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A Telemedicine Application Project in Emergency Handling.

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Abstract: - Wireless communication technology could strongly help in facing health emergency situation. Real time video and medical parameters transmission and storage are nowadays-possible thanks to wireless communication techniques. Medical data such as electrocardiogram, blood pressure and other patient's information are transmitted to a remote hospital/medical database center server. Actions taken by the emergency staff are stored for real time operative-center interaction and for a successive database consultation. The video recording of the emergency event can also be very useful as legal evidence in case of disputation. In this paper a system for telemedical real time connection is described. The system has been implemented using low-cost consumer technologies such as GPRS and WiFi for low-band data/video transmission, H.264 for the real time video stream encoding and database video storage. SQL relational database has been used for store and query data. All system is based on Microsoft .Net technology allowing great portability and stability to overall modules, such as HMI (Human Machine Interface) and codecs.

Key-Words: - Telemedicine, Audio-video coding, GPRS, Wi-Fi, secure data storage, MMI

1 Introduction and Previous Works

Telemedicine is the use of telecommunications for medical diagnosis and patient care. Telecommunication technology allows for the provision of medical services to sites that are physically separated from the provider [8]. That's why telemedicine can lead to great improvements to emergency handling, such as medical telemetry systems [10]. The commercial products and research prototypes today available evidence how these systems are rapidly evolving. A good example is the real-time remote arrhythmia monitoring system collects ECG signals from a patient [1]. The system uses an event recorder and transmits to a PDA via Bluetooth. Moreover, the PDA concurrently tracks the patient's location via a connection to a GPS receiver. A long-distance link is established via a standard Internet connection over GSM/GPRS wireless infrastructure. The digital signal is transmitted to a remote computer and viewed using embedded Web technology for monitoring by medical professionals [1].

Another healthcare wireless application is the WAP-based telemedicine system for patient monitoring. It utilizes WAP devices as mobile access terminals for general inquiry and patient-monitoring services. Authorized users can browse the patients' general data, monitoring blood pressure, and electrocardiogram on WAP devices in store-and-forward mode [2]. Other applications targets are emergency situations: documentation, triaging, presentation of checklists and medical data (e.g. electrocardiograms). These critical data are transferred from the ambulance over the data network to the receiving medical facility [3].

Our approach to emergency video, data transmission and storage is to use low cost standard devices and public available network. This paper describes the system implementation and the use of the system by the emergency staff.

2 System Description

2.1 Objectives

The system has been designed taking into account the following criteria:

- Support for health medical diagnosis like ECG, spirometry etc with real time data transmission.
- Video transmission and recording with good ratio between video quality and bandwidth occupation using H.264 [4]
- Wireless connection together with VPN interface using MPLS technology
- GPRS public available network together with private routing with proprietary LAN

- Wireless – Bluetooth® technology for inter-device connection
- User Friendliness

2.2 The project

The overall system is composed by a set of portable units (a suitcase containing devices and power supply see Fig. 1) and a Hospital central system (a set of clients and a video server interconnected by a local area network). The portable unit communicates with the central system using a GPRS public network. Data from the portable unit are routed to a VPN using a dedicated APN.

The portable unit system (Fig. 1) is divided into several modules connected each other as shown in Fig. 2

Each module performs tasks like data compression, decompression and human machine interface (HMI must be the simplest as possible to help emergency staff in their job [9]).

The two graphs in Figure 2 and Figure 3 are explaining system behavior. Figure 1 show the Mobile unit (used in ambulance or in the medical car)

Fig. 1:The real portable unit

The portable unit contains:

- A PDA with WiFi and Bluetooth® interfaces
- A GSM/GPRS Smartphone with Bluetooth® technology
- A Tablet Pc (lcd portable pc with no keyboard) with integrated WiFi technology and GPRS pc-card
- A WiFi Access Point
- A USB Video Camera connected to Tablet PC
- A SD-interface Video Camera connected to the PDA

All the described devices have battery power supply except the WiFi access point. It is possible to connect the portable unit to external power supply in order to recharge devices batteries. The use of the access point (when GPRS network coverage is unavailable) requests to connect the portable unit to an external power source. The portable unit support both 220V AC and 12V DC supply.

