side, handling multiple connection.

4. RESULTS AND DISCUSSIONS

As this is a medical application, reliability is needed in the first place. We used a reliable TCP protocol in this application which is implemented in LabVIEW.

The delay-time of UDP is much shorter and thus it is suitable for real-time transmitting but long-time evaluation shows that UDP needs protocol on upper layer to reduce packet loss rate.

Both TCP and UDP are implemented in LabVIEW. Comparing these two protocols leads to the following points:

a) TCP/IP

•Not suitable for real-time

– Retransmissions can lead to high delay and cause delay jitter

•Does not support multicast

•Congestion control mechanism (slow start) ,In fact we experienced a delay of 5 sec.

b) UDP/IP

•No defined technique for synchronizing

•Streams from different servers may collide

•A feedback channel must be defined for quality control

As LabVIEW has UDP nodes it should be able to implement just about any UDP based protocol, especially RTP as it runs on top of UDP.

5. CONCLUSION

In this paper, telemedicine application is presented which allows doctor to view his patient's ECG signal remotely and dynamically in a web page in real-time, and doesn't need to have any special requirements on his PC, all he needs is an internet access.

For the patient side, it is a home based LabVIEW application embedded in a home PC, during signal acquisition.

6. FUTURE WORK

In future work we will replace the used transport protocol (TCP/IP) by the Real Time transport protocol RTP, by implementing the RTP in our LabVIEW application.

Also, we could use GSM networks to transmit the patient information to the web server. This wireless network is available everywhere in the country. Therefore, there is no need of infrastructure specific requirements such as PC with LabVIEW embedded application.

Acknowledgment

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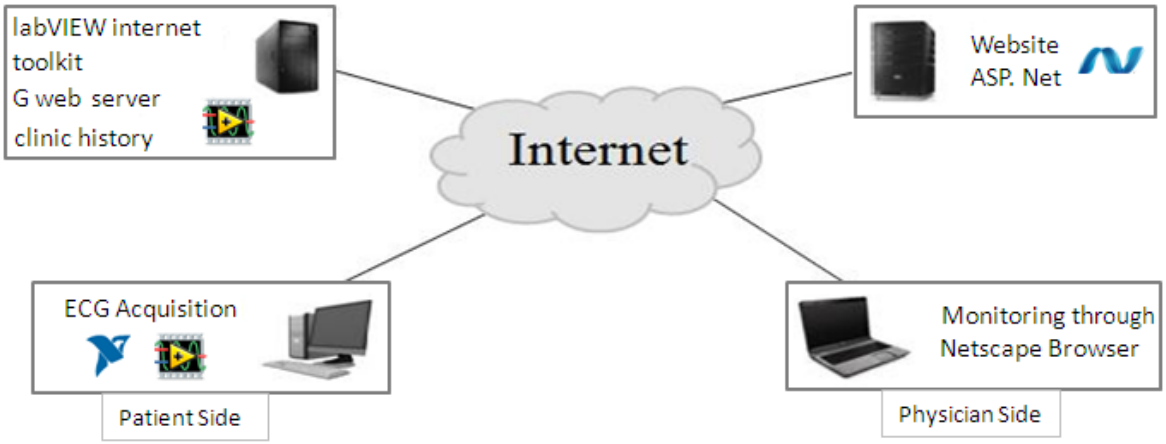

Figure 1: Real Time Remote Monitoring Schematic

Figure 2: Patient side, acquisition triggered remotely

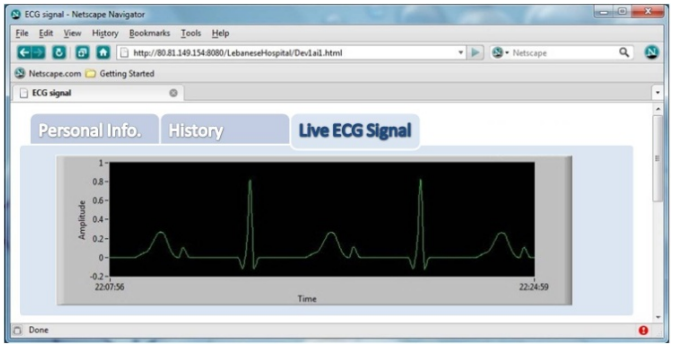

Figure 3: Physician side, ECG signal of selected patient