Health and Mobility: Current Status and Future Paradigms

Robert S. H. Istepanian*, Sapal Tachakra**, Konstantinos A. Banitsas*

* e-Med Systems and Health Engineering Group
Department of Electronic & Computer Engineering, Brunel University, Uxbridge, UB8 3PH, UK
www.brunel.ac.uk/departments/ee/Research_P`rogramme/e_med/pages/index.htm
[bany@hol.gr], www.bany.gr [robert.istepanian@brunel.ac.uk]

** A&E Department, North West London Hospitals NHS Trust, Central Middlesex Hospital, Acton Lane, London NW10 7NS. [sapal.tachakra@tinyworld.co.uk]

Abstract - **The movement of telemedicine to the wireless and mobile Internetable applications is imminent in the next few years. This migration from the desktop platforms to the wireless and mobile configurations will have significant impact on the future health care delivery system and their globalisation. The recent telecommunications and biomedical computing advances will significantly enhance the current methodologies of telemedicine and telecare systems. This editorial will present some of the evolutionary issues and important aspects that have to be considered in the developing technologies for the next generation of Internet and Third Generation of Mobile Systems (3G), geared for future telemedical applications. These will provide new dimensions to existing medical services and areas of outreach, that are not possible in the current generation and will have tremendous impact on how the health care delivery will be shaped for the 21 Century.**

I. NEXT GENERATION OF MOBILE SYSTEMS: A TELEMEDICINE PERSPECTIVE

Wireless telemedicine is a new and evolving area in telemedical and telecare systems. It involves the exploitation of the mobile telecommunication and multimedia technologies and their integration for new mobile health care delivery systems.

Essential new telemedicine technologies will be able to provide equal access to medical information and expert care by overcoming the boundaries of separation that exists between different users. This scenario will also be achieved with efficient use of resources and greater location independence.

The recent developments in these digital mobile telephonic technologies and their impact on mobility issues in different telemedical and telecare applications, are clearly reflected in the fast commercially growing domain of mobile telemedical services, that were not possible with the standard plain old telephone (POTS) and ISDN services. Current examples include mobile ECG transmissions, video images and teleradiology, wireless ambulance services to predict emergency and stroke morbidity and other integrated mobile telemedical monitoring systems [1-3]. However, the current (second) generation of digital cellular system has limitations in its bit rates (around 10 kbps that are much lower than the existing POTS services) but supports global operational coverage. Hence, it will provide limited performances for real-time transmission with narrow use and spectrum to these services and generic telecare and telehealth applications.

The current evolution of the third generation cellular telecommunication technologies will change such scenario and possibly the existing semantics of telemedicine. These advances will soon replace the current diverse collection of cellular technologies such as high and low mobility cellular/PCS, fixed access via cordless, and satellites, to a converging set of services including voice, data, multimedia, wireless messaging and computing [5,6].

These will provide the mobile patients and normal working end-users, the choices that will fit their lifestyle and make easier for them to interactively get the medical attention and advice, when and where is required and how they want it regardless of any geographical barriers or mobility constraints[7]. The concept of including data and high-speed services integrated with the voice services, is emerging as one of the main points of the future telecommunication and multimedia priorities, with the relevant benefits to a citizen centred healthcare systems. These creative methodologies will support the development of new and effective medical care delivery systems into the 21st century. The new wireless technologies will allow physicians to roam freely, while maintaining access to critical medical information [12].

The potential benefits of integrated Internet-based mobile telemedicine systems can be summarised in the following:

- The rapid response to critical medical scenarios regardless of any barriers.
- Flexible and swift access to expert opinion and advice to the point of care without delay and better management of medical resources.
- Interactive medical consultation and communication links of medical images and video data such as the videophones over Internet links in complete mobility and in global coverage and connectivity.
- Increased empowerment and management of medical expertise especially in rural and undeserved areas using the above technologies.

- Swift and better medical care delivery in emergency and management of medical data in catastrophes or natural disaster circumstances where conventional communication links could be unavailable.

