Non-telephone Healthcare: The Role of 4G and Emerging Mobile Systems for Future m-Health Systems

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Abstract The next generation of "m-health technologies" is a new and evolving topic in the areas of telemedical and telecare systems. These technologies involve the exploitation of mobile telecommunication and multimedia technologies to provide better access to healthcare personnel on the move, by removing the key disadvantage of trailing wires in current systems. These technologies provide equal access to medical information and expert care by overcoming the boundaries of separation that exist today between different users of such medical information. A great benefit to all users will be a more efficient use of resources and far greater location independence. In this paper we will address some notes and future trends in these emerging areas and their applications for m-health systems. Especially we will discuss the role of 4G and emerging mobile systems for future m-health systems. The new technologies can make the remote medical monitoring, consulting, and health care more flexible and convenient. But, there are challenges for successful wireless telemedicine, which are addressed in this paper.

Keywords mHealth · 4G · Mobile Telemedicine Systems

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1 Introduction

Time and space constitute barriers between health-care providers and their patients and among health-care providers. Patients in rural areas, on a space shuttle flight, at accident scenes, en route to a hospital, in a submarine, etc., are often physically remote to appropriate care providers.

Telecommunication technologies have presented themselves as a powerful tool to break the barriers of time and space. With the introduction of high-bandwidth, digital communication technologies, it is possible to deliver audio, video, and waveform data to wherever and whenever needed.

The health-care industry may be poised to adopt wireless devices and applications in large numbers. Wireless technology may provide improved data accuracy, reduce errors, and result in overall improvement of patient care. The number of wireless devices in health-care is expected to triple by 2005, according to a study by Technology Assessment Associates. Wireless-enabled handheld usage by U.S. physicians is likely to climb to 55% by 2005, up from the current 18% [1].

The benefits of the wireless technology can be illustrated in a number of different examples [2]. Patient information can be obtained by health-care professionals from any given location because they can be connected wirelessly to the institution's information system. Physicians' access to patient histories, lab results, pharmaceutical information, insurance information, and medical resources would be enhanced, thereby improving the quality of patient care. Handheld devices can also be used in home health-care, for example, to fight diabetes through effective monitoring.

The major step from second- to third-generation and further to fourth-generation and beyond mobile communications was the ability to support advanced and wideband multimedia services, including email, file transfers, and distribution services, including email, file transfers, and distribution services like radio, TV, and software provisioning (e.g., software download). In general the combination and convergence of the different worlds of information technology (IT), media, and telecommunications will integrate communications. As a result mobile communication together with IT will penetrate various fields of society and especially telemedicine.

4G is expected to support faster- and larger-capacity transmissions, in order to provide high-resolution video and other applications seamlessly in a mobile environment [3].

Mobile telemedicine is a new and evolving area of telemedicine that exploits the recent development in mobile networks for telemedicine applications [4]. It was suggested that the next step in the evolution of telemedicine would be mobile telemedicine systems [5].

2 Overview of Mobile Telemedicine Systems

2.1 Current Mobile Technologies

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 [6–14]. 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 the most promising segments of the health care structures in general. However, in recent years some emerging 2.5G- and 3G-based m-health systems with Bluetooth medical wireless technologies have been cited in the literature [2].

2.2 Limitations of Existing Wireless Technologies for m-Health

The current mobile telemedicine systems can be characterised by the following drawbacks:

- The lack of a flexible and integrated telemedical linkage of the different mobile telecommunication options. This lack of linkage exists due to the difficulty of achieving operational compatibility between the telecommunication services and the current mobile standards.
- The high cost of communication links, especially between satellites and global mobile devices.
- The limited data transfer rate of the current mobile telephonic systems (around 9.6 Kbit/s). Specially when compared to the costly new ISDN l and Primary Rate Interface (PRI) of less than 2 Mbit/s, or even DSL at 8 Mbit/s [11].
- The limited availability of mobile internet connectivity and information access due to the current bandwidth limitations.
- Healthcare is a very complex industry and difficult to change.
- Organisational changes are very often required for healthcare institutions to benefit from mobile telemedicine.
- Those required organisational changes most likely have an impact on how physicians and other staff members lose or gain power as a result of those changes.
- The short-term and long-term economic consequences and working conditions for physicians and healthcare systems are not yet fully understood.
- The methods of payment for such mobile telemedicine are not yet fully developed and standardised.
- There is a lack of incentive for busy specialists to practice mobile telemedicine because it is seen as yet another imposition for which they are not paid.

