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Mobile e-Health: The Unwired Evolution of Telemedicine

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ABSTRACT

The movement of telemedicine from desktop platforms to wireless and mobile configurations may have a significant impact on future health care. This paper reviews some of the latest technologies in wireless communication and their application in health care. 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.

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.

Mobile telemedicine is a new and evolving area of telemedicine that exploits the recent development in mobile networks for telemedicine applications.[3] It was suggested that the next step in the evolution of telemedicine will be mobile telemedicine systems.[4]

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EXISTING MOBILE TECHNOLOGY

The evolution and current mobile telecommunication technologies were described in a white paper by Trillium Digital Systems, Inc.[5] The paper also explains how the communication industry plans to implement 3G wireless technology to meet the growing demand for wireless multimedia services.

First-generation wireless technology

The first generation of wireless mobile communications was based on analog signaling. Analog systems, implemented in North America, were known as Analog Mobile Phone Systems (AMPS), while systems implemented in Europe and the rest of the world were typically identified as a variation of Total Access Communication Systems (TACS). Analog systems were primarily based on circuit-switched technology and designed for voice, not data.

Second-generation (2G) wireless technology

The second generation (2G) of the wireless mobile network is based on low-band digital data signaling. Most of the networks are based on circuit-switched technologies developed in different parts of the world: Global Systems for Mobile Communications (GSM) technology developed in Europe, which is a combination of Frequency Division Multiple Access (FDMA) and Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA) technology in North America and Personal Digital Communications (PDC), using TDMA-based technology, in Japan. GSM system is the most popular, which operates in the 900-MHz and 1.8-GHz bands throughout the world with the exception of the Americas where they operate in the 1.9-GHz band.

FDMA is the most common analog or first-generation mobile system. It is based on the relatively simple division of the frequency into traffic channels. With FDMA, each channel can be assigned to only one user at a time.

TDMA can divide a single radio frequency channel into six unique time slots, allowing a number of users to access a single channel at one time without interference. By dividing the channel into slots, three signals (two time slots for each signal) can be transmitted over a single channel. In this way, TDMA technology, also referred to as ANSI-136, provides a 3-to-1 gain in capacity over analog technology. Each caller is assigned a specific time slot for transmission.[6]

CDMA is a form of multiplexing, which allows numerous signals to occupy a single transmission channel, optimizing the use of available bandwidth. CDMA employs analog-to-digital conversion (ADC) in combination with spread spectrum technology. Audio input is first digitized into binary elements. The frequency of the transmitted signal is then made to vary according to a defined pattern (code), so it can be intercepted only by a receiver whose frequency response is programmed with the same code. This enhances privacy and makes cloning difficult.

The CDMA channel is nominally 1.23 MHz wide. CDMA networks use a scheme called soft handoff, which minimizes signal break-up as a handset passes from one cell to another. The combination of digital and spread-spectrum modes supports several times as many signals per unit bandwidth as analog modes. CDMA technology is recognized as providing clearer voice quality with less background noise, fewer dropped calls, enhanced security, greater reliability, and greater network capacity.

2G wireless networks are digital and expand the range of applications to more advanced voice services, such as Called Line Identification. 2G wireless technology can handle some data capabilities such as fax and short message service at the data rate of up to 9.6 kbps, but it is not suitable for web browsing and multimedia applications.

Second-generation (2G+) wireless networks

The data rate of 2G circuit-switched wireless systems is very slow for today's Internet usage. As a result, GSM, PDC, and other TDMA-based mobile system providers and carriers have developed 2G+ technology, which is packet-based. It increases the data communication speeds to as high as 384 kbps. These 2G+ systems are based on the following technologies: High-Speed Circuit-Switched Data (HSCSD), General Packet Radio Service (GPRS), and Enhanced Data Rates for Global Evolution (EDGE) technologies.

HSCSD is one step toward 3G wideband mobile data networks. This circuit-switched technology improves the data rates up to 57.6 kbps by introducing 14.4-kbps data coding and by aggregating four radio channels timeslots of 14.4 kbps.

