11

Telemedicine & Broadband

Annarita Tedesco[1], Donatella Di Lieto[2], Leopoldo Angrisani[3], Marta Campanile[4], Marianna De Falco[5] and Andrea Di Lieto[6]

[1]Telecommunications Engineer, Critical Infrastructure Expert, Scientific Collaborator, Dept of Computer Science and Control Systems, University of Naples Federico II

[2]Lawyer - Specialist in Legal Professions - Law of New Technologies and Communications

[3]Full Professor of Electrical and Electronic Measurements, Communication Systems and Networks Test and Measurement Expert, Dept of Computer Science and Control Systems, University of Naples Federico II

[4]Specialist in Obstetrics and Gynaecology - University High Professional Physician Operation Center of Conventional and Computerized Telecardiotocography – Medical School University Federico II of Naples.

[5]Specialist in Obstetrics and Gynaecology- PhD in Reproduction, Growth and Human Development - Head Physician - University Hospital Federico II of Naples.

[6]Full Professor of Obstetrics and Gynaecology - Director of Prenatal Unit - Responsible of Project of Telecardiotocography in Campania region - Responsible of European Project Conventional and Computerized Telecardiotocography - Medical School University Federico II of Naples.

Italy

1. Introduction

Advances in telecommunications and internet technology have greatly contributed to practically every aspect of our life. Medicine has taken a cue from this growing trend by combining telecommunications technology and medicine to create telehealth and telemedicine. Telehealth is “the practice of healthcare delivery using telecommunications technology including but not limited to diagnosis, consultation, treatment, transfer of medical data, education, dissemination of public health alerts and/or emergency updates”. Telemedicine is “the use of telecommunications technology to deliver clinical diagnosis, services and patient consultation”. Although different, for the purposes of this chapter telehealth and telemedicine are treated as one, and in the following referred simply to as “telemedicine” (Di Lieto et al., 2006), (Di Lieto et al., 2002), (Di Lieto et al., 2008).

There are two common types of telemedicine applications: “store-and-forward” and “real-time”. Store-and-forward applications exploit the transmission of digital images from one location to another. A healthcare professional takes a picture of a subject or an area of concern with a digital camera. The information on the digital camera is “stored” and then “forwarded” by computer to another computer at a different location. This type of applications are utilized for non-emergent situations, when there’s time for a diagnosis or consultation to be made, usually within 24 to 48 hours, with the findings then sent back.

Real-time applications come into play when the patient, along with his healthcare provider (a doctor or a nurse practitioner) and a telemedicine coordinator (or a combination of the three), gather at one site (the originating site), and a specialist is at another site (the referral site) which is usually at a large, metropolitan medical center. Videoconferencing equipment is placed at both locations allowing for a consultation to take place in "real-time". Almost all areas of medicine can benefit from this type of applications, including psychiatry, internal medicine, rehabilitation, cardiology, pediatrics, obstetrics, neurology and gynecology. Also, many different peripheral devices like otoscopes and stethoscopes can be attached to computers, aiding with an interactive examination (Khoumbati et al., 2010), (Hahm et al., 2009).

In Italy, the first application of telemedicine to prenatal medicine is represented by the TOCOMAT system of conventional and computerised cardiotocography and tele-ultrasonography. Cardiotocography (that is the simultaneous recording of the fetal heart rate pattern and of the uterine contractions during the second half of pregnancy) and ultrasonography are crucial for the assessment of fetal well-being, as expected by the modern prenatal medicine.

In its first version, born in 1998 at the University Federico II of Naples, the TOCOMAT network (Di Lieto et al., 2006), (Di Lieto et al., 2002) connected nine peripheral units located in small hospitals and consulting rooms in Campania, a region of Southern Italy, and two foreign units located at the Department of Obstetrics and Gynaecology of the Semmelweis University of Budapest (Hungary) and at the Hospital of Tripoli (Greece) [3]. The network Operation Centre is located in Naples, the regional capital, at the University Federico II. Peripheral units are equipped with a traditional cardiotocograph able to transmit via modem both fetal heart rate traces and data about patients to the Operation Centre. Transmission takes 40-60 seconds. At the Operation Centre, data are analysed by a software which provides the computerized analysis of the traces. Within few minutes, the computerized trace, together with the analysis and medical reports, is sent back to the peripheral unit by fax or by e-mail. Until December 2009, 3194 patients have been monitored with the TOCOMAT system, and about 10000 traces have been recorded and analysed. Admissions were efficiently planned, as a consequence of a continuous interaction between peripheral units and the Operation Centre.

Currently the main applications of Telemedicine fall within the conventional Telemedicine, which consists of connecting two different locations using a wired connection. This means that the conventional Telemedicine is not suitable for mobility, flexibility and portability. These three aspects encourage the use of wireless connections. When the Telemedicine equipment become mobile, flexible and portable, the chances of delivering a health consultation increase and are especially useful in case of emergencies. The availability of new technologies for the organization of wireless Telemedicine networks represents the ground of the recent updating of the TOCOMAT system, in order to allow intensive cardiotocographic monitoring of fetuses at risk independently from the mother and doctor location. In this way, the remaining space limitations related to the TOCOMAT network can be overcome.

In the updated version of the TOCOMAT network (Fig.1), each remote unit is equipped with a last generation, small, user-friendly cardiotocograph, able to transmit the traces and the data related to the patient and her pregnancy to a T-Mobile MDA GPRS Smart Phone using a Bluetooth wireless port. The Smart Phone is equipped with the software which allows receiving all signals coming from the cardiotocograph and sending them in real time to the Operation Centre. Moreover, the Smart Phone receives via e-mail the medical report and the report of the computerized analysis from the Operation Centre. This new system does not use a traditional telephone line for data transmission. So, it overcomes the considerable space limit of the old system, and could allow trace recording and transmission also of patients at home.

Fig. 1. Organization of the new TOCOMAT network for Telecardiotocography.

The new version of the TOCOMAT network also includes a Tele-Ultrasonography application (Fig.2). It is configured as a Mini-PACS system, able to manage ultrasound images, independently by the site where the patients have been examined (main hospital, remote hospital, patient's home, patient's bed, etc.). The Tele-Ultrasonography application of the TOCOMAT system consists of two workstations able to share ultrasound clinical data and images via Internet to the hospital network using a secure connection via VPN. Ultrasound scans are recorded using a portable last-generation scanner able to transmit the scans to the Operation Centre through a T-Mobile MDA GPRS Smart Phone using a Bluetooth wireless port. The availability of a portable scanner allows performing the examination independently from the location of the remote unit. Also for the Tele-Ultrasonography application of the TOCOMAT system, wireless networking is the milestone of the project.

Fig. 2. Organization of the new TOCOMAT network for Tele-Ultrasonography.

Telemedicine has been a matter of research and convulsive generation of pilot networks and trials in all the world, all aiming to find the most appropriate solution and draw the economic model that could be of reference to define directives and guidelines which may help to provide remote medical cares. The aim of this chapter is to focus on some of the most significant broadband technologies, which can be of help to identify solutions addressing sustainable telemedicine service networks. The reader is given some highlights on the enormous growth and development that have characterized the telecommunication industry in this last decade, which has seen the domination of Internet, the IP protocols along with the new and much more economic broadband approach, allowing end users to access advanced network services in a much easier, faster and economic way, than some years ago. These events have opened new frontiers of interactive applications, related to data transmission, video and IP voice, originating new services, which one can find useful and comfortable for itself, but in a more general contest, are essential tools to improve social benefits and communities quality of life.

2. Benefits of telemedicine

The growing use of telemedicine is giving rise to a great number of benefits, which are in the following summarized from three different points of view: 1) Economic development and quality of life, 2) Patients, and 3) Providers (*Benefits of Telemedicine*, 2004), (Darkins & Cary, 2000).

2.1 Economic development and quality of life

- *Advancements in delivery of services*
  Certain health services can be greatly enhanced via telemedicine. For example, home health services are receiving a great deal of attention and investment in some states. Telemedicine technologies enable home health providers to redefine patient treatment plans, as they are able to increase patient visits due to elimination of a significant percentage of travel to patients' homes. Rural patients can now have access to specialists.
- *Keeping money in the local economy*
  Telemedicine helps provide service locally so people don't have to travel out of the community for care. Spending on health care is an especially significant portion of any economy, especially rural economies. The more the money that can be kept locally the better off the local economy will be. Standard economic multiplier effects also apply here; any money spent locally ripples through the local economy.
- *Aiding business recruitment and retention*
  Telemedicine provides the capability to deliver clinical services in the community. Locally available quality health care and quality schools are two important factors in the recruitment of new businesses, especially for businesses in rural communities. So there is a potential business recruitment and retention factor to consider.
- *Workforce development/jobs*
  There is a severe shortage of medical staff, particularly nurses, in rural hospitals. At the same time there is high poverty and unemployment in rural communities. One way to address that problem is to equip local healthcare facilities with advanced telecommunications services for telemedicine purposes and then to appropriately share the videoconferencing capability in a partnership with educational institutions to train

more local people for the jobs in health care that are available locally. Local jobs for local people could be a significant economic impact particularly for people who could not afford to travel outside the community for training.

- *Quality of life and longevity gains are worth a lot*
  Use of telemedicine can have a significant impact on individual health and can therefore favorably impact longevity. The value to the economy of improvements in life expectancy is about as large as the value of all other consumption goods and services put together. It is an intriguing thought to contemplate that the social productivity of health-care spending might be many times that of other spending.

