PRACTICAL EVALUATION OF GPRS USE IN A TELEMEDICINE SYSTEM IN CYPRUS

S. Ch. Voskarides [1,3], C.S. Pattichis [2], R. Istepanian [3], C. Michaelides [4], C.N. Schizas [2]
[1] Department of Electrical Engineering, Higher Technical Institute, Cyprus, boss@spidernet.com.cy
[2] Department of Computer Science, University of Cyprus, Cyprus, {pattichi, schizas}@ucy.ac.cy
[3] Department of Electronic &Computer Engineering, Brunel University, U.K Robert.Istepanian@brunel.ac.uk
[4] Cyprus Telecommunication Authority, GSM Department, constantinos.michaelides@cyta.com.cy

Abstract- **The unceasing emergence of new technologies in wireless and mobile telecommunication networks, combined with the simultaneous rapid advances in information technology, are leading to many new solutions in the field of telemedicine, thus offering more opportunities for improving further existing and supporting new advanced services for healthcare. The objective of this paper is to carry out a practical evaluation of the performance of the GSM and GPRS systems in the transmission/reception of X-ray images and video in emergency orthopedics cases. As expected, the performance of GPRS is superior to that of GSM. The data transfer rate achieved with GPRS were in the range of 32 Kbps with the download time for typical X-ray images of a file size of 200 Kbytes to the mobile device to be in the region of 60 seconds. Similar performance was also recorded in the case of a moving station (simulating the ambulance) for the biggest part of the journey. In conclusion, although the medical imaging downloading timing was in the range of a few minutes, the physicians were very pleased by the benefits offered by the system through the freedom of access, anywhere and anytime even in motion.**

Keywords - **GSM, GPRS, UMTS, mobile, wireless, Telemedicine, Orthopedics.**

I. INTRODUCTION

Telemedicine can be defined as the distant delivery of health care and remote sharing of medical knowledge using telecommunication means. It aims at providing expert medical care to any place, anytime. Telemedicine as a concept was introduced in the early 70's when telephone and fax machines were the first telecommunication means used. In recent years, several telemedicine applications have been successfully implemented over wired communication technologies like POTS (Plain Old Telephone System), and ISDN (Integrated Services Digital Network).

However, nowadays, modern wireless telecommunication means like GSM and GPRS and the forthcoming UMTS (Universal Mobile Telephone System) mobile telephony standards allow the operation of wireless telemedicine systems freeing the medical personnel and/or the patient from fixed locations.

Telemedicine applications, which enable the availability of prompt and expert medical care, have been exploited for the provision of health care services at understaffed areas like rural health centers, ambulance vehicles, ships, trains, aeroplanes as well as for home monitoring [1]. In most of the wireless telemedicine projects the GSM technology was mainly used. GPRS which is a relatively new system was used only in a very few cases up to now [2].

Many times during emergency cases either in the accident department or the in the operating theatre there is the need of the prompt expert opinion of the specialist physician. The objective of this paper is to carry out a practical evaluation of the performance of the GSM and GPRS systems in the transmission/reception of X-ray images and video in emergency orthopedics cases. The target is the support of trainee doctors as well as doctors who may need a prompt second opinion for facing orthopedics injury cases by transmitting medical images and video with the use of wireless technologies.

II. THE GSM AND GPRS SYSTEMS

The main wireless technologies that are being used in wireless telemedicine systems are the GSM, GPRS, satellite, Wireless Local Area Network (WLAN) and Bluetooth. The GSM is considered as the second generation (2G) of the mobile communication networks.

TABLE I
GSM AND GPRS FREQUENCY BANDS AND DATA TRANSFER RATES

Type	Frequency band	Data transfer rates
GSM	900/1800/1900 MHz	9.6 – 43.3 kbps
GPRS	900/1800/1900 MHz	171.2 kbps

When GSM is in the standard mode of operation, it provides data transfer speeds of up to 9.6 Kbps (see Table I). Throughout the years a new technique was introduced in the GSM standard called HSCSD (High Speed Circuit Switched Data). This technology makes it possible to use several time slots simultaneously when sending or receiving data, so that the user can increase the data transmission up to 43.3 Kbps [3].