In recent years there has been increased research on wireless telemedicine using current mobile communication systems, especially in USA and Europe, for conventional civilian and military use [5-13]. However, the increased equipment cost, such as satellite-based systems and the limited bandwidth of the current generation of cellular telecommunication systems, have restricted the wider use of these systems within prospective the health care structures.
The new Third-Generation (3G) mobile communication systems strive to overcome these technical limitations of the preceding technology [15,16]. The 3G mobile (UMTS/IMT-2000) communication systems scheduled to operate globally by the year 2003 will offer significant user benefits including high-quality wireless multimedia services to a convergent network structure of fixed, cellular and satellite components. In recent years and with the explosive consumer use of digital cellular technology networks, there have also been a rapidly growing commercial market for digital mobile telephones and the adoption of the relevant digital cellular standards, such as D-AMPS (Digital Advance Mobile Phone Systems); USA based, GSM (Global System for Mobile communications); European based, PDC (Personal Digital Cellular); Japanese based and the CDMA (Code Division Multiple Access); USA based. It will likely be comprised of a family of standards, ensuring interoperability through network, air interface, and terminal standards [15]. By the third quarter of 2000, Japan will be one of the first countries in the world to roll out W-CDMA (Wide Band Code Division Multiple Access) wireless services with services that support voice, data, or video transmission. Such 3G wireless services with multimedia, mobility-enabled services or location and user customisation services with global roaming capabilities will be able to provide a near perfect platform for the next generation of global wireless telemedicine systems that encompass the use all these capabilities for new age healthcare delivery.

Wireless and mobile technologies are currently having a powerful impact on the way different healthcare organisations are delivering healthcare to their customers. Cellular digital networks, in-building wireless and portable information system appliances are extending the reach, range and manoeuvrability of applications and content [15,16]. The emergence of personal mobile telemedicine system using wireless links with video capabilities is imminent in next few years [14].
The third generation systems or the '3G' systems, demand the necessity and requirements.

The current mobile telemedicine systems are characterised by the following drawbacks:

- The lack of a flexible and integral telemedical linkage of the different mobile telecommunication options. These exist due to the difficult operational compatibility between the telecommunication services and current mobile standards.
- The high cost and expensive links, especially between the satellite and global mobile devices.
- The limited data transfer rate of the current mobile telephonic systems at 9.6 Kbit/s compared to the costly new ISDN land Links (primary rate) which is less than 2Mbit/s or even DSL at 8Mbit/s [15].
- The limited spread to the Internet connectivity and information access due to the current bandwidth limitations.

These constitute to some of the major limitations that restrict the wider use and globalisation of the current mobile telemedical services so far. However, most of the technical challenges and limitations of the previous generation of wireless telemedicine will be resolved by the introduction of the new 3G systems.

II. THE FUTURE PROSPECTS OF MOBILE AND WIRELESS TELEMEDICAL SYSTEMS

It is well known that the four basic parts of a cellular system are: Mobile phones, base stations, mobile switching centre, and interconnections. The details of these issues are beyond the scope of this paper and can be found in several mobile telecommunication texts [5, 15].
The most important issue for the current mobile phone systems to operate correctly is to conform to industry-accepted specifications. For example TDMA (Time Division Multiple Access) phones must conform to the North American IS-136 standard [5]. The widely used European systems must conform to the Global System for mobile communications (GSM) standard. However, the new 3G mobile system will *defacto* use the (W-CDMA) standard. The new 3G-CDMA will be able to provide the following capabilities that will have the most effective impact in the design and development of next generation of mobile /wireless telemedicine systems, these can be summarised as:

- Data rate of 144 kb/s for users in the moving vehicles and moving fast over large areas and data rates of 384 kb/s for slow moving objects and mobile persons over small areas. These will provide enough data rate for medical data and image transmissions in these scenarios.
- Phased-in support for 2 Mb/s operation for office use. These large rates will provide laptop telemedicine with mobile multimedia applications. This will also allow convergence with the existing wireless LAN technologies (IEEE802.11b, HiperLAN/2) as more and more WLANs are established in the telecare environment.

The major technical design issues of the 3G mobile systems and their synergy with telemedical applications can be summarised in the following issues:

- The integration issues of such new 3G systems for targeted telemedical applications.
- The integrated biomedical sensing design and signal processing issues that will allow the compatibility of these systems with medical applications in mobile environments.
- The performance and reliability issues of these new systems in different health care scenarios and the associated mobility conditions.