2.2 Patient's perspective

- *Access to healthcare*
  Access to quality, state of the art health care in underserved areas, such as rural communities, is one of the most important promised benefits of telemedicine. Rural residents are not second-class citizens; they deserve access to health care services that those in metropolitan areas enjoy.
- *Saving time, travel, and other expenses*
  Telemedicine entails moving from a service delivery system in which patients (and often parent or guardian) physically travel from a rural area where they reside to an urban area to consult with a medical specialist, to a system in which the specialist consults with the patient and rural primary care provider using telecommunications facilities. An obvious opportunity is the potential for transportation cost savings.
- *Healthcare at home*
  Home care and community based health services are becoming an increasingly important part of the healthcare service continuum. There are many reasons for this including: patients are leaving hospital sooner and need some additional care at home while they recover, treating patients at home is less expensive than treating them in the hospital, many patients prefer to stay in their homes as long as possible before moving onto a higher level of healthcare service, e.g. nursing home, hospice.
- *Health provider integration*
  Improved collaboration between providers (e.g., shared access to electronic medical records and provider to provider consultations) provides patients with enhanced confidence that all that can be done is being done.

2.3 Provider's perspective

- *Emergency Room "front line" support*
  Instant access to information, whether it be about a certain patient or a certain topic, can be essential or even life saving.
- *Accuracy of diagnosis: reduction of medical errors*
  Reduction of medical errors is a huge concern for the medical community. Getting it right on the first try is obviously the preferred way of doing things. With "tele-assistance" (e.g., communication with specialists), it is hoped that it will be easier for a doctor to get a "second opinion" on their diagnosis of a patient. With greater access to help, more patients will be treated correctly, the first time. This leads to even more benefits, such as quicker average recovery time, less use of unneeded medicines, and reduced costs to patients and hospitals.

- *A multifold increase in efficiency*
  Travel times for patients and doctors could be significantly reduced as well as research time and "paper handling" of medical records (which can be unbearably slow). It has already been seen that telemedicine on foreign military bases has sped up the whole process of treatment for soldiers abroad. Consultations from major medical centers to the military bases make diagnosis quicker and more accurate. Telemedicine saves time over traditional "paper-based" data transfer.
- *Continuing Medical Education / Lifelong learning*
  Telemedicine can enhance educational opportunities for health care providers, patients, and families, improving clinical outcomes and reducing hospitalizations. The opportunity to participate in continuing education on the latest in medical advances without having to travel long distances saves providers time, money and minimizes air pollution.

3. Benefits of broadband

Governments around the world increasingly view broadband as the "fourth utility" alongside water, heating and electricity. The power of broadband has been confirmed by recent research, which shows that broadband fosters GDP growth, creates jobs and stimulates innovation, while also enabling improvements in education, health care and other social services. In particular "Broadband is not just an infrastructure. It is a general-purpose technology that can fundamentally restructure an economy" (*World Bank*, 2009).

To realize the many benefits of broadband, governments around the world are implementing comprehensive nationwide plans, as well as more tightly focused broadband programs. When combined with strategies that ensure the availability and affordability of ICT, these efforts help countries reap the benefits of broadband more quickly and provide broadband services to more citizens at an affordable price (*Realizing the Benefits of Broadband*, 2010).

3.1 Defining broadband

Broadband can be defined in many ways, but is generally understood to be a service that enables reliable, high-speed transfer of data, voice and video over the Internet. The connectivity afforded by broadband is an essential element in a larger effort to make ICT resources available, affordable and reliable for individuals and businesses worldwide.

Broadband speeds vary greatly depending on technology, location, applications and other factors. Because of this, it may be more helpful to focus on "acceptable broadband" speeds, which are the speeds necessary to meet the particular demands of any given market segment, such as schools, homes, businesses or medical centers. In emerging markets, download speeds during peak hours of at least 1 to 3 megabits per second (Mbps) should be granted to most citizens. Although this is currently an acceptable minimum, by 2012, developing countries should aim for much higher speeds of 3 to 6 Mbps, and up to 15 Mbps soon after 2012.

Broadband networks can be accessed through a variety of wired and wireless services, each of which offers unique advantages in speed, reliability and affordability. Wired, or fixed, broadband services (ADSL, cable, etc.) tend to be faster than wireless alternatives, but often cannot reach geographically remote areas. Wireless broadband networks, which can be accessed via cell phones, satellite, WiMAX and Wi-Fi signals, provide advantages in mobility and convenience. Users can access broadband services through a range of equipment, including desktop computers, notebooks, netbooks, tablets, cell phones and smartphones. The access speeds for these devices vary greatly, with download speeds as low as 200 Kbps for wireless, entry-level 3G cell-phone services. Other wireless broadband options such as WiMAX can deliver higher speeds, less latency, and in many cases, lower costs.

3.2 Why broadband?

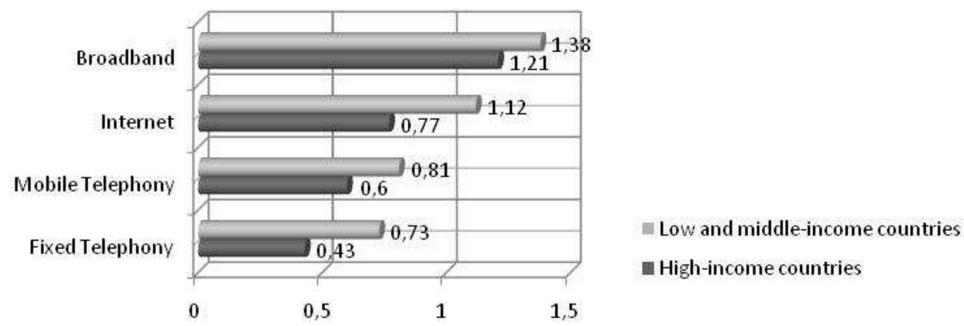
Compared to narrowband connections, broadband networks provide unique benefits that enable emerging economies to enter and compete in world markets. When combined with other ICT resources, broadband delivers benefits including:

- *Ubiquitous access*
  Broadband networks are always on and always available for usage.
- *Enhanced multimedia applications*
  Broadband speeds enable ready access to online video content, interactive applications, gaming and other multimedia resources.
- *Cost reductions*
  Web browsing, e-mail and other online activities can increase labor productivity and lower the cost of gathering market intelligence.
- *Improved communication*
  Broadband networks enable real-time communication through e-mail, instant messaging, Voice-over-Internet Protocol (VoIP) and more, enabling businesses to communicate more frequently and at a lower cost with suppliers, customers and business partners worldwide.
- *Energy efficiencies*
  Broadband reduces travel demands and leads to lower carbon emissions and greater overall energy efficiency.

3.3 Economic benefits of broadband

For more than a decade, a variety of case studies, anecdotes and qualitative studies have detailed the economic benefits of broadband networks in developed economies. More recently, quantitative research and empirical analyses have gone further, firmly establishing the fact that broadband networks support GDP (Gross Domestic Product) growth and many other economic benefits in both developed and developing economies.

- *GDP growth*
  An analysis by the World Bank found that in developing economies, every 10 percent increase in broadband penetration accelerates economic growth by about 1.38 percentage points — more than the increase of 1.21 percentage points for developed economies, and more than the increases seen for other telecommunications services (Fig.3). Moreover, countries in the top tier of broadband penetration have exhibited 2 percent higher GDP growth than countries in the bottom tier.
- *Job growth*
  Along with its direct and positive impact on GDP, research has repeatedly shown that increased broadband penetration leads to significant job growth. In the United States, the Information Technology and Innovation Foundation estimates that a stimulus package spurring or supporting $10 billion of investment in broadband networks would support nearly 500.000 new or retained jobs.



	Fixed Telephony	Mobile Telephony	Internet	Broadband
Low and middle-income countries	0,73	0,81	1,12	1,38
High-income countries	0,43	0,6	0,77	1,21

Fig. 3. Growth impact of telecommunications. (GDP percentage point increase due to 10 percentage-point increase in penetration).

- *Other economic benefits*
  Other proven economic effects of broadband include trade creation and facilitation, lower costs for international communications and greater access to foreign markets. Broadband can also help countries attract, train and retain a valuable "creative class" of workers, and the presence of broadband leads to new business models and new business opportunities to employ those and other workers.
  Mobile communications in general, and broadband in particular, have an especially strong impact on the economies of rural areas, which are home to nearly three out of four of the world's poor. Expanding broadband networks to rural areas leads to new opportunities for nonagricultural employment, better-paying agricultural jobs and greater overall productivity. Access to broadband also fosters small-business growth, allows citizens in remote areas to work from home, provides greater access to crop market prices and enables rural businesses to compete more effectively in world markets.

3.4 Social benefits of broadband

The social benefits of broadband are difficult to quantify, but they are nonetheless an essential part of the overall value of broadband. By connecting citizens to each other, as well as to businesses, governments and social services, broadband helps people become more informed and more active in their communities, leading to a better quality of life, and richer personal and business opportunities.

The benefits and opportunities broadband creates for all people, regardless of location, lifestyle or income, can help nations cross the digital divide. As broadband access becomes more available and less expensive, citizens and businesses in rural and remote areas can engage more directly in the national economy. Broadband is a cultural equalizer with the potential to allow all citizens to access essential government services and take advantage of new economic opportunities such as working from home.

Broadband networks also provide a more efficient and less expensive way to deliver essential public services such as health care, education, public safety and emergency services. Broadband-enabled telemedicine provides better access to specialized care, reduces unnecessary travel, and facilitates rapid diagnosis and treatment.16 Mobile health workers, who deliver health care to remote regions around the globe, often rely on mobile broadband to communicate their findings and patient concerns with regional clinics.

