Design of a Web-based Wireless Mobile Teleconsultation System with a Remote Control Camera

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Abstract **- In this paper, the design of a mobile teleconsultation system is presented. A wireless frequency hopping spread spectrum link is used to provide mobility of the system in a hospital. The user-interface has been greatly simplified by accessing the video data and controlling the camera via any common Web-browser. Special emphasis has been put on using off-the-shelf available software/hardware components and open systems. This approach has enabled the system to have the most up-to date features while being cost effective and upgradable at any time.**

Keywords **- Telemedicine, open systems, wireless.**

I. INTRODUCTION

Telemedicine has been tremendously developed during the past few years to cater for the cases in which a physical distance separates those who seek treatment (patients) from those who are able to offer it (medical doctors). In developing regions, the scarcity of expert physicians encourages its deployment while other obstacles still impede its success [1]. Among the human factors that need to be adequately addressed before any successful implementation of a new technology is training. Educating users, both physicians and patients, will increase efficient use and acceptability of the whole system. Simplifying the user interface will also help the success of telemedicine projects.

There has been a considerable amount of pilot projects that were started with great enthusiasm. However, these projects were stopped as soon as the supporting grants, usually from the local government, ended. On the other hand, the cost-benefit analysis of such projects requires a long-term evaluation [2], something difficult knowing that most of the grants last usually for a maximum of three years only.

In developing countries, the extent by which telemedicine can be deployed is very variable: while in some of these countries high-speed data lines are available at a cost, in others whole regions are still waiting for an ordinary telephone line. Therefore, the concept of telemedicine has to be fine-tuned in each case to address higher priorities first [3].

The aim of this project is to design a system that will concentrate on a specific need: teleconsultation. In order to increase user acceptance, a very simple user-interface based on any common Web-browser is provided. Therefore a major obstacle in the path of the successful deployment of these systems e.g. the resistance of the non-technical physician to use a complex system has been addressed. Mobility has been provided so as to increase the number of cases by transporting the system and not the patients.

II. DESIGN CRITERIAS

During the design, special emphasis has been put on the following:

- Open systems: the project relies only on commercially available hardware/software components based on the open-system model. Modularity and scalability have therefore been guaranteed, so that with the rapid technological advances, any subsystem can be easily replaced as soon as a new version with higher performance appears on the market. This approach ensures that the system is cost-effective at any particular time.

- No extra manpower: the commercially available video camera used in this project has the unique feature of being remotely controllable from a distant location. Therefore there will be no need for locally adjusting the pan, tilt or zoom functions. This feature will eliminate the constant need for a technical operator to manipulate the camera.

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- Full mobility within the covered range: the utilization of a wireless communication link ensures that no physical wires are required near the patient.

- Simple user interface: a Web interface provides a straightforward user interface for the generally not technically sound users (medical doctors).

III. SYSTEM DESCRIPTION

The whole system consists of three different modules in different geographical locations (Fig. 1): a patient (mobile), a relay (fixed) and a physician (fixed) module. The patient module is in the vicinity of the patient (e.g. in a hospital ward); the relay module is close to the required communication access point (e.g. in an administrative office) while the physician module is in a remote area (as far as the boundary of the telecommunication network permits).

The patient module consists of one video camera, a multimedia notebook and a wireless interface mounted on a mobile cart. The camera (EVI-D31 from SONY, Inc., with a 450 x 400 resolution, high-speed auto focus and x12 optical zoom) can also be used as a scanner to send previous laboratory records. This camera has two interfaces with the multimedia notebook (Wallstreet G3 from Apple, Inc.). The video interface is established via a PCMCIA card (iREZ CapSure video capture card from PAR Technologies, Inc.) and the control interface is implemented via an RS-232C serial port using the VISCA (Video System Control Architecture from SONY, Inc.) protocol. This protocol enables the pan/tilt/zoom functions to be remotely controlled by a computer. The camera is placed on an adjustable tripod on the cart to give more flexibility for the viewing area.
A video-server software (SiteCam 4.1 from Rearden Technology, Inc.) combined with a Web-server running concurrently in the notebook transform the video stream into Internet Protocol (IP) packets. The video-server, using a fixed IP address, adapts automatically the frame rate to the selected resolution and available bandwidth. The minimum required bandwidth by the video-server is 128 kbps. At this rate, a new image is available in less than 12 seconds. For these packets to reach the network, a wireless serial interface (Mercury RF-1 from Nomadic Technologies, Inc.) is used. The Industrial-Scientific-Medical (ISM) band at 2.4 GHz and frequency hopping spread spectrum (FHSS) technique used by the wireless interface ensure electromagnetic compatibility with all devices in the vicinity of the system. Wireless, battery operation of the devices on the mobile cart ensures mobility. An attendant is in charge of positioning the cart.