- The currently available telemedicine equipment can sometimes be difficult to handle.
- There is a lack of integration between mobile telemedicine systems and other information systems e.g. referral and ordering systems, medical records etc.
- There are not enough numbers of demonstration projects that show mobile telemedicine's real savings potential.

The above are some of the factors that have hindered the wider applications of mobile telemedicine technologies thus far across health-care systems and on critical medical applications.

3 4G Technology

It is expected that the 4G mobile system will focus on seamlessly integrating the existing wireless technologies including GSM, wireless LAN, Bluetooth, and other newly developed wireless systems. So 4G system benefits from all those wireless technologies, as that currently there is no single system that is good enough to replace all the other technologies. Some key features of 4G networks are stated as follows:

1. High usability. 4G networks are all IP based heterogeneous networks that allow users to use any system at anytime and anywhere. Users carrying an integrated terminal can use a wide range of applications provided by multiple wireless networks.
2. Support for multimedia services at low transmission cost. 4G systems provide multimedia services with high data rate, good reliability and at low per-bit transmission cost.
3. This new-generation network will provide personalised service, in order to meet the demands of different users for different services.
4. 4G systems also provide facilities for integrating services. Users can use multiple services from any service provider at the same time.

The main technological characteristics of 4G systems are as follows:

1. The transmission speed is higher than 3G (min 50–100 Mb/s, average 200 Mb/s).
2. The system capacity is larger than 3G by 10 times.
3. The transmission cost per bit is decreased to 1/10 to 1/100 of 3G.
4. It should support internet protocols (IPv6).
5. 4G should have various qualities of services in order to provide many kinds of best effort multimedia services corresponding to users' demand.
6. User friendly services provider, as that user can access to so many services in short time as compared to other wireless systems that encounters long time waiting for response.

The future 4G service can provide communication with realistic sensation, in which 3D sound, light, and pressure fields are sent to another party to reproduce a

situation. Therefore, virtual reality can be generated, letting you experience things as if you are "actually there" with bit rate of 50 Mb/s [14]. While via 3G system only the voice can be transmitted with any 2D image as the realistic sensation of the transmitted place with bit rate of 3.4 kb/s [14]. The current trend of research in field of wireless technology is towards building technology based human feelings (human communication). Human communications involves conveying feelings to communicate smoothly. Although videophones featuring images and virtual reality have accomplished visual communication of the user's appearance and the senses of virtual movement of the user environment, they alone are not enough to help convey feelings. So by adding voice, image, or data, and import the real physical sensations that complement feelings, the atmosphere around the user, and his/her physical movements in communication, it should be possible to establish a more sympathetic physical communication style. Such a communication style may be applied to a wide range of fields, including remote medical care.

4G advances will provide both 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 they need. When and where is required and how they want it regardless of any geographical barriers or mobility constraints. The concept of including high-speed data and other services integrated with voice services is emerging as one of the main points of the future telecommunication and multimedia priorities with the relevant benefits to citizen centered healthcare systems. These creative methodologies will support the development of new and effective medical care delivery systems into the 21-century. The new wireless technologies will allow both physicians and patients to roam freely, while maintaining access to critical medical information.