Although not broadband-specific, studies have shown that household Internet access is also associated with better educational performance. Numerous examples demonstrate that broadband-specific education creates valuable educational opportunities that can help countries develop a competitive, technology-literate workforce. Students with access to broadband connectivity become entrepreneurs, employers and employees with the skills and experience necessary to compete and succeed in the 21st-century global economy.

3.5 Telemedicine benefits of broadband

Broadband is entitled to play an increasingly important role in healthcare by enabling a universe of telemedicine services that, in turn, can provide a number of life-enhancing, and potentially lifesaving, benefits. The wide range of impacts that broadband is capable of producing on telemedicine can be summarized as follows:

- *Increase of range of healthcare*
  Broadband-enabled telemedicine tools can extend the range of healthcare to rural and unserved parts of a country, thus assisting in leveling the quality of care across all demographics and geographies. These tools can, for example, help to compensate for a lack of physicians in some rural areas.
- *In-home care made easier*
  The wide availability and increasing affordability of broadband can enable the use of effective in-home diagnostic, monitoring, and treatment services. Seniors in particular can benefit from these tools by having the ability to receive more care at home.
- *Streamlining of administration of healthcare*
  Health information technology (HIT) systems, especially electronic health records (EHRs), can create efficiencies in back-office operations and enable a number of cost-savings.
- *Enhancement of care for children, seniors and people with disabilities*
  Broadband-enabled telemedicine can provide effective and affordable care to rural and low-income children. Tools and services can be crafted for use by senior citizens and people with disabilities, leading to vast savings.

With healthcare costs soaring, broadband-enabled telemedicine offers policymakers, healthcare providers, and patients a set of tools that have the potential to drastically cut costs and enhance the quality of care. Moreover, broadband-enabled telemedicine services are expected to provide enormous benefits to rural users and to user groups that require more acute care. With the senior population expected to largely increase by 2050, and with senior care accounting for an extremely high percent of healthcare spending, broadband-enabled telemedicine holds much immediate and long-term promise for this user group in particular. However, intensive and efficient adoption and usage of broadband-enabled telemedicine services is poised to increase rapidly as the many barriers discussed in the last part of the chapter are eliminated by policy and cultural changes.

4. Broadband technologies

As the bandwidth revolution continues, the ever increasing completion in the broadband service market is forcing broadband service suppliers to plan their strategies for delivery of "triple play" services, with voice, data and video provided by a single connection. Over recent years, as the internet and intranets have evolved, increasing requirements for bandwidth intensive applications such as peer-to-peer file sharing and tele-working have resulted in relentlessly increasing demands for higher broadband bandwidth provisioning. However, it is the bandwidth required by next generation television and video services, such as video-on-demand (VoD) and, more significantly, high definition television (HDTV), which have recently begun to place the most pressure on bandwidth provisioning in broadband networks. Even with the latest data compression techniques, HDTV requires in the order of 15 to 20 Mpbs of downstream downlink and this is testing the capabilities of a number of broadband technologies (Solymar, 1999), (Huurdeman, 2003), (Angrisani et al., 2006), (Angrisani & Narduzzi, 2008), (*Broadband Technology Overview*, 2005).

There are a myriad of competing broadband technologies potentially capable of providing the bandwidth necessary to efficiently support telemedicine applications, but each technology has its limits in terms of reliability, cost or coverage. Optical fiber offers almost limitless bandwidth capabilities, has excellent reliability and is becoming increasingly economical to install. Consequently, fiber seems to be unsurpassed in its superiority over the other broadband technologies. However, many competitive copper and wireless technologies are developing at a significant pace and some technologies have so far managed to definitively meet the bandwidth requirements of typical telemedicine services.

In general, broadband solutions can be classified by two groups: fixed line technologies or wireless technologies. The fixed line solutions communicate via a physical network that provides a direct "wired" connection from the user to the service supplier. The best example is the plain old telephone systems (POTS), where the user is physically connected to the operator by a pair of twisted copper cables. Wireless solutions use radio or microwave frequencies to provide a connection between the user and the service supplier; mobile phone connectivity is a prime example (Bates, 2002), (Sauter, 2006).

4.1 Fixed line technologies

Fixed line broadband technologies rely o a direct physical connection to the user's (subscriber's) residence or business. Many broadband technologies such as cable modem, xDSL (digital subscriber line) and broadband powerline have evolved to use an existing form of subscriber connection as the medium for communication. Cable modem systems use existing hybrid fiber-coaxial Cable TV networks. xDSL systems use the twisted copper pair traditionally used for voice services by the POTS. Broadband powerline technology uses the power lines feeding into the subscriber's home to carry broadband signals. In general, all three aforementioned technologies strive to avoid any upgrades to the existing network due to the inherent implications for capital expenditure (*Broadband Technology Overview*, 2005).

By contrast, fiber to the home (FTTH) or fiber to the curb (FTTC) networks require the installation of a new (fiber) link from the local exchange (central office) directly to or closer to the user. Consequently, although fiber is known to offer the ultimate in broadband bandwidth capability, the installation costs of such networks have, up until recently, been prohibitively high.

The fixed line technologies described here include:

- *Hybrid Fiber Coax*: Cable TV – Cable Modems;
- *Digital Subscriber Line* (xDSL);
- *Broadband Power Line* (BPL);
- *Fiber to the Home/Curb*.

- *Hybrid Fiber Coax*: Cable TV – Cable Modems
  Digital cable TV networks are able to offer bi-directional data transfer bandwidth in addition to voice and digital TV services. Using a cable modem in the user premise and a Cable Modem Termination System (CMTS) at the network's head-end, the well established HFC standard, DOCSIS 1.1, provides for a data transmission service with speeds of up to a 30 Mbps on one 8 MHz channel (6 MHz is used in USA) using quadrature amplitude modulation (QAM) techniques. The successive HFC standard, DOCSIS 3.0, is nowadays capable of 100 Mbps of bandwidth per channel. Data transmission over Cable TV networks has the advantage that where the coaxial cable is in good condition and radiofrequency (RF) amplifiers exist (or can be installed) to extend the network reach, relatively high bandwidths can be provided to the end user without distance limitations. However, a cable TV broadband service relies on a shared network architecture (Fig.4); this results in the limitation that the amount of bandwidth delivered to the user is dependent on how many people share the connection back to the head-end. Typically, a service of 1 Mbps downstream and 128 kpbs upstream is offered (more recently a 3-5 Mbps downstream service has become available), but up to 1000 users may share the connection to the head-end and so the actual bandwidth obtained can be lower due to excessive loading of the system by other users.

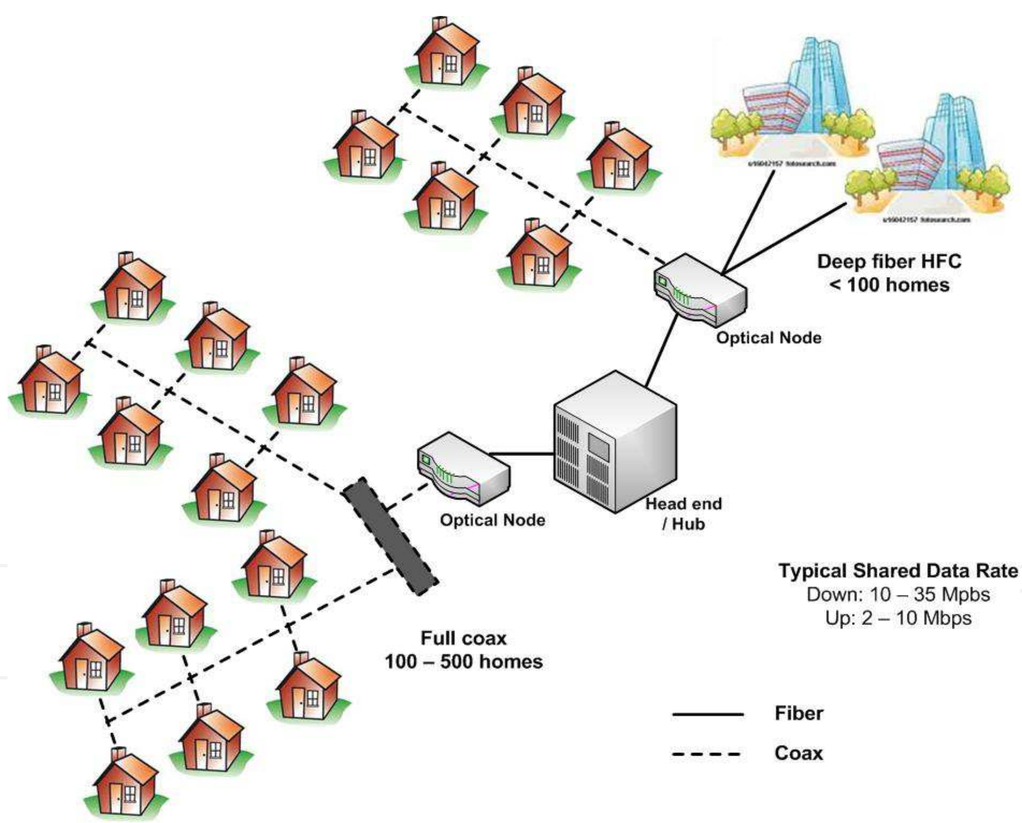


Fig. 4. Cable TV, Hybrid Fiber Coax (HFC) architectures.

- *Digital Subscriber Line (xDSL)*
  DSL delivers broadband to more people today than any other technology. Roughly two-thirds of all broadband subscribers are DSL subscribers, and there are more new DSL subscribers each month than new subscribers for all other broadband access technologies combined.

