

Mobile Healthcare Communication Infrastructure Networks

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INTRODUCTION

M-health is defined as “mobile computing, medical sensor, and communications technologies for healthcare” (Istapanian & Zhang, 2004). The use of the m-health terminology relates to applications and systems such as telemedicine and biomedical sensing systems (Budinger, 2003). The rapid advances in information and communication technology (ICT) (Godoe, 2000), nanotechnology, bio-monitoring (Budinger, 2003), mobile networks (Olla, 2005a), pervasive computing (Akyildiz & Rudin, 2001), wearable systems, and drug delivery approaches (Amy & Richards, 2004) are transforming the healthcare sector. The insurgence of innovative technology into healthcare practice is not only blurring the boundaries of the various technologies and fields, but is also causing a paradigm shift that is blurring the boundaries between public health, acute care, and preventative health (Hatcher & Heetebry, 2004). These developments have not only had a significant impact on current e-health and telemedical systems (Istapanian & Zhang, 2004), but they are also leading to the creation of a new generation of m-health systems with convergence of devices, technologies, and networks at the forefront of the innovation.

The phenomenon to provide care remotely using ICT can be placed into a number of areas such as m-health, telemedicine, and e-health. Over the evolution of telemedicine, new terminologies have been created, as new health applications and delivery options became available and the application areas extended to most healthcare domains. This resulted in confusion, and identification of what falls under telemedicine and what falls under telehealth or e-health became more complicated as the field advanced. New concepts such as pervasive health and m-health are also adding to this confusion. The first section of this article provides the background of telemedicine and the advancements of mobile networks, which are collectively the foundation of m-health. The evolution and growth of telemedicine is highly correlated with ICT advancements and software development. Telemedicine advancements can be categorized into three eras (Bashshur, Reardon, & Shannon, 2000; Tulu & Chatterjee, 2005) discussed in the next section.

There are numerous wireless infrastructures available for healthcare providers to choose from. Mobile networks that provide connectivity within buildings use different

protocols from the standard digital mobile technologies such as global mobile systems (GSMs), which provide wide area connectivity. The second section of this article provides a summary of these mobile technologies that are having a profound impact on the healthcare sector. This section is then followed by the conclusion.

ERAS OF TELEMEDICINE

The *first era* of telemedicine solely focused on the medical care as the only function of telemedicine. This era can be named the telecommunications era of the 1970s. The applications in this era were dependent on broadcast and television technologies in which telemedicine applications were not integrated with any other clinical data. The *second era* of telemedicine was a result of digitalization in telecommunications, and it grew during 1990s. The transmission of data was supported by various communication mediums ranging from telephone lines to integrated service digital network (ISDN) lines. During this period there was a high costs attached to the communication mediums that provided higher bandwidth. The bandwidth issue became a significant bottleneck for telemedicine in this era. Resolving the bandwidth constraints has been a critical research challenge for the past decade, with new approaches and opportunities created by the Internet revolution; now more complex and ubiquitous networks are supporting the telemedicine. The *third era* of telemedicine was supported by the networking technology that was cheaper and accessible to an increasing user population. The improved speed and quality offered by Internet2 is providing new opportunities in telemedicine. In this new era of telemedicine, the focus shifted from an technology assessment to a deeper appreciation of the functional relationships between telemedicine technology and the outcomes of cost, quality, and access.

This article proposes a *fourth era*, which is characterized by the use of Internet protocol (IP) technologies, ubiquitous networks, and mobile/wireless networking capabilities, and can be observed by the proliferation of m-health applications that perform both clinical and non-clinical functions. Since the proliferation of mobile networks, telemedicine has attracted a lot more interest from both academic researchers and industry (Tachakra, Wang, Istapanian, & Song, 2003). This has resulted

in many mobile/wireless telemedicine applications being developed and implemented. Critical healthcare information regularly travels with patients and clinicians, and therefore the need for information to become securely and accurately available over mobile telecommunication networks is key to reliable patient care and reliable medical systems.