The theoretical maximum downlink data rate for GPRS is 171.2 kbps assuming that CS-4 (coding scheme 4) and eight timeslots are simultaneously used (see Table I). Today, however, GPRS coding is limited to CS-2 and transmission can take place onto four timeslots at most, giving a maximum throughput of around 45 kbps (under ideal radio conditions) [4]. This means that pure data throughput

approximates to 35 kbps given that overhead data comprises around 20% of the raw bit stream. Of course this can decrease under non-ideal radio conditions such as frequency interference, traffic congestion and poor radio coverage. The same applies to uplink data rates except that today one or two timeslots can be simultaneously used giving throughputs of 8-16 kbps.

It should be noted that in most cells GSM data channels have priority over GPRS channels. In addition, GPRS packet transmission offers a more user - friendly billing than that offered by circuit switched services.

The evolution of mobile telecommunication systems from 2G to 2.5G (iDEN-Integrated Digital Enhanced Network- 64 kbps, GPRS 171 kbps, EDGE - Enhanced Data rates for Global Evolution - 384 kbps) and subsequently to 3G Code Division Multiple Access (W-CDMA, CDMA2000, TD-CDMA) will enable faster data transfer rates thus facilitating the development of telemedicine systems that require high bandwidth and are currently only feasible on wired communication networks.

GPRS enabled networks offer 'always-connected', higher capacity, mobile data services, such as Internet/WAP (Wireless Application Protocol) browsing, e-mail on the move, powerful visual communications, multimedia messages and location-based services[3].

Satellite systems have the advantage of worldwide coverage but lack in flexibility. Wireless LANs offer much faster and flexible data communications within restricted geographical coverage (hot spots) and can be used in conjunction or as an extension to GPRS and UMTS networks as well as to other wired systems. Bluetooth is a very short-range radio technology that allows wireless data transmission between various computing and communication devices. It is expected to prove very useful as an overlay to other networks such as GPRS/UMTS.

III. METHODOLOGY

The network infrastructure in support of the emergency orthopedics medicine system is given in Fig.1. The Figure illustrates: (i) the server of the internet service provider (ISP), (ii) the accident and emergency department's server (and the departmental LAN) that is connected to the internet via ADSL and (iii) the GSM/GPRS mobile stations which may be a laptop PC or a handheld PC.

A simple scenario of the use of the system follows: X-ray images and/or video clips of orthopedics cases captured at the accident and emergency department or the operating theatre of the hospital are uploaded to the server of the internet service provider. Figure 2 shows typical X-ray images. The physician is informed about the availability of the medical images to be assessed via SMS, voice or email. The physician is then connected to the server via GSM/GPRS modem installed in the laptop or the handheld PC and downloads the images. The physician evaluates the images on the screen of the mobile station and communicates with the accident and emergency department via SMS, voice or email so as to give his comments or instructions.

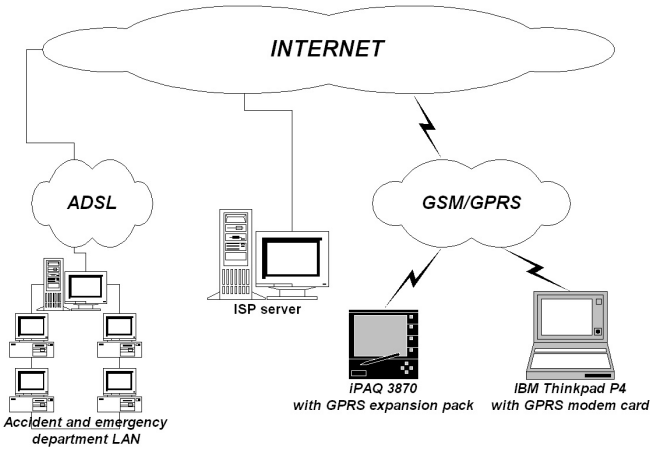

Fig. 1. Network infrastructure of the Tele Biomedical Support System.

In some cases he may as well add part of his instructions on the X-ray image received and then send them to his colleagues via the ISP server.