DSL is a technology that delivers broadband speeds over distances of miles or kilometers via copper wiring. DSL was originally delivered over the same wires that are used to provide traditional voice telephony services. These wires run from a telephone company's central office, the location where voice switching and other traditional telephony functions are performed, to the user's home or business. Increasingly, DSL is delivered from a device situated closer to the user's home or business that is connected to a central office via an optical fiber link, and then to the user's premises via copper wires. In all cases, however, DSL delivers broadband over the copper connections that exist already in almost every residence and business in the developing and developed worlds.

This architecture is depicted in Fig.5. At the central office, or at a remote location typically connected to the CO via fiber optics, there is a DSL Access Multiplexer (DSLAM) that sends and receives broadband data to many users via DSL technology. At each user's location, there is a modem (modulator-demodulator) that communicates with the DSLAM to send and receive that user's broadband data to and from the Internet and other networks. A DSLAM communicates with many individual modems. Each user's modem is dedicated to that subscriber's broadband connection.

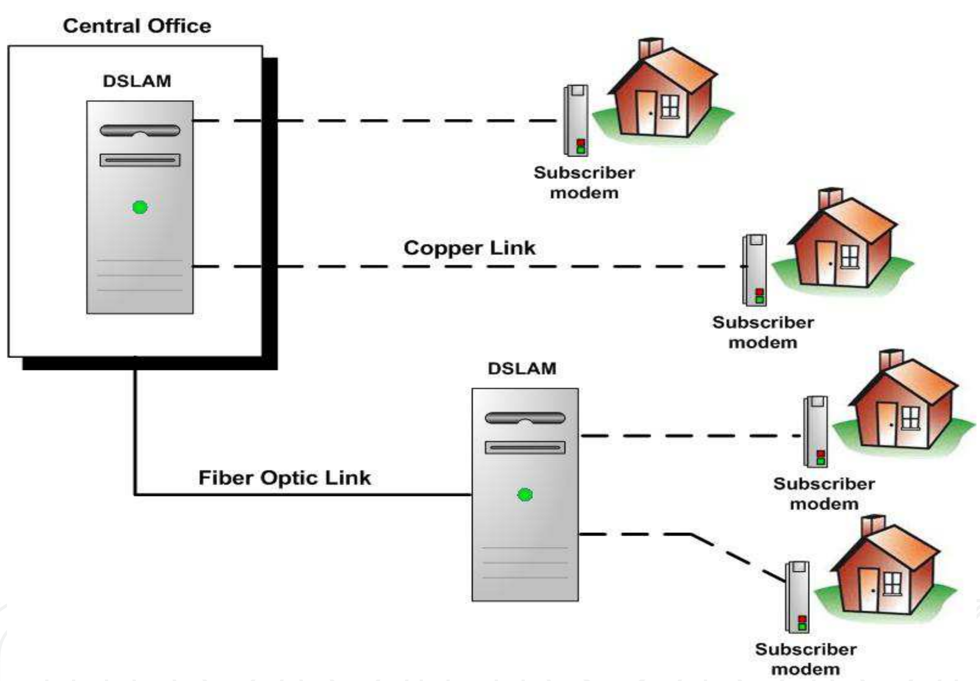


Fig. 5. DSL architecture

Voice services utilize only a small fraction of the total information carrying capacity of copper connections. In an analogous manner to Ethernet technology, which can transmit a Gigabit per second of data over copper connections or the equivalent of tens of thousands of simultaneous phone conversations, DSL exploits the information carrying capacity of copper lines to deliver broadband services over long distances.

To engineers, "DSL" means a set of formal standards for communicating broadband signals over copper lines. It also means equipment that complies with those standards. The principal DSL standards are published by the International Telecommunications Union (ITU), a standards body based in Geneva, Switzerland, that establishes standards for communications systems. Within the ITU, there is a division responsible for communications over copper, named the ITU-T, and a division responsible for communications using radio technology, known as the ITU-R. The ITU has several other divisions including one devoted to telecommunications in the developing world, known as the ITU-D.

DSL standards have evolved significantly since the first DSL standards were established in the early 1990's. The DSL standards have evolved to support higher data rates, to take advantage of advances in equipment technologies, and to ensure that DSL can coexist on copper lines with other communications standards such as Integrated Services Digital Network (ISDN), an early digital voice and data service that is still in use in many countries. Table I lists some of the principal DSL standards in use today (*ADSL Technology – Overview*).

Common Name	*Peak Speed*	*Standard*	*Deployment Status*
ADSL1	8 Mbps	ITU-T G.992.1	Pervasive
ADSL2+	24 Mbps	ITU-T G.992.5	Pervasive
VDSL2	50-75 Mbps	ITU-T G.993.2	Pervasive
Vectored VDSL2	120+ Mbps	ITU-T G.993.5	Standard complete, field use by 2011

1. "Mbps" means Megabits per second. A Megabit is a million of bits.
2. DSLAMs and Subscriber modems are capable of the peak speeds listed in the Table. Lower speeds may be delivered depending on the service packages offered by a subscriber's DSL provider, and also on the provider's network design and management practices.
3. There are several variants of the VDSL2 standard. The peak speed is dependent on the particular VDSL2 variant implemented by the DSL service provider.

Table I. Main DSL standards

With few exceptions, DSL technology is unique among broadband access technologies in that subscribers do not compete with one another for broadband access. Because each subscriber has their own copper connection to the DSLAM, all subscribers can achieve the peak speeds listed in the table above so long as the connection from the DSLAM to the Internet or other networks has adequate capacity. This is a significant advantage of DSL relative to other broadband access technologies where subscribers share a single physical connection, such as in a cable network, or a limited allocation of radio frequencies, such as in a 3G or 4G wireless network (*DSL Technology Tutorial*, 2010).

- *Broadband Powerline (BPL)*

  BPL systems allow for high speed data transmission over existing power lines, and do not need a network overlay as they have direct access to the ubiquitous power utility service coverage areas. BPL systems are being promoted as a cost-effective way to service a large number of subscribers with broadband. In a BPL system, the data is transmitted over the existing power line as a low voltage, high frequency signal, which is coupled to the high voltage, low frequency power signal. The frequency transmission band has been chosen to ensure minimum interference with the existing power signal. Typical data rates in actual tests are 2 to 3 Mbps. Most BPL systems at present are limited to a range of 1 km within the low voltage grid, but some operators are extending this reach in to the medium voltage grid. Experience has shown that BPL requires a high investment cost, to upgrade the power transmission network and bypass transformers, to support high speed and reliable broadband services, like those peculiar to telemedicine. In addition, the frequencies used for BPL often interfere with amateur radio transmission, and some BPL experiments have consequently suffered considerable opposition. At present, given the cost and the lack of an upgrade path, it seems unlikely that BPL will emerge as a leading broadband technology, but will remain as a nice fixed-line broadband option (*Broadband Technology Overview*, 2005).

- *Fiber to the Home/Curb*

  FTTx is a generic term for those technologies that bring fiber a step closer to the user. However, not all fiber solutions in access networks bring the fiber directly to the home/subscriber. Some technologies in the access that rely on fiber, like VDSL, bring fiber from the local exchange (central office) down to a node in the access network or to the curb, where equipment is housed in a street cabinet to convert signals from optical to electronic, ready for the final hop to the subscriber over twisted copper pair. This level of fiber provision in the network would be called FTTC (fiber to the curb) or FTTN (fiber to the node). Other architectures include FTTB (fiber to the building) and FTTP (fiber to the premises), where the fiber is brought as far as the building and then distributed amongst the resident subscribers over twisted copper pair or using wireless technology. FTTH is the ultimate fiber access solution where each subscriber is connected to the optical fiber.

  As FTTH has matured, applications have converged on to two consensus solutions. Th first is the Passive Optical Network (PON).PONs have been described for FTTH as early as 1986. In this architecture, th main signal from the local exchange is passively split in such a way that it is shared by several subscribers (Fig.6). Privacy is ensured by time shifting, and personal encryption of each subscriber's traffic. Upstream traffic is enabled by Time Division Multiple Access (TDMA) synchronization. Fixed network and exchange costs are shared among all subscribers. The PON solution benefits from having no outside-plant electronics. This reduces network complexity and life-cycle costs, while simultaneously improving reliability.

  The second common FTTH architecture is a point-to-point (P2P) network, which is often referred to as an All Optical Ethernet Network (AOEN). In this solution, each home is directly connected by an optical fiber to the local exchange. This provides a dedicated line of connection to the operator for each subscriber, which is the main advantage of P2P networks over PONs. The dedicated connection lines of a P2P network facilitate subscriber specific service supply, higher subscriber bandwidth with improved traffic security, and simple provision of symmetric services. The P2P network architecture is similar to the common enterprise Local Area Network (LAN) design, and so has the advantage of being able to use existing components and equipment, which helps to reduce system cost. However, P2P networks require activities in the field, which can increase installation, operating and life-cycle costs and also reduce reliability.

Standards are established for both PON and P2P networks, and suppliers exist for both PON and P2P systems, offering either Asynchronous Transfer Mode (ATM) or IP/Ethernet transmission on either architecture type.
Current Ethernet PON (EPON) systems can operate at up to 2.5 Gbps over distances of up to 20 km. Even with the EPON bandwidth shared amongst 64 users, the bandwidth offered to the FTTH consumer can grealy outstrip anything achievable by cable services or ADSL2+ over a radial coverage area of 20 km. In addition, Wavelength Division Multiplexed PON (WDM PON) is being explored. This technology, by bringing a single optical channel to each subscriber (eliminating bandwidth sharing), will furher increase the bandwidth offered by PON systems (*Broadband Technology Overview*, 2005).