The future systems and studies will focus on these issues to provide the telemedicine providers with a better understanding of the engineering and medical aspects of the compatibility issues of the future mobile standards and their integration with next generation of mobile telemedicine applications for enhanced quality and better performance and flexibility.

CONCLUSIONS

This paper addresses some of the fundamental issues and future scenarios regarding the next generation of mobile telemedicine systems. The current structures of telemedicine will be more geared towards the wireless solutions of the different telemedical applications that are not feasible with the current generation of cellular telephonic Internet services. The launch of the next generation of wireless and Internet technologies will fundamentally change the current structures of telemedical and healthcare delivery systems.

REFERENCES

[1] D.A. Perendina and A. Allen, Telemedicine technology and clinical applications, *JAMA*, Vol. 273, No. 6, pp. 483-488, 1995.

[2] Wootton, R., and Craig, J., "Introduction to Telemedicine", *The Royal Society of Medicine Press*, London, 1999.

[3] N.M. Fisk, S. Bower, W. Sepulveda, Fetal telemedicine: "Interactive transfer of real time ultrasound and video via ISDN for remote consultation", *J. Telemedicine and Telecare*, Vol. 1, No. 1, pp. 38-44,1995.

[4] W. Tuttlebbe, "You'll never talk alone", *IEE Review*, pp.99-102, May 1997.

[5] E. Rosen, "Mobile telemedicine arrives", *Telemedicine Today*, Vol.5, No.5, pp.14,42, Oct. 1997.

[6] S.M. Redhl, M.K. Weber and M.W. Oliphant, "An introduction to GSM", Artech House Publishers, London-Boston, 1995.

[7] Istepanian, R.S.H., Tachakra, S. and Banitsas, K., "Medical Wireless LAN Systems (MedLAN): State of Art, Challenges and Future", *Proceedings of the 3rd Int. Conference in the Delivery of Care, E-Health; a Future Prospective, E. Carson, F. Harvey and Mike Hughes (Eds.), pp. 43-49, City University, London, 4-6 April 2001*.

[8] Istepanian, R.S. H., "Telemedicine in the United Kingdom, Current Status and Future Prospects", *IEEE Trans. Information Technology in Biomedicine*, Vol.3, 1, pp.158-159, 1999.

[9] B. Hoffman, A multiparameter, PC-based telemetry unit for biomedical signals, *J. Telemedicine and Telecare*, Vol.2, pp.143-147, 1996.

[10] R.H. Istepanian, M. Brien and P.Smith, "Modelling of photoplethysmography mobile telemedical system", *Proceedings of the 19th Annual IEEE International Conference of the Engineering in Medicine and Biology Society*, Chicago, USA, pp. 987-990, Oct. 30- 2 November ,1997.

[11] Istepanian, R S. H., B. Woodward, P. Balos S. Chen, and B.Luk, "The comparative performance of mobile telemedical systems using the IS-54 and GSM cellular telephone standards", *Journal of Telemedicine and Telecare*, Vol.5, 2, pp.97-104, 1999.

[12] Istepanian, R. S. H., "Hybrid signal processing technologies for next generation wireless telemedicine systems", *Proceedings of the joint meeting of the 2nd International conference on telemedical information society/2nd International conference on information technology applications in biomedicine ITIS-ITAB'99*, Amsterdam, Holland, pp.21-23, 12-13, April 1999. Also published in *The Virtual Medical Worlds Magazine*, Feb.2000 (www.hoise.com/vmw/00/articles).

[13] R. H. Istepanian, **"**Modelling of GSM–based Mobile Telemedical System", *Proceedings 20th. IEEE Annual International Conference of Engineering in Medicine and Biology*, Hong Kong, pp.1166-1169, November 1998.

[14] R. S. H. Istepanian and Chandran, S., "Enhanced telemedicine applications with next generation of wireless systems", *Proceedings of the 21th. IEEE Annual International Conference of Engineering in Medicine and Biology*, Atlanta,October,1999.

[15] Lettieri, P. and Srivastava, M., "Advances in Wireless Terminals", *IEEE Personal Communications*, pp. 6-18, Feb.1999.

[16] R. Prasad, (Ed.), "Third Generation Mobile Communication Systems", Artech House Publishers, London-Boston, 2000.

[17] N.J. Muller, "IP Convergence: The next Revolution in Telecommunications", Artech House Publishers, London-Boston, 2000.