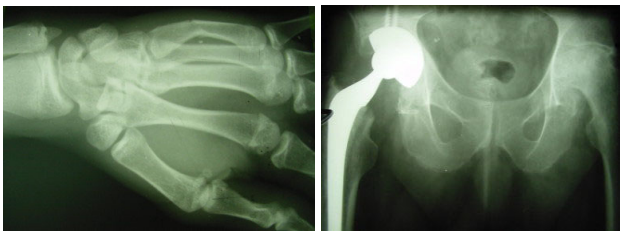

Fig.2. Sample X-ray images transmitted. Left image: right hand. Right image: pelvis. (Image size 210 Kbytes (tiff format), resolution 2000x1400).

The performance of the system was evaluated using wireless communication channels in the transmission of medical images of varying size in the following cases:

i. Downloading of X-ray images via SMTP (as email attachment) or via FTP using both GSM and GPRS, and
ii. Downloading of images via FTP over GPRS.

In addition the performance of the GPRS system using FTP access was evaluated in the cases of:

iii. Repetitive downloading of a video file of size 450 Kbytes for 20 hours from a fixed location, and
iv. Downloading of an image file of size 180 Kbytes on a moving handheld PC at a speed of 100 km/hr.

For the handheld PC the Compaq iPAQ 3870 equipped with the GSM/GPRS expansion pack modem was used, whereas for the laptop PC, the IBM Think Pad with a Globe Trotter high speed GPRS wireless PCMCIA modem card was used. The laptop PC was also used with the Ericsson R520 mobile phone serving as a modem that allowed the

Ericsson TEMS GSM/GPRS monitoring software to be used for field measurements.

IV. RESULTS

The results presented in this study were carried out using the Compaq iPAQ 3870 handheld PC with the medical images and videos varying in size between 10 Kbytes to 2 Mbytes.

Figure 3 illustrates the comparison of GSM and GPRS for both SMTP and FTP protocols. The throughput for GPRS FTP varied between 30 to 35 Kbps, whereas for the GPRS SMTP varied between 13 to 19 Kbps. The throughput performance for GSM for both SMTP and FTP varied between 5 to 10 Kbps. It is clearly shown that for FTP the throughput performance of the GPRS is approximately triple to that of the GSM, whereas for SMTP the GPRS performance is 1.5 times to four times to that of GSM.

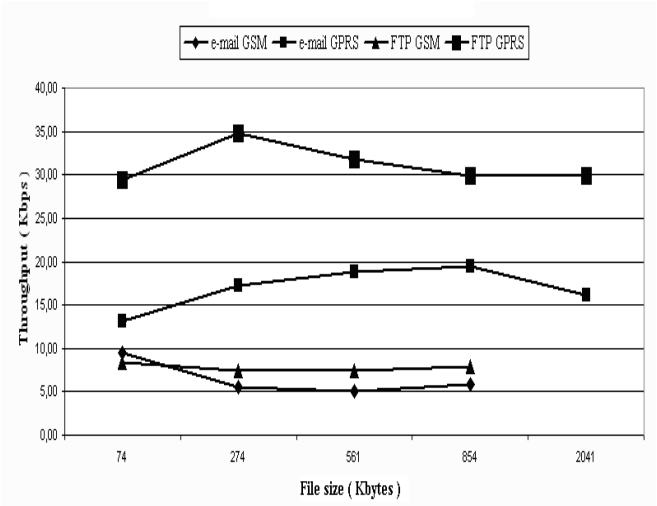

Fig. 3. Comparison of SMTP and FTP protocols over GSM and GPRS.

Figure 4 illustrates the FTP download timing for varying size of image files carried out from a fixed point. As expected, the download timing is increasing proportionally with the increase in the size of the file. It is seen that for files of about 200 Kbytes (size of a typical X-ray image) the download speeds are about one minute.