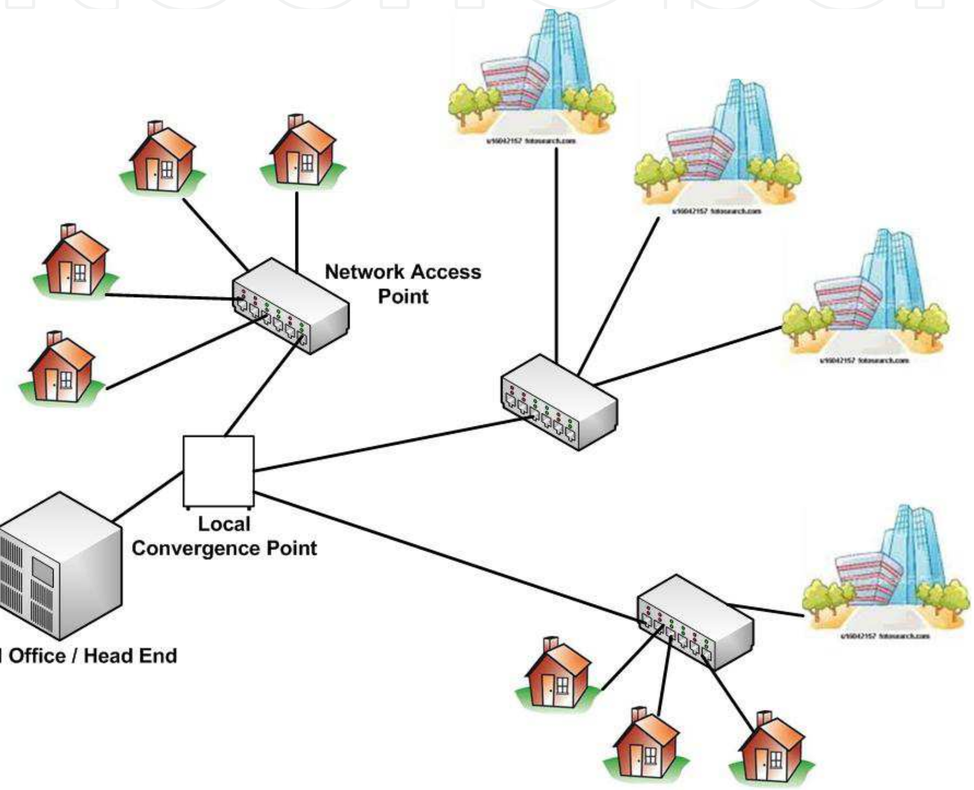


Fig. 6. Passive Optical Network (PON) architecture.

4.2 Wireless technologies

Wireless broadband generally refers to technologies that use point-to-point or point-to-multipoint microwave in various frequencies within 2.5 – 43 GHz to transmit signals between hub sites and an end-user receiver. While on the network level, they are suitable for both access and backbone infrastructure, it is in the access network where wireless broadband technology is proliferating. As a consequence, the terms “wireless broadband” and “wireless broadband access” are used interchangeably.
There is a wide range of frequencies within which wireless broadband technologies can operate, with a choice of licensed and unlicensed band. Generally speaking, higher frequencies are advantaged relative to lower frequencies a more spectrum is available at high frequencies and smaller antennas can be used, enabling ease of installation. Most higher bandwidth systems use frequencies above 10 GHz. However, high frequency systems are severely attenuated by poor weather conditions, and suffer from distance limitations.

Wireless technologies can be broadly categorized into those requiring line-of-sight (LOS) and those that do not. Point-to-point microwave and broadband satellite require line-of-sight for reliable signal transmission, while cellular technologies like UMTS, WiFi, WiMax require no line-of-sight between the transmission hub and receiving equipment. Clearly, the non line-of-sight technologies provide advantages in terms of case of deployment and wider network coverage (*Surfing into the Future*, 2007), (Webb, 1999), (Pahlavan & Levesque, 2005), (Arslan et al. 2006), (Schwartz, 2005).

The wireless technologies described here include:

- *Microwave links;*
- *Broadband satellite;*
- *UMTS-TDD* (Universal Mobile Telecommunication Access-Time Division Duplexing);
- *HSPA* (High Speed Packet Access);
- *Wi-Fi* (Wireless Fidelity);
- *WiMAX* (Worldwide Interoperability for Microwave Access).

- *Microwave links*
  Microwave links are the traditional workhorse of fixed-wireless broadband systems and were around long before the term wireless broadband was coined. It is the point-to-point LOS wireless transmission method for up to 155 Mbps, with a range of up to 5 km. Single channel microwave links are relatively inexpensive and simple to install. This is particularly true in areas of difficult (e.g. mountainous) terrain or of high population density where the installation costs of a traditional buried cabled network are prohibitively high. However, microwave networks have the great disadvantage of being limited by a very low data rate and are therefore of little use for high capacity links or for networks where it is essential to ensure that bandwidth capability is never outstripped by user bandwidth demand. Microwave capacity can be enhanced by installing more links, but deployment of additional links will soon push the overall cost of a microwave network to the point where it outstrips the cost of a much higher bandwidth traditional buried cables system. For networks with a low predicted capacity, microwave can be the lowest cost solution, but microwave will inhibit significant capacity expansion and in the longer term may result in lost business opportunity [20].
- *Direct Broadcast Satellite (DBS)*
  Primarily a direct-to-home digital TV broadcasting wireless solution, newer Direct Broadcast Satellite (DBS) services also provide two-way high-speed data transmission services. DBS uses geostationary satellites operating in the Ku band with a 12 GHz downlink and a 14 GHz uplink. Fig.7 shows the architecture of a DBS wireless broadband network, where the satellite relays the composite signal of digitized video and data services from a headend via an earth station and then broadcasts that signal to an area of targeted subscribers. Data rates within 16 – 155 Mbps can be obtained, but the major drawback is that geostationary satellites being 22300 km from the earth's surface introduce a 250 ms delay into the network. For most broadband services this latency is unacceptable. The use of a network of low-earth-orbit or LEOS satellites orbiting at only 1000 km will reduce this latency to 50 ms, but such systems are not widely available as yet. However, satellites, like all other systems using the radio spectrum, are limited in capacity by the bandwidth available. For satellites operating in the Ku band, there is a limit of 2 GHz of available bandwidth (*Surfing into the Future*, 2007).

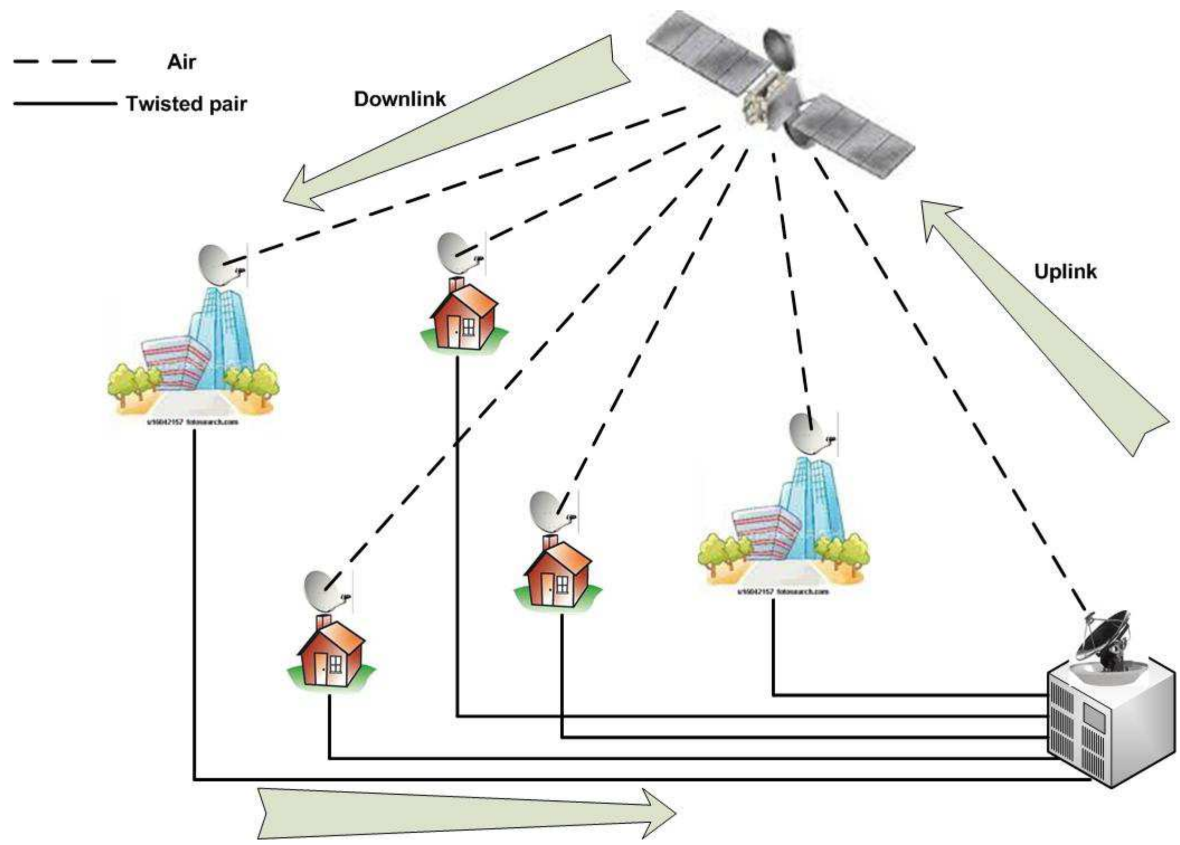


Fig. 7. Direct Broadcast Satellite (DBS) network architecture.