The telecommunication industry has progressed significantly over the last decade. There has been significant innovation in digital mobile technologies. The mobile telecommunication industry has advanced through three generations of systems and is currently on the verge of designing the fourth generation of systems (Olla, 2005b). The recent developments in digital mobile technologies are reflected in the fast-growing commercial domain of mobile telemedical services. Specific examples include mobile ECG transmissions, video images and tele-radiology, wireless ambulance services to predict emergency and stroke morbidity, and other integrated mobile telemedical monitoring systems (Istepanian & Zhang, 2004; New Scientist, 2005; Istepanian & Lacal, 2003; Warren, 2003). There is no doubt that mobile networks can introduce additional security concerns to the healthcare sector.

As security is a major concern, it is important to implement a mobile trust model that will ensure that a mobile transaction safely navigates multiple technologies and devices without compromising the data or the healthcare systems. M-health transactions can be made secure by adopting practices that extend beyond the security of the wireless network used and implementing a trusted model for secure end-to-end mobile transactions. The mobile trust model proposed by Wickramasinghe and Misra (2005) utilizes both technology and adequate operational practices to achieve a secure end-to-end mobile transaction. The first level highlights the application of technologies to secure elements of a mobile transaction. The next level of the model shows the operational policies and procedures needed to complement technologies used. No additional activity is proposed for the mobile network infrastructure since this element is not within the control of the provider or the hospital.

The next section will discuss the mobile network technologies and infrastructure which are key components of any m-health system; the network infrastructure acts as a channel for data transmission and is subject to the same vulnerabilities, such as sniffing, as in the case of fixed network transaction. The mobile networks discussed in the next section are creating the growth and increased adoption of m-health applications in the healthcare sector.

MOBILE HEALTHCARE COMMUNICATION INFRASTRUCTURE

The implementation of an m-health application in the healthcare environment leads to the creation of a mobile

healthcare delivery system (MHDS). An MHDS can be defined as the carrying out of healthcare-related activities using mobile devices such as a wireless tablet computer, personal digital assistant (PDA), or a wireless-enabled computer. An activity occurs when authorized healthcare personnel access the clinical or administrative systems of a healthcare institution using mobile devices (Wickramasinghe & Misra, 2005). The transaction is said to be complete when medical personnel decide to access medical records (patient or administrative) via a mobile network to either browse or update the record.

Over the past decade there has been an increase in the use of new mobile technologies in healthcare such as Bluetooth and wireless local area networks (WLANs) that use different protocols from the standard digital mobile technologies such as 2G, 2.5, and 3G technologies. A summary of these technologies are presented below, and an overview of the speeds and range is presented in Table 1.

These mobile networks are being deployed to allow physicians and nurses easy access to patient records while on rounds, to add observations to the central databases, and to check on medications, among a growing number of other functions. The ease of access that wireless networks offer is matched by the security and privacy challenges presented by the networks. This serious issue requires further investigation and research to identify the real threats for the various types of networks in the healthcare domain.

Second-Generation (2G/2.5G) Systems

The second-generation cellular systems were the first to apply digital transmission technologies such as time division multiple access (TDMA) for voice and data communication. The data transfer rate was on the order of tens of kbit/s. Other examples of technologies in 2G systems include frequency division multiple access (FDMA) and code division multiple access (CDMA).

The 2G networks deliver high-quality and secure mobile voice and basic data services such as fax and text messaging, along with full roaming capabilities around the world. 2G technology is in use by more than 10% of the world's population, and it is estimated that 1.3 billion customers across more than 200 countries and territories around the world use this technology (GSM, 2005). The later advanced technological applications are called 2.5G technologies and include networks such as general packet radio service (GPRS) and EDGE. GPRS-enabled networks provide functionality such as: 'always-on', higher capacity, Internet-based content and packet-based data services enabling services such as color Internet browsing, e-mail on the move, visual communications, multimedia messages, and location-based services. Another complimentary 2.5G service is enhanced data rates for GSM evolution (EDGE), which offers similar capabilities to the GPRS network.

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