GPRS technology is packet-based and designed to work in parallel with the 2G GSM, PDC and TDMA systems that are used for voice communications and for table look-up to obtain GPRS user profiles in the Location Register databases. GPRS uses a multiple of the one to eight radio channel timeslots in the 200-kHz-frequency band allocated for a carrier frequency to enable data speeds of up to 115 kbps. The data are packetized and transported over Public Land Mobile Networks (PLMN) using an IP backbone so that mobile users can access services on the Internet, such as SMTP/POP-based e-mail, ftp, and HTTP-based Web services.

EDGE technology is a standard that has been specified to enhance the throughput per time slot for both HSCSD and GPRS. The enhancement of HSCSD is called ECSD, whereas the enhancement of GPRS is called EGPRS. In ECSD, the maximum data rate per time slot will triple. Similarly, in EGPRS, the data rate per time slot will triple, and the peak throughput will exceed 384 kbps.

2.4 Third-Generation (3G) Wireless Networks

Third-generation (3G) wireless technology represents the convergence of various 2G wireless telecommunications systems into a single global system that includes both terrestrial and satellite components. One of the most important aspects of 3G wireless technology is its ability to unify existing cellular standards, such as CDMA, GSM, and TDMA, under one umbrella. The following three air interface modes accomplish this result: wideband CDMA, CDMA2000, and the Universal Wireless Communication (UWC-136) interfaces.

Wideband CDMA (W-CDMA) is compatible with the current 2G GSM networks prevalent in Europe and parts of Asia. W-CDMA will require bandwidth of between 5 Mhz and 10 MHz, making it a suitable platform for higher-capacity applications. It can be overlaid onto existing GSM, TDMA (IS-36), and IS95 networks.

The second radio interface is CDMA2000, which is backward compatible with the second-generation CDMA IS-95 standard predominantly used in United States. The third radio interface, Universal Wireless Communications, UWC-136, also called IS-136HS, was proposed by the TIA and designed to comply with ANSI-136, the North American TDMA standard.

3G wireless networks consist of a Radio Access Network (RAN) and a core network. The core network consists of a packet-switched domain, which includes 3G SGSNs and GGSNs, and provides the same functionality as a GPRS system and a circuit-switched domain. RAN functionality is independent from the core network functionality. The access network provides a core network technology independent access for mobile terminals to different types of core networks and network services. Either core network domain can access any appropriate RAN service.

The RAN consists of new network elements, known as Node B and Radio Network Controllers (RNCs). Node B is comparable to the Base Transceiver Station in 2G wireless networks. RNC replaces the Basic Station Controller. It provides the radio resource management, handover control, and support for the connections to circuit-switched and packet-switched domains. The interconnection of the network elements in RAN and between RAN and core network is over Iub, Iur, and Iu interfaces based on ATM as a layer 2 switching technology. Data services run from the terminal device over IP, which in turn uses ATM as a reliable transport with QoS. Voice is embedded into ATM from the edge of the network (Node B), and is transported over ATM out of the RNC. The Iu interface is split into two parts: circuit-switched and packet-switched. The Iu interface is based on ATM with voice traffic embedded on virtual circuits using AAL2 technology and IP-over-ATM for data traffic using AAL5 technology. These traffic types are switched independently to either 3G SGSN for data or 3G MSC for voice.

An architecture of 3G wireless network is shown in Figure 1.[5] Although there are many similarities between 2G and 3G wireless networks (and many of the 2G and 3G components are shared or connected through interworking functions), there are also may differences between the two technologies. Table 1 compares the differences between the core network, the radio portion and other areas of the two networks.

The satellite communication system offers a number of advantages,[7] including:

1. Wide geographic coverage including interconnection of remote terrestrial networks ("islands").
2. Bandwidth on demand, or Demand Assignment Multiple Access (DAMA) capabilities.
3. An alternative to damaged fiber-optic networks for disaster recovery options.
4. Multipoint-to-multipoint communications facilitated by the Internet and broadcasting capability of satellites.

Satellite systems are able to provide a variety of data transfer rates starting from 2.4 kbps and moving to high-speed data rates of up to 2 × 64 kbps, and even more. Satellite links also have the advantage of operating all over the world.[8]

In recent years, other wireless technologies became popular because they linked the mobile network and Internet together. These technologies, namely Wireless LAN (WLAN), Bluetooth, and Wireless Application Protocol (WAP) are implemented as an extension to or as an alternative for wired LAN to make the communication more flexible and powerful.