- *UMTS TDD*
  UMTS TDD uses Time Division Duplexing (TDD) and is a packet data based technology of the 3G (Third Generation) UMTS standard. It is being supported by the 3GPP alliance and is also known as Time Division-Code Domain Multiple Access (TD-CDMA). The technology has the advantage of having a larger user base, which includes the numerous operators across Europe and Asia, who use the IMT-2000 TDD frequencies of 1900-1920 MHz and 2010-2025 MHz. There is also the provision of operating in the 3.6 GHz licensed band.
  The peak downlink speeds are around 12 Mbps. UMTS TDD is one of three standards supported by UMTS that share the same higher layer protocol stacks (*Surfing into the Future*, 2007), (Holma & Toskala, 2006).
- *HSPA*
  HSPA (High Speed Packet Access) is the UMTS Forum's generic term for improvements in the UMTS Radio Interface in Releases 5 and 6 of the 3rd Generation Partnership Project (3GPP) standards, and represents the packet data service for the Wideband CDMA (WCDMA) standard. This means both improvements in the downlink allowing operators to increase throughput, often referred to as High Speed Downlink Packet Access (HSDPA), and in the uplink, often called High Speed Uplink Packet Access (HSUPA) but also called Enhanced Dedicated Channel (E-DCH).
  3GPP Release 5 (announced in 2003 and initially rolled out in 2005) introduced HSDPA. With HSDPA, WCDMA has been extended with additional transport and control channels, such as the high-speed downlink shared channel (HS-DSCH), which provides improved support for interactive, background and, to some extent, streaming services.

HSDPA enables speeds of up to a maximum of 14.4 Mbps, subject to network conditions. HSDPA is a software upgrade that doubles the air interface capacity of WCDMA networks and provides a 5 – 10 fold increase in downlink speeds of standard GSM/WCMDA networks. It enables users to access the Internet on mobile phones and PC notebooks, at speeds previously reserved for DSL. Release 5 also introduced the IP Multimedia Subsystem (IMS) architecture to enhance integrated multimedia applications and offer mobile operators a more efficient way of offering these services.
3GPP Release 6 provides for High Speed Uplink Packet Access (HSUPA) with increased speed up to 5.8 Mbps via a dedicated uplink channel, the second phase of IP Multimedia Subsystem (IMS), inter-working with Wireless Local Area Networks (WLAN), Multimedia Broadcast Multicast Service (MBMS), and Enablers for Push-to-talk (PoC).
The next phase of HSDPA is specified in 3GPP Release 7 and enhances Release 6 HSPA performance. Release 7's main priority is improved support and performance for conversational and interactive services such as Push-to-talk, picture and video sharing, and Voice and Video over IP (*Surfing into the Future*, 2007), (Holma & Toskala, 2006).
However, there is also a 3GPP vision of Long Term Evolution (LTE). The overall aim is to improve the capacity of the 3GPP system to cope with ever-increasing volumes of traffic in the longer term - over 10 years. The system needs to continually evolve to remain competitive in cost and performance versus the other mobile data technologies. LTE goals include:

- downlink peak data rates up to 100 Mbps with 20 MHz bandwidth;
- uplink peak data rates up to 50 Mbps with 20 MHz bandwidth;
- operation in both TDD and FDD modes;
- increased spectral efficiency over Release 6 HSPA by a factor of two to four;
- reduced latency.

- *Wi-Fi*

Wireless local area networks (WLANs) compliant with the family of IEEE 802.11 standards (also known as Wi-Fi standards) are nowadays one of the most successful emerging network technologies in the wireless communication scenario. They are commonly used to provide wireless access to the Internet and network connectivity for personal digital assistants, laptops, and modern consumer electronics. In particular, they are widely available worldwide, through thousands of public hotspots located anywhere, in millions of homes, factories, and university campuses.
A great interest in Wi-Fi technology is also rapidly growing in the field of real-time multimedia, for audio/voice and video streaming applications over a wireless link, like those peculiar to telemedicine. With regard to video streaming, although new applications are very likely to appear soon with upcoming WiMAX or DVB-H enabled devices, the research community is in-depth studying new protocols, able to make Wi-Fi apparatuses overcome some notable drawbacks, thus allowing them to satisfy the stringent real-time unicast and multicast requirements.
The family of IEEE 802.11 standards concerns wireless connectivity for fixed, portable, and moving stations within a local area. It applies at the lowest two layers of the Open System Interconnection (OSI) protocol stack, namely, the physical layer and the data link layer. The physical layer (PHY) essentially provides three functions. First, it interfaces the upper media access control (MAC) sublayer for transmission and

reception of data. Second, it provides signal modulation through direct sequence spread spectrum (DSSS) techniques or orthogonal frequency division multiplexing (OFDM) schemes. Third, it sends a carrier sense indication back to the upper MAC sublayer, to verify activity in the wireless bandwidth. The data link layer includes the MAC sublayer, which allows the reliable transmission of data from the upper layers over the PHY media. To this aim, it provides for a controlled access to the shared wireless media, called carrier-sense multiple access with collision avoidance (CSMA/CA). It also protects the data being delivered through proper security policies.

The 802.11 family currently includes multiple extensions to the original standard, based on the same basic protocol and essentially different in terms of modulation techniques. The most popular extensions are those defined by the IEEE 802.11a/b/g amendments (also referred to as standards), on which most of the today's manufactured devices are based. Nowadays, IEEE 802.11g is becoming the WLAN standard more widely accepted worldwide. It involves the license-free 2.4GHz ISM band (2.4–2.4845 GHz), like the IEEE 802.11b standard, and supports a maximum data rate of 54 Mbps, like the IEEE 802.11a. IEEE 802.11g devices are backwards compatible with IEEE 802.11b ones. They use the OFDM modulation scheme for the data rates of 6, 9, 12, 18, 24, 36, 48, and 54Mbps and revert to complementary code keying (CCK, as in the case of the IEEE 802.11b standard) for 5.5 and 11Mbps and differential binary phase shift keying (DBPSK)/differential quadrature phase shift keying (DQPSK) + DSSS for 1 and 2 Mbps.

In the 2.4GHz ISM band, the IEEE 802.11g standard defines a total of 14 frequency channels, each of which is characterized by 22MHz bandwidth. In USA, channels 1 through 11 are allowed, in Europe channels 1 through 13 can be used, and in Japan only channel 14 is accessible. Due to the available bandwidth, channels are partially overlapped, and the number of nonoverlapping usable channels is only 3 in USA and Europe (e.g., channels 1, 6, and 11) (*Surfing into the Future*, 2007), (IEEE Standard 802.11, 1999), (Angrisani et al., 2010).

- *WiMAX*

  Worldwide interoperability for microwave access (WiMAX) is the latest wireless broadband technology that is designed to deliver Wi-Fi type connectivity over a much greater range, and thereby compete as a point-to-multipoint last-mile broadband wireless access solution. There are two types of WiMAX : line of sight (LOS) and non-line of sight (NLOS). The LOS WiMAX systems are point-to-point only, while the NLOS WiMAX are point to multi-point.

  Although the LOS systems have much better reach capabilities, they will not facilitate a large consumer service coverage area, and so it is the much shorter reach. Conversely, NLOS systems are being developed to offer an alternative large-scale consumer broadband service technology. WiMAX is based on the IEEE 802.16 standard and refers both to fixed-wireless and mobile broadband technology. WiMAX equipment suppliers aim to provide fixed, nomadic, portable and, eventually, mobile wireless broadband connectivity without the need for direct line-of-sight with a base station within a given sector cell. In a typical cell radius deployment of 3 to 9 km, WiMAX Forum Certified™ systems aim to ultimately deliver capacity of up to 75 Mbps per channel, for fixed and portable access applications. Mobile network deployments are aiming to provide up to 15 Mbps of capacity within a typical cell radius deployment of up to 3 km.

WiMAX System Type	Reach Capability	Max Downlink Bandwidth per Sector	Max Uplink Bandwidth per Sector	Downlink Bandwidth per CPE at Cell Edge	Uplink Bandwidth per CPE at Cell Edge
Standard					
LOS	10 – 16 km	8 – 11.3 Mbps	8 – 11.3 Mbps	2.8 – 11.3 Mbps	2.8 – 11.3 Mbps
NLOS	1 – 2 km 0.3 – 0.5 km (indoor self-install)	8 – 11.3 Mbps	8 – 11.3 Mbps	2.8 – 11.3 Mbps	2.8 – 11.3 Mbps
Full-Featured					
LOS	30 – 50 km	8 – 11.3 Mbps	8 – 11.3 Mbps	2.8 – 11.3 Mbps	2.8 – 11.3 Mbps
NLOS	4 – 9 km 1 – 2 km (indoor self-install)	8 – 11.3 Mbps	8 – 11.3 Mbps	2.8 – 11.3 Mbps	0.7 – 0.175 Mbps (assumes only one subchannel is used to extend to edge of sector cell)

Table II. Typical performance of current WiMAX systems

For NLOS systems, there is a further choice between indoor self-install or outdoor consumer premise equipment (CPE). The indoor self-install equipment will be favoured by the consumer market as it has the distinct advantages of simplicity of installation, but the reach is severely reduced as the signal is attenuated by the infrastructure of the building. There are also two grades of WiMAX network installations: standard and full-featured. Table II shows that the performance of WiMAX varies greatly and is a very complex function of the type of WiMAX deployed, be it NLOS or LOS, the user friendly indoor self-install or the outdoor equipment, a standard or a full-featured installation.
Table II shows that standard WiMAX equipment aims at delivering an upstream and downstream bandwidth per channel within 8 - 11 Mbps, but only over a range of 1 –2 km for NLOS operations. Equivalent indoor self-install WiMAX solutions aim to achieve similar bandwidths, but only over 0.3 – 0.5 km of range. The latest generation of full-featured WiMAX equipment aims at delivering a bidirectional bandwidth of up to 11 Mbp over 3 – 9 km with NLOS capability and the same bandwidth over a range within 1 – 2 km for NLOS indoor self-install applications (*Surfing into the Future*, 2007), (Angrisani & Napolitano, 2010).