The relay module consists of the receiving wireless serial interface and an Integrated Services Digital Network (ISDN) modem. Given the availability of ISDN lines in Malaysia, the Basic Rate Interface (BRI) at 128 kbps has been selected. The relay module serves as a wirelessly accessible contact point for the patient module. Both wireless serial interfaces, set-up in the passthrough mode, act like a direct cable connection enabling the notebook serial port to be connected to the ISDN modem (at the relay module) in a totally transparent mode. This configuration provides full mobility of the patient module within a 170 meters (500 feet) indoors range or 330 meters (1000 feet) outdoors of the available ISDN line connection. Therefore a reasonable mobility within a hospital environment is available.

The physician module consists of the other ISDN modem connected to a multimedia desktop PC equipped with a Web-browser. All the functions of the remote video camera are controlled by the Web-browser via the VISCA protocol. A printer allows for the printout of relevant data.

IV. PROTOCOLS

Practical implementation and relevant tests including clinical trials on this system are the two most critical steps in this project. Two medical areas have been identified for the deployment of this system: obstetrics-gynecology (OBGYN) and otolaryngology (ORL). In the first part of this study, only the OBGYN specialty will be under review. At a later stage and with the development of a second unit, ORL will also be considered for trials.
In the specific case of the OBGYN specialty, the practical need arises from the fact that the physician in question lives far from the hospital in which she practices. There are many situations during which the physician has to check the status of her hospitalized patient in the late hours of the night. In some cases, a visual evaluation of her patient could have saved her the trouble of the late trip in the night. This system will be deployed between the hospital and her home, for which an ISDN line will be installed. Each time an emergency occurs, the hospital attendant will first call the physician who will decide whether she has to go personally to the hospital or alternatively use the teleconsultation system.

During the testing phase, the attendant will note all events according to Table 1. For each event, the time at which the event occurred will be noted (in our hypothetical case of Table 1, it is 2:45 AM). Then a short description of the reason for the call will be given under "Event description". Then the procedures that were actually administered will be described, followed by comments. At the end, an overall evaluation of the effectiveness of the teleconsultation system will be given.

The accumulated data will enable running a survey at the end of this study and trace back the history of each event.

TABLE I
PROPOSED FORMAT FOR DOCUMENTING EVENTS DURING THE STUDY. THE SECOND COLUMN IS A HYPOTHETICAL EVENT.

Time	2:45 AM
Event Description	36 weeks pregnant patient having major discomfort with each contraction
Actual Procedures	Visual check - Patient position has been modified
Comments	-
Overall Teleconsultation Effectiveness in this Case	No need to travel to the hospital

V. FUTURE EXPANSIONS

Although current wireless FHSS technology allows data rates up to a few Mbps, only 128 kbps is used. The current bottleneck is the ISDN data rate. This rate has been selected to simplify practical deployment of this project and is upgradable. The added bandwidth can be used to implement a full-motion video with synchronized voice. An interesting feature is a private voice link between the physician and the attendant. Another usage for the extra bandwidth is to have another camera transmit the images in real-time. This would allow for the simultaneous viewing of the patient from different angles without the need to move the patient.

The range of the wireless connection can be extended by the use of dipole antennas and slightly more power. This will enable the teleconsultation system to be deployed on a wider radius (few tens of kilometers). An immediate application would be emergency medicine.

The availability of the Asynchronous Digital Subscriber Line (ADSL) technology will definitely improve the quality of the video stream. The modularity in the current design simplifies replacement of the ISDN line by the ADSL one.

Another possible expansion is the use of 3rd generation GSM mobile phones providing data rates of few Mbps. This approach allows both patient and physician modules to be mobile. In this case, the BRI-ISDN link can be replaced with a GSM connection, providing full-mobility for both patient and physician. At the same time the relay module will no more be necessary, simplifying the whole system.