WLAN is effectively Ethernet without wires. It allows users to access a data network like the Internet at high speeds of up to 11 megabits per second (Mbps) as long as users are located within a relative short range (typically 30–50 meters indoors and 100–500 meters outdoors) of a WLAN base station (or antenna).[9] A WLAN network core components consists of:

1. A WLAN access point, which is effectively a base station (typically about the size of a shoe box) that can support many clients. It broadcasts messages on a certain frequency and listens for responses from clients.

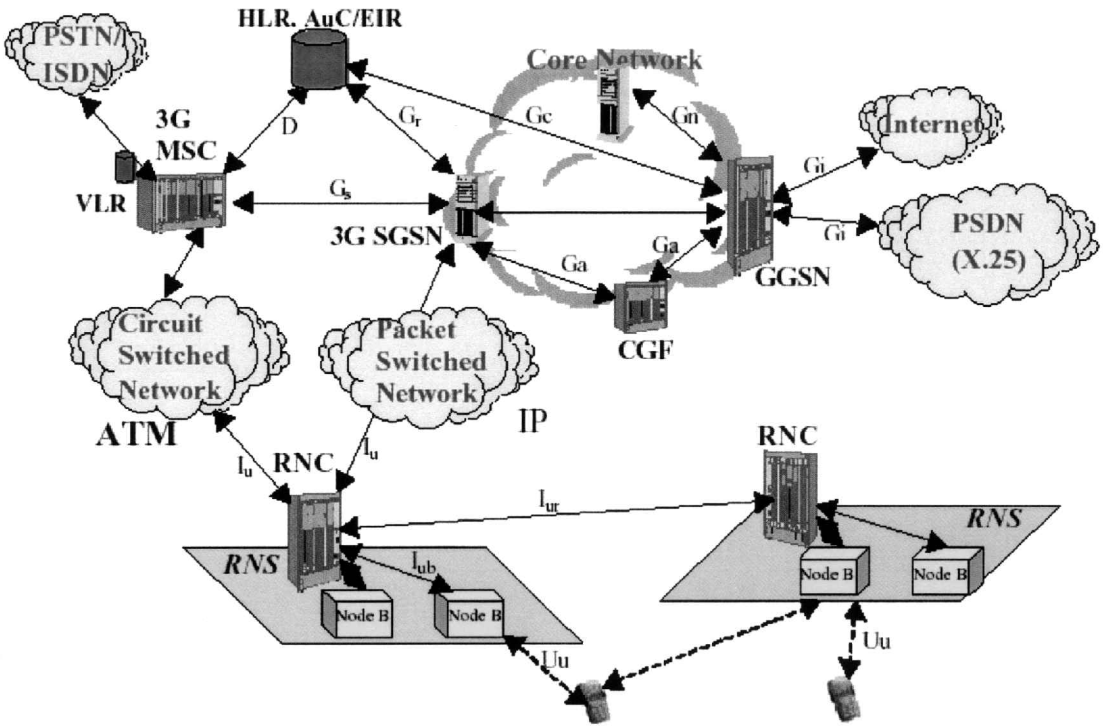

FIG. 1. 3G wireless network architecture.