Using an ad-hoc application the described device set is able to transmit video and medical data to the Hospital central system

Video and data are transmitted using direct GPRS connection between TabletPC and central system (Fig 3). In the case of GPRS not availability, data are stored locally in TabletPc in order to synchronize the central database using WiFi connection once the emergency staff returns to the Hospital central system.

The portable unit also allows emergency staff to send real time video far from the medical car (or ambulance), where the suitcase is placed. The PDA can send video and data using the SD video camera and the smartphone through the Bluetooth interface. The smartphone is connected to the Hospital central system using the GPRS interface.

Fig. 3 shows the central system: a real-time video/data receiver and server for each remote client in the Hospital central local area network. The video server implements an event database where each client can query for every stored emergency-event. Moreover, each client can connect to the central system for getting real-time data and video.

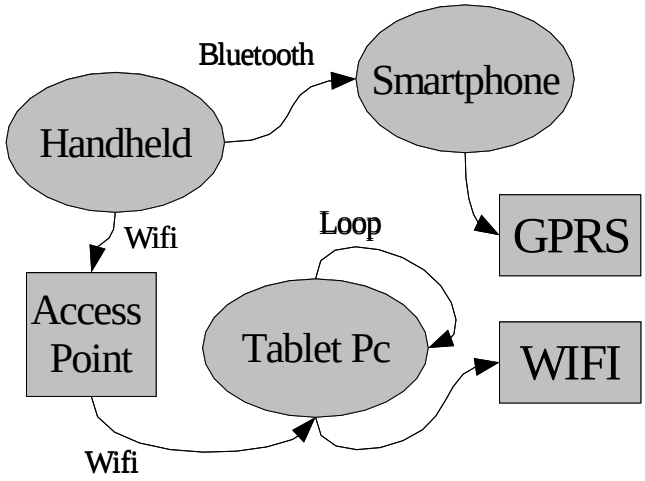

Fig. 2: Portable unit (suitcase)

HMI allows multiple real time video stream play (up to 16 visualizations at a time). User can select between a single, a quad or a sixteen contemporary real time video streaming. The central server has its own video database administration interface. Administrators can add and remove emergency video event or perform other common database administrative operations. The video server is also a

web server that allows querying the video database through a simple web interface. This feature is useful especially to interface the system to external-LAN users. The access is protected by a user-account control service.

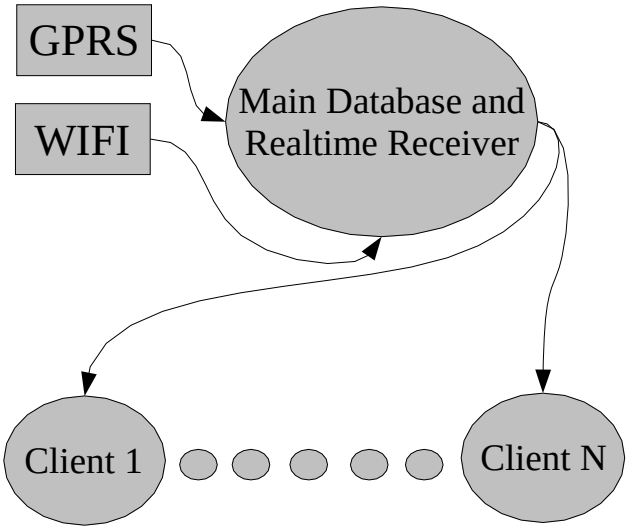

Fig. 3: Hospital central system and hosted internal clients

2.2 Software Structure

In this section system's critical issues implementation and design choices are described. Windows XP Professional has been chosen for the client terminals and Windows 2003 Server for the video-server application. Windows DotNet technology is suited for the HMI that is written in visual basic .net with a sub layer implemented in Visual C++ for a better overall system performance. The database has been implemented using Mysql for both performance (stability) and economical reasons. The central server should manage in real time up to 16 video and data stream. This means to be able to store and to play 16 contemporary video streams and at the same time to respond to several client requests. A critical issue for the system is the video database management. Several solutions were explored in order to find an efficient storage technique. The reliable solution resulted in storage the video as distinct files and not as blob on database. User can retrieve video streams directly with a hided ftp download of the stream (transparent for user). This technique avoids database overload due to video data high bit-rate being able to store long event sequences even during database disk tasks such as data reordering or defrag. Reference data are stored on database as records. When a user query the database the record found contains only a pointer to video files located on server in a special directory on a mirrored SCSI hard disk. This pointer is the absolute path of video directory, and the server can easily access to it for playing the video sequence. Another critical issue was to design the Human Machine Interface (HMI). HMI should be easy to use and very intuitive to not hamper emergency staff in their job. The primary target of this kind of HMI is simplicity and intuition of use.
Visual Basic .Net offer a lot of facilities for engineering this kind of interface, with useful component like for example info tool tips, and a very large set of available font for buttons and labels. Figure 4 shows the resulted client HMI.