5. Open challenges for broadband adoption in telemedicine

This part outlines the wide array of still open, policy and non-policy challenges to further adoption and usage of broadband in the telemedicine sector (*Barriers to Broadband Adoption*, 2009). As an overview, these challenges involve:

- *Outdated and fragmented privacy policies for the electronic transmission of health data;*
- *Lack of security standards for data generated from telemedicine services;*
- *Lack of standards to guide the interoperability of new telemedicine services;*
- *Negative perceptions and inadequate value propositions for using telemedicine services by patients;*
- *Costs/Evaluation/Outcomes.*

5.1 Outdated and fragmented privacy policies for the electronic transmission of health data

An outdated set of privacy policies that may not provide adequate protection to sensitive medical information is a challenge to more robust adoption and use of telemedicine services. Indeed, the security of personal health information is paramount to doctors and patients as more advanced telemedicine services and devices collect and transmit an increasingly large volume of medical data over the Internet. Although transferring personal health information electronically via e-mail or an EHR may be efficient, it raises important issues regarding the confidentiality of patient data and the possibility of private medical information being illegally viewed or stolen by a third-party. Privacy laws, however, have largely failed to keep pace with technological change and afford suboptimal protections for patients.

Patient medical data is generally protected by state law. To this end, most states have enacted laws of general applicability regarding the electronic transmission of health information. However, these were crafted in response to the mostly intrastate nature of many modern telemedicine services that have been launched and may be inadequate in a world where broadband-enabled telemedicine services allow for the transmission of health data in real-time manner across state lines and international borders.

5.2 Lack of security standards for data generated from telemedicine services

In addition to privacy challenges, there is a general lack of standards to ensure the security of medical data being transferred via the Internet.

The amount of data generated from telemedicine services is substantial. Indeed, telemedicine enables the use of devices such as video, audio, sensors, and various health meters to send patient information over a broadband network in real time. At a time when harmful content like spam and malware continues to threaten the general user experience, more robust policies that protect sensitive medical data are especially needed.

In addition, enhancing the security of networks could increase more regular usage of these services. Issues continue to arise when data is sent over an unencrypted network or is accessed by unauthorized personnel. A string of cyber-attacks against epileptic patients in 2008 is illustrative of how certain parts of the Web remain vulnerable to criminals who use networks to inflict harm. In one case, a group of hackers "descended on an epilepsy support message board used JavaScript code and flashing computer animation to trigger migraine headaches and seizures in some users." At first, the hackers "used a script to post hundreds of messages embedded with flashing animated gifs." However, subsequent attacks used a similar tactic to "redirect users' browsers to a page with a more complex image designed to trigger seizures in both photosensitive and pattern-sensitive epileptics." Other such attacks have targeted visually impaired users.

Other security concerns arise from the increased use of Wi-Fi networks for in-home monitoring. These types of networks tend to be less secure than wire-based ones, but their relative affordability and ability to interact with other wireless technologies (e.g., wireless sensors) have made them very attractive to researchers and patients.331 As one article recently observed, "If patients are not confident that their information is acquired, transmitted and stored in a secure and confidential way, they will probably not be keen to reveal accurate and complete information." Consequently, the overall quality of telemedicine care may diminish as a result of improper data security controls.

The Civic Research Institute in USA has found that four key factors determine electronic data security. These include: (1) the authentication of users requesting access to data, (2) the authorization of users before providing access, (3) the confidentiality of data while it is sent over the network, and (4) the integrity of the sent data. These factors protect the network from service disruptions (denial of service), the destruction or changing of data (viruses or worms), and the theft of data (copying from the network or server). Passwords, cryptography, and biometrics are used for the authentication and authorization of users, and log files track user access to data files. Unauthorized communications can be filtered out through the use of firewalls, and secure networks, such as Virtual Private Networks, are utilized to protect data confidentiality and integrity. While such technologies provide enhanced network security from external threats, the risks arising from internal negligence are another critical concern.

Internal threats resulting from employee and patient activity may also compromise network security. The American Computer Security Institute and the FBI recently found that half of all security breaches are the result of internal errors. Employees may unintentionally expose networks to attack by misplacing passwords, leaving confidential files open, failing to update the list of authorized employees, opening unsafe email attachments, and losing critical data.

Training of personnel is an often neglected aspect of system implementation, and may result in complications if employees are unprepared to properly operate the network and secure patient data. A 2005 survey of computer security practitioners found that the vast majority of participants believed security awareness training was important. However, respondents from all industry sectors believed that their organization failed to invest enough resources in it. When security measures are overly complicated and difficult to use, both employees and patients may have difficulty complying with the system requirements. For example, if safety alerts are provided too frequently, users may ignore the warnings and become unresponsive. Older adults in particular may experience difficulty when operating complicated interfaces and may abandon the system all together.

Security threats vary significantly by type of network and the requirements of users. However, a lack of data security standards for telemedicine services, for telemedicine practitioners, and for other stakeholders creates an important barrier towards further usage of these services.

5.3 Lack of standards to guide the interoperability of new telemedicine services

Telecommunications systems often operate on networks that do not facilitate the interoperability of telemedicine services. In particular, interoperability is a significant issue for EHRs, the vast majority of which do not interoperate well with other applications. If advanced telemedicine applications (e.g., various proprietary HER programs) are unable to work with one another, then their value will be limited.

A variety of standards-setting bodies have been established to help ensure interoperability. HHS, for example, launched the Healthcare IT Standards Panel (HITSP) in 2005. This panel "serve[s] as a cooperative partnership between the public and private sectors for the purpose of achieving a widely accepted and useful set of standards specifically to enable and support widespread interoperability among healthcare software applications, as they will interact in a local, regional, and national health information network for the United States." A number of other such efforts have been launched in recent years, including the Nationwide Health Information Network, the National Institute for Standards & Technology, and the Certification Commission for Health IT, among others. As doctors and hospitals across the country migrate from paper-based medical records to EHRs, and as innovative new broadband-enabled telemedicine tools continue to be deployed, these efforts will be essential to ensuring that these new services are interoperable and thus of value to all stakeholders.

However, until robust and widely accepted standards are developed and adopted by the vast array of service providers, innovators, and other stakeholders in the market, broadband-enabled telemedicine tools may remain fragmented in nature and unable to leverage true economies of scale to provide efficient and effectives services.

5.4 Negative perceptions and inadequate value propositions for using telemedicine services by patients

A significant number of patients, many of whom are older adults, remain wary of telemedicine services generally. This skepticism often stems from an unawareness of the true value of using these types of tools or a preference to continue using traditional healthcare methods (e.g., face-to-face consultations).

Studies have shown that, while patient satisfaction with telemedicine services is generally positive, patients express negative concerns both before and after receiving treatment. A recent study of remote monitoring patients found that "[a]lthough the response to the home telehealth service [for congestive heart failure] was overwhelmingly positive, respondents remained undecided regarding the perceived benefits of telehealth versus in-person care." Though the majority of patients advocated its future use, most still favored the in-person visit over the tele-visit. Moreover, while significant advantages were identified by patients, the most common disadvantages cited include confusion with the technology, the monotony of repetitive processes, and disruption of activities. In addition, research suggests that patients are more willing to use telemedicine services as a supplement to, rather than a replacement for, traditional face-to-face consultations "as long as privacy safeguards are maintained."

The current baby boomer and senior populations are especially wary of one type of telemedicine application: in-home health monitoring services. Two-thirds of both groups currently see little to no value in such technologies. According to AARP (American Association of Retired Persons), "Older adults often find little of interest to convince them of the value of making the change, and very frequently, poor design makes technology products very hard to learn or use." More specifically, many older adults fear that remote home health monitoring will reduce the personal relationships they have built with their doctors and their social interaction overall. Indeed, many older patients see "aging in place" with the help of home health monitors as a negative aspect of telemedicine and would rather "age in community" without losing social interaction. Sufficient interpersonal contact is not only beneficial to an older patient's health, but also a critical aspect to an older adult's quality of life. In addition, a perceived stigma towards aging and disease may cause seniors to resent the monitoring devices and view them as a constant reminder of their poor

physical condition. Wearing a health monitor in public may cause older adults to feel old and weak in the eyes of others. Anecdotal evidence also supports the observation that many older adults may resent the lack of privacy afforded by in-home monitoring technologies, and they may dislike ceding authority over their medical state to their children, who often assume control over the monitoring system.
Thus, a primary barrier to further adoption and utilization of these services by all patients, especially older adults, is overcoming initial negative perceptions associated with telemedicine, shifting preferences away from traditional medical care, and providing adequate value propositions to spur use.

5.5 Costs/Evaluation/Outcomes

Although much anecdotal evidence exists, there is scant hard evidence that the communications technology will provide appropriate health care at a reasonable cost, despite the fact that in certain situations the cost-effectiveness of telemedicine appears obvious. Therefore, before payers and providers are willing to move on the issue, they want to know the likely economic effects of the use of telemedicine. Reimbursement policy issues are further complicated by rapid changes in equipment technology and faster communications networks that are making telemedicine capability more mobile, available for more applications, and with lower equipment costs and operational expenses. Metrics for telemedicine outcomes should be developed to demonstrate sufficient evidence of socio-economic benefit to indicate ongoing investment is appropriate. Evaluations should include examination of the social, cultural, organizational, and policy aspects of telemedicine. Suitable frameworks for economic analysis should capture non-monetary and unintended consequences, as well as monetary measures. Full integration of telemedicine will increase its use and decrease the per contact episode cost. Investment in information and communications technology infrastructure should be considered as an investment not only in health, but also in business, education, and other e-sectors. Sustainable telemedicine 'programs' and not 'projects' should be targeted.