TABLE 1. COMPARISON BETWEEN 2G AND 3G WIRELESS NETWORKS

Feature	*2G*	*2G+*	*3G*
Core network	MSC/VLR, GMSC, HLR/AuC/EIR	MSC/VLR, GMSC, SGSN, GGSN, HLR/AuC/EIR, CGF	3G MSC/VLR (with added interworking and transcoding), GMSC, HLR/AuC/EIR, 3G-SGSN, GGSN, CGF
	MM, CM, BSSAP, SCCP, ISUP, TCAP, MAP, MTP 3, MTP 2, MTP 1	GMM/SM/SMS, MM, CM, GTP, SNDCP, NS, FR LLC, BSSGP, BSSAP, BSSAP+, SCCP, TCAP, MAP, ISUP, MTP 3, MTP 2, MTP 1	GMM/SM, MM, CM, BSSAP, RANAP, GTP, SCCP, MTP3B, M3UA, SCTP, Q.2630.1 (NNI), TCAP, MAP, ISUP, MTP 3, MTP 2, MTP 1, Q.2140, SSCOP
	TDM transport	TDM, Frame Relay transport	ATM, IP transport
Radio access	BTS, BSC, MS	BTS, BSC, MS	Node B, RNC, MS
	FDMA, TDMA, CDMA	TDMA, CDMA, EDGE	W-CDMA, CDMA2000, IWC-136
	MM, CM, RR, LAPDm, LAPD, BSSAP, SCCP, MTP 3, MTP 2, MTP 1	MAC, RLC, GMM/SM/SMS, LLC, SNDCP, BSSGP, NS, FR, RR, BSSAP, SCCP, MTP 3, MTP 2, MTP 1	GMM/SM, MAC, RLC, PDCP, RRC, Q.2630.1 (UNI+NNI), NBAP, RNSAP, RANAP, SCCP, MTP3B, M3UA, SCTP, GTP-U, Q.2140, Q.2130, SSCOP, CIP
Handsets	Voice only terminals	New type of terminal Dual mode TDMA and CDMA Voice and data terminals WAP, no multimedia support	New type of terminal Multiple modes Voice, data and video terminals WAP, multimedia mgmt
Databases	HLR, VLR, EIR, AuC	HLR, VLR, EIR, AuC	Enhanced HLR, VLR, EIR, AuC
Data rates	Up to 9.6 Kbps	Up to 57.6 Kbps (HSCSD) Up to 115 Kbps (GPRS)	Up to 2 Mbps
Applications	Advanced voice, Short Message Service (SMS)	SMS, Internet	Internet, multimedia
Roaming compatibility	Restricted, not global Not compatible to 3G	Restricted, not global Not compatible to 3G	Global Compatible to 2G, 2G+ and Bluetooth

2. The WLAN access card is the client interface that talks to the access point. Typically it can be a PC card or compact Flash card format that can be inserted into a laptop or Personal Digital Assistant (PDA).

In the United States, WLAN operates in two unlicensed bands[9]:

1. 802.11b and 802.11g operate in the 2.4-GHz band, together with many other devices including Bluetooth and cordless telephones.
2. 802.11a operates in the 5-GHz band, which at this point is relatively free of interference from other electrical devices operating in this band.

Bluetooth was originally conceived by Ericsson in 1994, when they began a study to examine alternatives to cables that linked mobile phone accessories. It is a wireless technology that enables any electrical device to communicate in the 2.5-GHz ISM (license-free) frequency band. It allows devices such as mobile phones, headsets, PDAs and portable computers to communicate and send data to each other without the need for wires or cables to link two devices together. It has been specifically designed as a low-cost, low-size, and low-power radio technology, which is particularly suited to the short range Personal Area Network (PAN) application but distinguishes from the wireless LAN technology.[10]

The main features of Bluetooth are[11]:

1. Operates in the 2.4-GHz frequency band without a license for wireless communication.
2. Real-time data transfer usually possible between 10 and 100 m.
3. Close proximity not required as with infrared data (IrDA) communication devices as Bluetooth does not suffer from interference from obstacles such as walls.
4. Supports both point-to-point wireless connections without cables between mobile phones and personal computers, as well as point-to-multipoint connections to enable ad hoc local wireless networks.
5. 400 kbps of data symmetrically or 700 to 150 kbps of data asymmetrically

WAP was founded by the major players in the mobile industry, including Nokia, Ericsson, Motorola, and Openwave.[12] It is an open, global specification that empowers mobile users with wireless devices such as mobile phones, pagers, two-way radios, PDAs, etc., to access internet content and services instantly.[13] WAP is designed to work with most wireless networks such as CDPD, CDMA, GSM, PDC, PHS, TDMA, FLEX, ReFLEX, iDEN, TETRA, DECT, DataTAC, Mobitex, etc., and can be built on any operating system including PalmOS, EPOC, Windows CE, FLEXOS, OS/9, JavaOS, etc.

The other reasons for the popularity of WAP include:

1. It provides a standardized way of linking the Internet to mobile phones, thereby linking two of the fastest growing industries.
2. Mobile information services, a key application for WAP, have not been as successful as many network operators expected. WAP is seen as a way to rectify this situation.[12]

Multi-point multi-channel distribution system (MMDS)[14] is a broadband wireless technology that is sometimes referred to as wireless DSL, or by more generic term broadband wireless. It is an option for small businesses not near to the central offices of networks that support DSL. Print Corp. and WorldCom are the two largest providers for this service.