The corresponding download speeds for the above experiment are shown in Fig. 5 for that specific time and point. The download speed was in the region of 30 Kbps, varying between 23.5 to 34 Kbps. Figure 6 illustrates the repeated downloading of a 450 Kbytes video clip file from a fixed location to the iPAQ pocket PC over a period of 20 hours. Speeds in the range of 30 Kbps were achieved where with the exception of two cases this varied between 27 to 32 Kbps. The download speed versus distance in the case of a mobile station (i.e. the case for an ambulance) traveling in a highway at 100 km/h, downloading repeatedly a 180 Kbytes image file using FTP over GPRS is given in Figure 7. The performance of the system for a significant length of the journey was very satisfactory, with throughput values in the range of 30 to 32 Kbps. However, there were segments of the journey both in the normal and the return journeys where poor performance was recorded, with data transfer rates in the range of 7 to 11 Kbps. In the region of 30 Km in the normal journey there were very bad weather conditions, which must have affected negatively the performance of the wireless network.

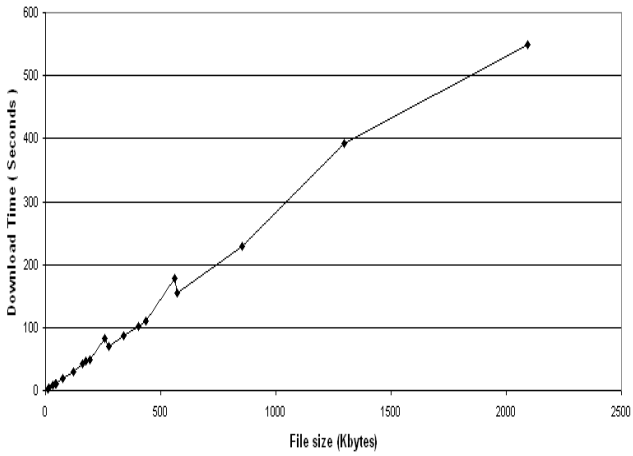

Fig. 4. Download timing for files of varying size using FTP over GPRS.

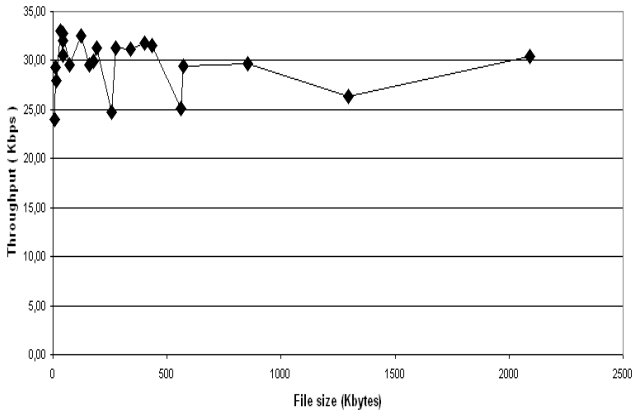

Fig. 5. Download speeds for varying file size using FTP over GPRS.

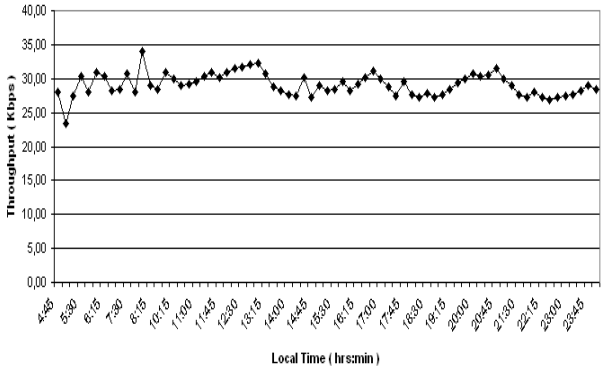

Fig. 6. Repeated downloading of a 450 Kbyte video clip over a period of 20 hours using FTP over GPRS.

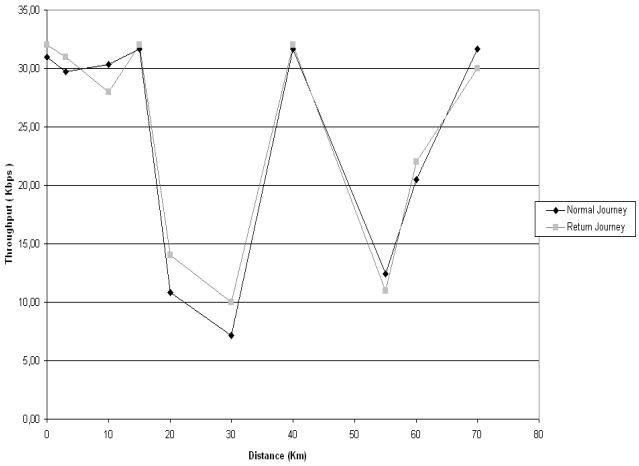

Fig. 7. Download speed versus distance in the case of a mobile station traveling at 100 Km/hr when downloading repeatedly a 180 Kbytes image file using FTP over GPRS.