6. Conclusions

Recent research firmly establishes broadband as an essential part of the global information society. Broadband fosters GDP growth, can create new jobs, spur innovation and improve public services, like telemedicine. Delivering affordable, reliable and accessible broadband to more citizens will help countries become stronger, more competitive and more prepared for continued growth in the years and decades to come.
More specifically, the notes hereby given have made the point on how consolidated broadband technologies, properly assembled and merged with well-defined medical needs, can successfully be exploited in many countries as a suitable aid to provide better cares to elderly and weak persons, as well as a compelling support to healthcare and telemedicine applications and services. Broadband-enabled telemedicine has the potential to transform healthcare by connecting more institutions and allowing for the faster transmission of vital information. It is pushing healthcare into homes with the consequent decrease of reliance on hospitals and nursing homes, and it is empowering individual patients by providing them with access to personal health and medical information.
It is essential, however, to bear in mind that technology suitability and availability are not the only issues to make a feasible solution replicable and widely deployed in a sustainable

manner. Successfulness is still cost related, and a more critical factor is the identification of the most appropriate telemedicine business model. As a matter of fact, telemedicine applications addressed a few years ago would have a cost impact higher than 30-40% or even more compared to today's solutions and broadband cost benefits. Policymakers should thus implement (or continue to implement) policies that support investment and encourage innovation while also reforming and updating a variety of healthcare-related laws in order to spur the adoption and use of telemedicine services. To this end, stimulus funding should be allocated to support broadband deployment and adoption, to spur use of cutting-edge services like electronic health records, and to support innovative pilot programs

7. References

ADSL Technology - Overview, Line Qualification and Service Turn-up. JDSU White Paper, (available at http://www.jdsu.com/product-literature/ADSL_Technology_White_Paper.pdf).

Angrisani, L.; Napolitano, A. & Sona, A. (2010). Cross-layer measurements on an IEEE 802.11g wireless network supporting MPEG-2 video streaming applications in the presence of interference, *EURASIP Journal on Wireless Communications and Networking*, Hindawi Publishing Corporation, Vol.2010, Article ID 620832, April 2010, pp.1-11.

Angrisani, L. & Napolitano, A. (2010). Modulation quality measurement in WiMAX systems through a fully digital signal processing approach, *IEEE Trans. on Instr. and Meas.*, vol.59, No.9, September 2010, pp.2286-2302.

Angrisani, L. & Narduzzi, C. (2008). Testing communication and computer networks: an overview, *IEEE Instrumentation & Measurement Magazine*, October 2008, pp.12 24.

Angrisani, L.; Peluso, L.; Tedesco, A. & Ventre, G. (2006). Measurement of processing and queuing delays introduced by an open-source router in a single-hop network, *IEEE Trans. on Instr. and Meas.*, Vol.55, No.4, August 2006, pp.1065 1076.

Arslan, H.; Chen, Z.N. & Di Benedetto, M.G. (2006). *Ultra Wideband Wireless Communication*, John Wiley & Sons Inc., ISBN 0-471-71521-2, New Jersey, USA.

Barriers to Broadband Adoption: A Report to the Federal Communications Commission (2009). The Advanced Communications Law&Policy Institute Literature, New York Law School, (available at http://www.law.northwestern.edu/searlecenter/uploads/ACLP%20Report%20to%20the%20FCC%20-%20Barriers%20to%20BB%20Adoption.pdf).

Bates, R.J. (2002). *Broadband Telecommunications Handbook*, The McGraw−Hill Companies Inc., ISBN 0−07−139851−1, USA.

Benefits of Telemedicine (2004). Telemedicine Association of Oregon Literature, January 2004, (available at http://www.ortcc.org/PDF/BenefitsofTelemedicine.pdf).

Broadband Technology Overview, (2005). CORNING – Discovering Beyond Imagination, June 2005, (available at http://www.corning.com/docs/opticalfiber/wp6321.pdf).

Darkins, A.W.& Cary, M.A. (2000). *Telemedicine and Telehealth - Principles, Policies, Performance, and Pitfalls*, Springer Publishing Company Inc., ISBN 0-8261-1302-8, New York, USA.

Di Lieto, A.; De Falco, M.; Campanile, M.; Papa, R.; Torok, M.; Scaramellino, M.; Pontillo, M.; Pollio, F.; Spanik, G.; Schiraldi & P.; Bibbò, G. (2006). Four years' experience with antepartum cardiotocography using telemedicine, *J Telemed Telecare*, Vol.12, No.5, pp.228-33.

Di Lieto, A.; De Falco, M.; Campanile, M.; Török, M.; Gábor, S.; Scaramellino, M.; Schiraldi, P. & Ciociola, F. (2008). Regional and international prenatal telemedicine network for computerized antepartum cardiotocography, *Telemed J E Health*, Vol.14, No.1, (Jan-Feb 2008), pp.49-54.

Di Lieto, A.; Scaramellino, M.; Campanile, M.; Iannotti, F.; De Falco, M.; Pontillo, M. & Pollio, F. (2002). Prenatal telemedicine and teledidactic networking. A report on the TOCOMAT project, *Minerva Ginecol*, Vol.54, No.5, pp.447-51.

DSL Technology Tutorial (2010). ASSIA Literature, (available at http://www.assia-inc.com/DSL-technology/DSL-knowledge-center/tutorials/DSL-technology-tutorial.php).

Hahm, J.S.; Lee, H.L.; Choi, H.S. & Shimizu, S. (2009). Telemedicine System Using a High-Speed Network: Past, Present, and Future, *Gut and Liver*, Vol.3, No.4, December 2009, pp.247-251 (available at http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2852732/pdf/gnl-3-247.pdf).

Holma, H. & Toskala, A. (2006). *HSDPA/HSUPA for UMTS - High Speed Radio Access for Mobile Communications*, John Wiley & Sons Ltd, ISBN-13 978-0-470-01884-2, England, UK.

Huurdeman, A.A. (2003). *The Worldwide History of Telecommunications*, John Wiley & Sons, Inc., ISBN 0-471-20505-2, Hoboken, New Jersey, USA.

IEEE Standard 802.11-1999 (1999).Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications.

Khoumbati, K.; Dwivedi, Y.K.; Srivastava, A. & Lal, B. (2010). *Handbook of Research on Advances in Health Informatics and Electronic Healthcare Applications: Global Adoption and Impact of Information Communication Technologies*, Medical Information Science Reference, ISBN 978-1-60566-030-1, Hershey, New York, USA.

Pahlavan, K. & Levesque, A.H. (2005). *Wireless Information Networks*, John Wiley & Sons Inc., ISBN-13 978-0-471-72542-8, New Jersey, USA.

Realizing the Benefits of Broadband (2010). Intel Corporation White Paper, (available at http://www.intel.org/Assets/PDF/Article/WA-323857001.pdf).

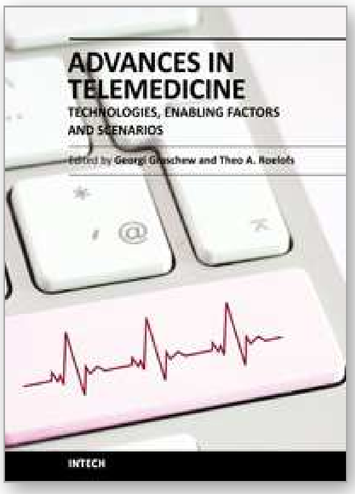
Sauter, M. (2006). *Communication Systems for the Mobile Information Society*, John Wiley & Sons Ltd, ISBN-13 978-0-470-02676-2, England, UK.

Schwartz, M. (2005). *Mobile Wireless Communications*, Cambridge University Press, ISBN 0-521-84347-2, Cambridge, UK.

Solymar, L. (1999). *Getting the Message - A History of Communications*, Oxford University Press Inc., ISBN-019 850333-4, New York, USA.

Surfing into the Future: Mobile Broadband Technologies (2007). Juniper Research Limited White Paper, (available at **Error! Hyperlink reference not valid.**).

Webb, W. (1999). *The Complete Wireless Communications Professional: A Guide for Engineers and Managers*, Artech House Inc., ISBN 0-89006-338-9, Norwood, Massachusetts, USA.



Advances in Telemedicine: Technologies, Enabling Factors and Scenarios
Edited by Prof. Georgi Graschew

ISBN 978-953-307-159-6
Hard cover, 412 pages
Publisher InTech
Published online 16, March, 2011
Published in print edition March, 2011

Innovative developments in information and communication technologies (ICT) irrevocably change our lives and enable new possibilities for society. Telemedicine, which can be defined as novel ICT-enabled medical services that help to overcome classical barriers in space and time, definitely profits from this trend. Through Telemedicine patients can access medical expertise that may not be available at the patient's site. Telemedicine services can range from simply sending a fax message to a colleague to the use of broadband networks with multimodal video- and data streaming for second opinioning as well as medical telepresence. Telemedicine is more and more evolving into a multidisciplinary approach. This book project "Advances in Telemedicine" has been conceived to reflect this broad view and therefore has been split into two volumes, each covering specific themes: Volume 1: Technologies, Enabling Factors and Scenarios; Volume 2: Applications in Various Medical Disciplines and Geographical Regions. The current Volume 1 is structured into the following thematic sections: Fundamental Technologies; Applied Technologies; Enabling Factors; Scenarios.