MMDS, which operates in the United States and Canada at 2.5GHz and in many international markets at 3.5GHz can serve a radius of up to 35 miles, with hubs typically located on top of the mountains or other high points. Just one tower can provide coverage of vast, heavily populated areas at a relatively low cost to the service provider. The net result is practical data throughput of 500 Kbps to 1 Mbps, ideal for small and midsize business customers as well as consumers.

The popular application for MMDS is Internet access: normally a router port with a connection for the external ISP network, typically an Ethernet connection to a wireless modem. A cable runs from the modem to a radio, which connects to the antenna. This antenna is mounted directly on a building or on a pole and points at the service provider's tower. The tower is a hub in a point-to-multipoint architecture that multiplexes communication from multiple users.

Such service provides a 10-Mbps link with a maximum downlink throughput of 5 Mbps and typical throughputs of 500 Kbps to 1.5 Mbps. The maximum uplink speed is 256 Kbps. MMDS remains an important alternative for those geographical areas where wire line technologies such as DSL are not available.

WIRELESS TELEMEDICINE

Although the new technologies in mobile telecommunication emerged recently, its advantages to send the multimedia information in large amounts are quickly realized by the health-care sector. Mobile telemedicine is not too far from us. Some commercial products have come into everyday use, as shown by the following examples.

NASA space program

One of the most important usages of mobile telemedicine is for the space program, which it relies on telecommunications to conduct routine medical operations. A telemedicine program developed at NASA comprises of the patient (astronaut), the consultant (flight surgeon and external consultants), data acquisition and handling hardware, and software and the telecommunications connection.[15] A device, Telemedicine Instrumentation Pack (TIP), is built to collect medical audio, video, and data from the patient in space. Data capabilities include electroencephalogram (ECG) waveforms, heart rate, blood oxygenation, and blood pressure. Medical video capabilities include eye, skin, ear-nose-throat, and general macro imaging. An electronic stethoscope permits collection of auscultation data. Data obtained with the TIP is available at the digital outputs compatible with the communication systems of the space vehicle and then sent back to earth.

Ambulance emergency services

A mobile telemedicine system has been established for ambulance emergency services.[16–18] The system consists of two major components: a mobile unit for ambulance installation and a receiving base station for hospital Intranet connection. The real-time patient vital signs data, audio, and video images of care activities from inside an ambulance are transmitted to a trauma center using wireless digital cellular communications and in-hospital Intranet technology. In the ambulance, patient vital signs data are captured from the monitoring equipment by the patient records computer.

The system transmitting real-time patient vital signs data, audio, and video images of care activities from inside an ambulance en route to a trauma center using wireless digital cellular communications and in-hospital Intranet technology.

The ambulance-based system uses a video system and a patient monitor interface to capture images automatically from a moveable camera in the ceiling of the ambulance, above the patient's head. The images are compressed using the JPEG standard and transmitted over the digital Sprint PCS spectrum, using up to four 'bonded' digital wireless phone lines to transmit voice, images, and data. Bandwidth is currently limited to about 5 Kbps per phone line, which in turn limits the typical aggregate transmission rate to about 20 Kbps. The wireless signals are transmitted to an NT server at the University hospital. There, they are forwarded to the computer monitor of any enabled clinician on the hospital Intranet, where they can be viewed in Netscape or Internet Explorer.

The video images are captured at 30 frames per second. But, because the wireless bandwidth is limited to about 20 Kbps, the images are transmitted in "slow scan" fashion at about 1 image every 2.5 seconds at FCIF resolution (320 bits $\times$ 240 lines $\times$ 24-bit depth). The technology allows on-the-fly tradeoffs between motion handling and resolution, and a special button allows the emergency personnel in the ambulance to capture specific images or video clips at 5 fps, which can be sent in a store-and-forward fashion.

The system integrates the existing commercial technologies and the use of open-system standards. This approach uses proven, modular components to keep costs low, mitigate system risk, and simplify the introduction of new technological developments.