4 Next Generation m-Health Systems

The next few years will witness a rapid deployment in both wireless technologies and mobile internet based m-health systems with pervasive computing technologies. The increasing data traffic and demands from different medical applications and roaming application will be compatible with the data rates of 3G systems in specific mobility conditions. The implementation and penetration of 4G systems is expected to help close the gap in medical care. Specifically, in a society penetrated by 4G systems, home medical care and remote diagnosis will become common, check-up by specialists and prescription of drugs will be enabled at home and in underpopulated areas based on high-resolution image transmission technologies and remote surgery, and virtual hospitals with no resident doctors will be realised. Preventive medical care will also be emphasised: for individual health management, data will constantly be transmitted to the hospital through a built-in sensor in the individual's watch, accessories, or other items worn daily, and diagnosis results will be fed back to the individual. However, it is well known that current Healthcare systems are stuck with the equation:

Current organisation + New technology = Expensive current organisation.

Hence, the expectations are for these new-generation mobile and wireless technologies to be acceptable for sort of examples that represent challenges for these technologies such as:

1. Citizens become customers
2. Input measures are replaced by output measures
3. Citizen relationship costs fall
4. Taxes are lowered because of competition

In addition there is hope for the wider deployment of mobile telemedicine system because of some global changes, which are likely to have a major effect on the health-care industry. Those changes are:

- Increasing numbers of older adults and fewer young people so that to sustain the economy, the elderly will have to be persuaded to continue working longer. To be able to do this, a greater emphasis on the health of the elderly will mean an increase in demand for healthcare. At the moment an obstacle to the implementation of telemedicine is that commercial organisations do not regard the health economy as large enough to invest time and research. The growing demand for healthcare services and the reduced supply of service providers and caregivers will mean that telemedicine suddenly acquires a heightened importance.
- Fragmentation of care caused by the twin pulls of generalisation to push down costs and specialisation to meet the increasing needs of rapid advances. Co-operation in health-care, which has been anathema to healthcare workers, will have to be achieved by patient power rather than central directive.
- Increased patient expectation because of easier access to information will mean that the pre-eminence of the physician will be challenged. Patient lifestyles will mean that at least affluent ones will demand treatment wherever they are at the time because of a new leisure-oriented lifestyle. On the other hand patients at the lower end of the socio-economic scale may have to settle for lower expectations.
- Increased complexity of assessment, diagnosis, investigations and treatment will mean a knowledge explosion and the falling short of the quick dissemination of the knowledge and expertise. Again, telemedicine may serve a useful function of rapid dissemination of the skills and knowledge.

5 Cultural, Commercial and Operational Change

A nation's health service is fashioned by its economy, demography, culture, and medical tradition, among other factors. This identity poses a challenge to tele-medicine, which can make it better. In addition it has to deal with the problem of component management. Component management derives from the observation

that the providers and payers of health-care view health challenges only through the specific window of care for which they are responsible. One of the main incentives of health-care is the reimbursement, which is basic to the cost of health-care. Providers are forced to organise their packages into reimbursable ones. Any task, which falls outside these packages, tends to be overlooked or receive low priority. Thus component management systems serve patients poorly. Thus the emphasis is on treatment rather than prevention, there is a lack of incentive for providers to treat the entire disease process, which leads to an uncoordinated delivery system. Some other key factors that may accelerate the diffusion of m-health systems are:

1. Management perspective when planning the implementation of telemedicine to favour mobile solutions rather than fixed ones.
2. Economic perspective—mobile telemedicine costs and savings will probably appear on different accounts.
3. Development of payment systems to include mobile telemedicine.
4. Government intervention to fund exemplars of mobile telemedicine integrated into the health-care system.
5. Comprehensive assessments rather than feasibility reports by enthusiasts.
6. A need to educate and inform key players of what is available and what can be achieved in the future.
7. Clarification of the legal and ethical issues.

6 Conclusions

This paper addresses some of the fundamental issues and future scenarios regarding the next generation of mobile telemedicine systems. It is conclusive that some of the current and successful telemedicine systems will be more geared toward emerging wireless solutions in health-care scenarios that are not feasible with the current generation of cellular telephonic and internet services. The imminent launch of the next generation of wireless and internet technologies will fundamentally change the current structures of telemedical and healthcare delivery systems.

We can conclude that the main characteristics of the future 4G are: high communication speed, high capacity, low bit cost and IP-based technology. This promising technology will play a very important roll in telemedicine applications.

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