VI. CONCLUSION

The proposed teleconsultation system has focused on a specific need: the video communication between a ward within a hospital/clinic and a remote physician. The selected communication medium is ISDN, given its availability in Malaysia.

The mobility provided by deploying wireless communications is one of the main advantages of this system. Reliance on open systems and hence greater modularity are other advantages allowing for easy expansions in the future. In the context of Malaysia, given that the local government is committed to develop telemedicine, the emphasis on open-systems and off-the-shelf technologies ensures smooth integration of this project with other projects currently under development.

The deployment of this system and adherence to the proposed clinical protocols will enable a cost-benefit analysis of such projects in the context of developing countries.

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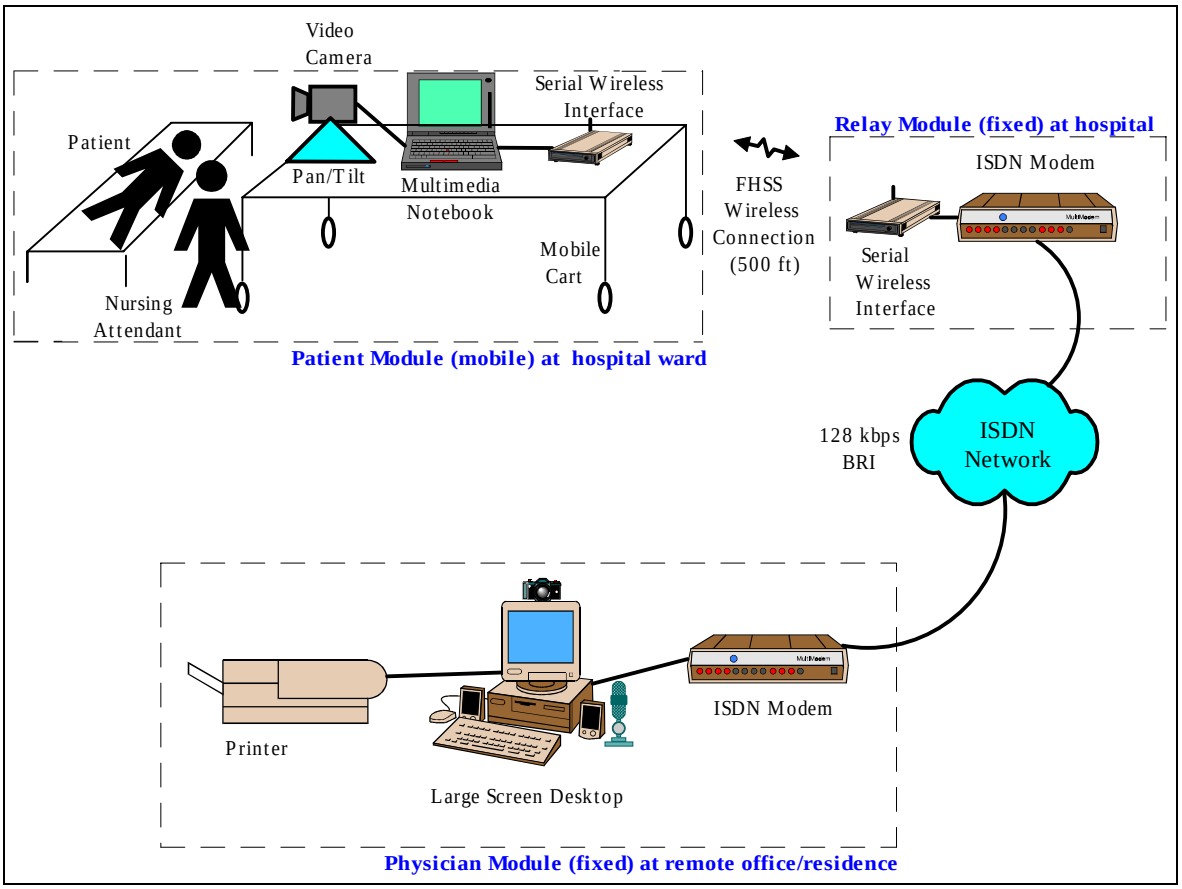

Figure 1- System architecture.