Biotronik Home Monitoring System

In Germany, a new device, known as the Biotronik Home Monitoring System, allows doctors to keep track of their patients' hearts between office visits.[19] The device includes a transmitter that sends information to a cell phone-like device carried by the patient. The phone then sends the information to a company service center, where it is faxed to the patient's doctor. The device can be programmed to collect data as needed, from once a day to once a month. It works from any location that offers digital cell phone service.

TeleCardio-FBC

TeleCardio-FBC is a telemedicine system developed and deployed in Brazil to enable cardiologists at the Unit of Cardiology and Cardiovascular Surgery to cooperate with other physicians.[20] The system will provide specialized medical care in cardiology for patients who live far from metropolitan areas, reducing costs, and enabling better follow-up for discharged patients. The system was designed considering desktop computers as the only computational platform. As a consequence, access to the system functionalities on different computer platforms is not possible.

A new system, Called TeleCardio Mobile,[20] was developed taking advantage of the advances of the third generation of mobile technology to provide on-line access to the information in the TeleCardio-FBC system through personal digital assistants and mobile telephones connected to the Internet by wireless modem cards.

The TeleCardio Mobile consists of two platform-independent systems, M-TeleCardio and WapCardio. M-TeleCardio will allow the access to all the functionalities of TeleCardio-FBC through personal digital assistants, like palmtops and laptops, connected to the Internet by wireless modem cards. WapCardio will supply important information, for instance, remote consultation requests and results of medical procedures, to physicians on mobile telephones using the WAP technology. The system satisfies TeleCardio-FBC restrictions, and extends the range of TeleCardio-FBC functionalities by allowing medical consultations to be done independent of the local infrastructure.

Mobile telemedicine in India

India[21] inaugurated its first mobile telemedicine unit this year. The complete intergrated mobile unit is assembled in a multiutility vehicle. It has facilities for online transmission of patient data, X-ray, ECG, microscopic images, and vital parameters of a patient to other parts of the world. Communication can be established using a variety of options, including ordinary telephone lines, mobile telephone, and wireless local looper V-Sat. The unit can also be used to conduct direct simultaneous videoconferencing between four different sites.

GCS 7600 Mobile Telemedicine System

The GCS 7600 Mobile Telemedicine System,[22] shown in Figure 2, is a complete diagnostic system consisting of a hospital-grade cabinet, desktop PC with videoconferencing system, and a comprehensive suite of telemedicine examination equipment. The system allows examinations being performed to be viewed live by remotely located supporting specialists. The video or data signal, e.g., eye exam or stethoscope heart sound, is captured by the GCS 7600 and is transmitted via ISDN or satellite to other places around the world.

FIG. 2. GCS 7600 Mobile Telemedicine System.

Momeda Project

The EU-funded Momeda Project[23] uses special software to enable sending of computer tomography images, magnetic images, and patient information wirelessly from the hospital workstation via the GSM network to the pocket-sized terminal (Nokia 9110 Communicator) of the neurosurgeon or radiologist for initial consultation and diagnosis. The software running on the pocket-sized device enables the analysis and diagnosis of images utilizing patient information and the features of the hospital imaging workstations. Using wireless data communications technology, the Momeda solution enables remote consultation, and thus increases the probability of receiving the best possible expertise and appropriate course of treatment.

Mobile phone technology

Another novel electronic application has been developed in the United Kingdom that allous signals from medical monitoring equipment to be transmitted across the mobile phone network.[24] The idea of using mobile phone technology is that someone who is not confined to a bed can be monitored remotely by a consultant in a hospital. For example, someone who lives in the Highlands of Scotland a hundred miles from the nearest hospital could be given a routine check up by mobile phone. The system could also be used by emergency rescue teams and in sports science to take physiological measurements of athletes while they are training.

Sens Vest

One of the more recent contributions came from a researcher at Birmingham University in the United Kingdom,[25] who built a wireless vest, Sens Vest, that can monitor heart rate, body temperature, and acceleration, and then sends the results back to a remote computer.