V. Concluding Remarks

The experiments carried out showed that the GPRS system can be used successfully for the transmission of medical images and video employing the Tele Biomedical Support System using – so far - the store and forward method. The results showed clearly that the method of using FTP over GPRS was by far superior to e-mail.

In this study, a practical evaluation of the performance of the GSM and GPRS systems in the transmission/reception of X-ray images and video in emergency orthopedics cases was carried out. The target is to support trainee doctors as well as doctors who may need a prompt second opinion for handling orthopedics injury cases by transmitting medical images and video with the use of wireless technologies.

As expected, the performance of GPRS is superior to that of GSM. The data transfer rates normally achieved with GPRS were in the range of 32 Kbps which is what was expected since the downlink bit rate for a 4+1 phone connection is between 5 Kbps and 40 Kbps [5].

The download time for typical X-ray images of file size 200 Kbytes to the mobile device was in the region of 60 seconds. The system was also used in an emergency scenario where a prompt second opinion was requested remotely from the orthopedics surgeon in the case of a serious operation. In this case, the doctors in the operating theatre transmitted X-ray images and a video clip to the mobile station via the ISP server, and then the X-ray images were retransmitted back including the surgeon's notes/instructions as well as text and/or voice files. The whole teleconsultation scenario was carried out in less than five minutes.

The performance of the system was also evaluated in the case of a moving station (simulating the ambulance) for the downloading of an X-ray image with speeds reaching 32 Kbps for the biggest part of the journey.

Furthermore, it should be noted that the experts rated the quality of the medical images and video clips transmitted as very satisfactory.

Concluding, a simple and cheap telemedicine system was evaluated that supports wireless access for the transmission of medical images in emergency orthopedics cases. Although the medical imaging downloading timing was in the range of a few minutes, it was compensated by the benefits offered by the system through the freedom of access, anywhere and anytime even in motion.

Future work will focus in the provision of a wireless telemedicine support system covering the needs of the whole island. The system will focus primarily in emergency services covering both the accident and emergency department as well as the ambulance services. Moreover, the UMTS system envisioned to be investigated by CYTA in the near future will greatly leverage telemedicine services, thus enabling the offering of a better service to the citizen.

Acknowledgment

This project was partially supported via the Cyprus Telecommunications Authority (CYTA), the Research Promotion Foundation of Cyprus (project IASIS), and the University of Cyprus. Special thanks to the engineers P. Charalambous, G. Demetriou and H. Panayiotou as well as to the technicians A. Papaconstandinou, A. Theodorou, M. Tovletian and M. Christofidou of the Department of GSM of CYTA for their valuable help. Last but not least we thank Dr Agathoklis N. Schizas, Department of Orthopedics, Nicosia General Hospital for his valuable support to this project.

References

[1] C.S. Pattichis, E. Kyriacou, S. Voskarides, M.S. Pattichis, R. Istepanian, C.N. Schizas, Wireless Telemedicine Systems: An Overview, *IEEE Antennas & Propagation Magazine*, Vol. 44, No. 2, pp. 143-153, 2002.

[2] S. Voskarides, C.S. Pattichis, R. Istepanian, E. Kyriacou, M.S. Pattichis, C.N. Schizas, Mobile Health Systems: A Brief Overview, Proceedings of SPIE AeroSense 2002: Digital Wireless Communications IV, Ed. by R. M. Rao, S. A. Dianat, M. D. Zoltowski, Vol. 4740, Orlando, Florida, USA, pp. 124-131, 2002.

[3] GSM webpage: http://www.gsmworld.com

[4] IEEE Communications Society webpage : http://www.comsoc.org

[5] Christofer Anders son GPRS and 3G Wireless Applications. professional Developer's Guide Series. John Wiley & sons inc., *ISBN: 0-471-41405-0*