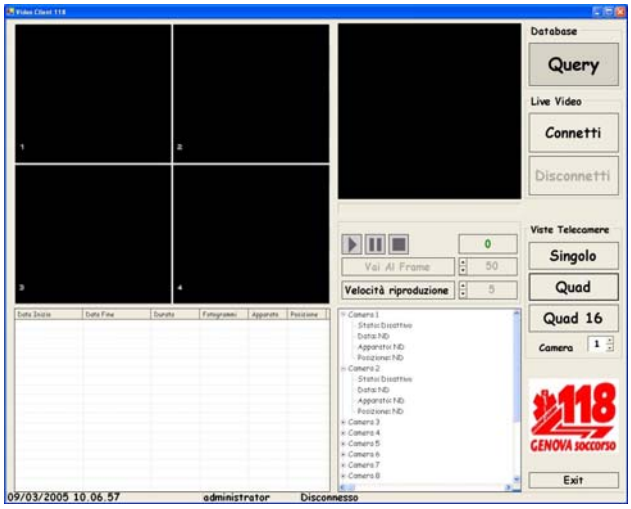

Fig. 4:HMI for client in the Hospital

One of the development challenges was to employ a low bandwidth together with a good video quality using a GPRS connection [5]. It takes a long time to select a good compromise for packet length in order to achieve the requested quality/bandwidth ratio with a low frame rate and, fixed bitrate using an H.264 encoder. The chosen fixed rate maintains good video quality even during GPRS band lowering for bad signal coverage, with auto frame skipping during video grabbing. Then good video quality constraint is accomplished even when a frame dropping is present. In this situation (dramatic with GPRS band lowering) we tested this is the best obtainable compromise. To decrease the video-encoder (H.264) computational weight a number of algorithm and software optimisation have been implemented. A fast motion estimation module has been used [6]. A set of modules has been implemented using optimised assembly
(WMMX for the Handheld and MMX and Transmeta Crusoe SIMD instructions for TabletPC) in order to improve software performance and to decrease power consumption [7].

3 System use by Emergency staff

Emergency staff use is definitely a meaningful test case for verifying system functionalities, efficiency and usability. Some points have been collected during the utilization of the system by the medical staff.

In the real-time-video transmission case :

- The video transmission is clear even in GPRS band lowering (worst case).
- The system is a good support in taking decisions helping with the direct vision of the event by specialist located in remote Hospital.
- Sometimes, external point of view is useful to bypass any eventual emotion and can have also a more general vision of the emergency area.
- System dynamic connections permit staff to stay remote from ambulance, contacting Hospital directly with handheld and GPRS phone (a sub set of portable system)

In the recorded-video case:

- Database query allows bypassing some paper documentation, used before system introduction.
- Hospital staff can review each moment of an emergency event to evaluate the event handling.
- The video documentation allows giving an advice in legal disputation like ambulance accidents or mistake in patient recovery.
- Educational purposes: the possibility to use videos for new staff members training.

For all this points, emergency staff evaluates the introduction of the system as a positive improvement in the emergency handling.

4 Conclusion

In this paper a low cost system for supporting emergency medical situation based on wireless connection and database storage have been described. The system allows real time video transmission, storage, and medical parameters transmission providing reliable and timely data to clinicians. It is transportable allowing also handling situations where the radio connection coverage (GPRS) is absent. The system has been tested in actual emergency situation receiving positive feed back from the emergency staff. Future development will be focused on the use of the UMTS standard, in order to improve video and data transmission effectiveness. Moreover the design of a more compact hardware set could further improve the system usability.

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