More examples and research projects in mobile telemedicine could be found in Pattichis et al.[26] From these examples, the potential benefits of integrated wireless telemedicine can be summarized as follows:

1. It provides rapid response to critical medical care regardless of geographic barriers. Hence, severely injured patients can be managed locally and access to a trauma specialist obtained by wireless telemedicine. It is possible to capture the data in a resuscitation room of an emergency department, but the availability of a trauma specialist has hitherto not been assured. If such a specialist could move around, especially out of office hours, she/he would be prepared to make him/herself available more than has been the case up until now.[27] Other scenarios may be the interpretation of rhythm disorders in the resuscitation of a cardiac arrest.
2. Flexible and swift access to expert opinion and advice at the point of care without delay and better management of medical resources. Patients would benefit from locally provided services especially when they have ready access to a second opinion. Thus, if they are in a remote location, they would expect to be able to call their specialist on their mobile phone and show him/her an image of the part of their body that they were worried about or discuss the management of an existing chronic condition that has been exacerbated. There may be some early problems with the technical quality of the consultation,[28] but over a period of time these can be overcome.
3. 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. The Internet is already being used for some medical applications.[29] This might need more than just mobile phones whose transmission bandwidth is likely to be limited, and the large amounts of images and data require some of the characteristics of fixed link installation using black fiber links.[30]
4. Increased empowerment and management of medical expertise especially in rural and underserved areas could be improved using these technologies. Several forces are dictating these changes.[31] The favored model has been that of a large central hospital with associated local hospitals to which patients are discharged. Acute services can be thought of as a simple system that comprises a medical emergency that usually occurs in the patient's home, a journey to the hospital, assessment, admission, a treatment process, and then discharge. A large central hospital eventually means longer journeys. This has immediate therapeutic implications. With many conditions, minutes matter. Long journeys mean long ambulance rides—and two fully equipped ambulances would cost the same as a medical ward. Increased distance also poses problems for families, and weakens the links with primary care and social services, which are crucial for discharging the patient. Further problems then arise with assessment and admission.

5. The local hospitals usually do not share care or staff with larger hospitals. Consequently, some may suffer from weak medical and nursing staff who may be uncomfortable managing seriously ill patients. Some have proposed that patients must be admitted first to the local hospital, which would in effect be an assessment arm of the large hospital. The medical and nursing staff would be part of the team working with the large hospital, and staff would rotate between hospitals. The local unit would have local imaging and laboratory support and high quality telemedical links with the central hospital that would allow the specialists there to know almost as much about the patients as if they were examining them directly.[32] Similar future portents have been seen by others.[33]
6. Swift medical care can be made available in emergency and management of medical data in catastrophes or natural disasters where conventional communication links may be disrupted.[34] Proper mobile communications have always been the weakest link in the management of major disasters. The weakest link has been traditionally between the disaster site and the base hospital. This has been in part alleviated by the use of first and second generation mobile phones. But, it will be the rapid consultation and liaison capabilities of 3G that will transform such communication links. How much more efficient will it be to show images from the disaster site than to describe them? How much more efficient to use more persons doing triage than the lower number that is used now? There is enough evidence that collaboration between many emergency services spread around the country work in the setting of mass gathering.[35] The infrastructure of agreement is fairly easy to achieve.

CHALLENGES OF THE MOBILE HEALTH CARE

The current common goal in medical information technology today is the design and implementation of telemedicine solutions, which provide chronically ill patients with mobile services that enhance their quality of life, and support and optimize their treatment in case of emergency. This would require micro-technological sensors to be used in mobile applications, modularity, a wireless communication network, local intelligence in the form of a powerful mobile information unit, connection to a global network, and a conclusive system design for improving the efficiency of health care-related procedures.[36]

The first step to encourage mobile health care is to build the right devices to handle the needs of the industry. “One of the major challenges for the take-up of mobile data applications is getting the right form factor,” as health care needs an adequate throughput rate.[37]

The challenge for the mobile trade in convincing the health-care industry to adopt wireless technology is in getting the devices to a manageable size. This kind of application works best when inconvenience to the patient is minimized. Once new innovations make the load a bit more easy to carry, and once a new generation of technology-friendly doctors start rebuilding their profession, they are myriad ways wireless technology could take over serious roles in medicine.[37]

With the suitable devices, it also has to make sure the seamless (including safety and privacy) data flow (images, data, text, voice) to/from mobile terminals (and from mobile sensors directly from the patients, e.g., the diabetics) through the mobile and fixed network to the hospital/health care communication infrastructure.[38]

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