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An Introduction to Wireless Mobile Internet

The wireless mobile Internet, which was a dream just a few years ago, is now progressing so fast that it could revolutionize the whole framework of the telecommunications industry. The wireless mobile Internet is not just an extension of the Internet into the mobile environment giving users access to the Internet services while they are on the move. It is about integrating the Internet and telecommunications technologies into a single system that covers all communication needs of human beings. With the extensive progress achieved during the last decade in wireless access technology, switching and routing in the Internet, and sophisticated hardware and software design, such a comprehensive Internet technology would no longer be a dream but a practical reality. Whilst the first cellular-based mobile Internet services provided users with flavors of an actual wireless mobile Internet system, there is still a need to research more to achieve the systematic goals of this network. In this chapter we will review the main related telecommunications technologies and then give some statistics on global trends toward wireless Internet. These trends include those within the telecommunications technology as principles and those within the Internet applications. A general understanding of the requirements of wireless Internet is also included in this chapter.

1.1 TELECOMMUNICATION TECHNOLOGIES

Wireless has been the most significant technology breakthrough among all human achievements in the past few decades. Barely twenty years ago, it was very difficult to assume that telecommunication services can be provided to people irrespective of their geographical

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location and while they are moving around, but now for many people it is very difficult to imagine life without continuous availability of communications using a mobile phone. Telecommunications technology has indeed completed its biggest improvement in just a few years so that sometimes its future growth is doubtful. What would be the next breakthrough in this fast-growing industry? Is there still anything that we can add to telecommunications? Where will be the end of the telecommunication industry's progress and when will that end come?

1.1.1 Telecommunications: Wired, wireless, and cellular

Telecommunications services started with voice communications; the most natural requirement of human beings is to talk, no matter where they are, at the same location or thousands of miles away from the person they want to talk to. Invention of the wired telephony fulfilled this natural desire and has been considered as the most significant breakthrough of its time. This enormous breakthrough, however, needed 75 years to get its first 50-million users for the wired telephony network.

Radio technology started a new era in telecommunications history with the invention of the electromagnetic wave. Replacing wires with space as the medium for transmission of communication signals brought new ideas for the emerging telecommunications. Researchers started work on improvement of communication techniques so that more information could be sent on air. New coding algorithms have been developed so that a better quality radio signal could be received. Analog modulation schemes have been invented so that more users could access the same frequency spectrum and could share the available bandwidth resources. Radio and television broadcasting started their dominance in the user market all around the world. In particular, television brought in new media for connecting people in a visual manner, more desirable than the voice-only service, and satellite communications made it possible to transmit radio and television signals in just a few seconds to all parts of the world. Even these breakthrough inventions needed some time to get sufficient popularity. Broadcasting radio received its first 50-million users in 35 years, and the popular television required 13 years for the same number of subscribers. This was just the start of wireless communications.

1.1.1.1 Multiple access schemes

As people started using telecommunications resources at such a rapid pace, researchers started working on methods that would enable the efficient sharing of these resources. They found out from the beginning that telecommunications resources are limited, whether you use wire or radio frequency (RF). Multiple-access schemes thus started to be developed. Discussions on different multiple-access schemes can be found in all classic communication texts such as References [1–4] and in more specialized literature [5–13]. Frequency modulation (FM) gave the idea of sharing the frequency among many people so that they send their signals at different frequency bands. As a result, frequency division multiple access (FDMA) schemes have been invented. In FDMA, as shown in Figure 1.1a, each user is granted with a small fraction of frequency or channel within the available frequency bands. A small amount of frequency spectrum is allocated between each pair of

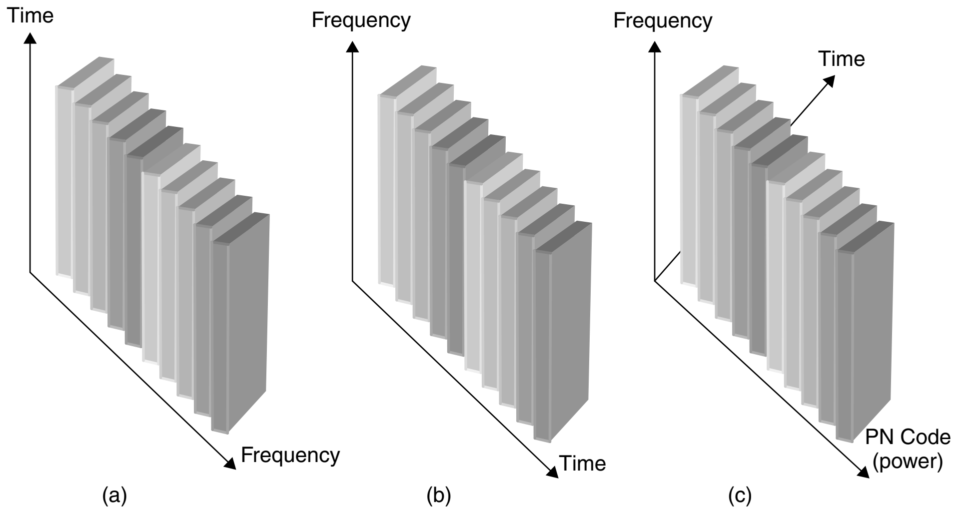

Figure 1.1 Telecommunications resource allocations through different multiple-access schemes: (a) FDMA; (b) TDMA; and (c) CDMA

adjacent frequency channels as guard-band, to reduce the interference from adjacent channels. First wireless systems, including satellite systems, used FDMA as the main method of accommodating many users. One reason for this selection was that FM is more robust to the nonlinearity, and thus the satellite's analog amplifiers could operate at their highest gain range where the amplification is no longer a linear process.

With the invention of digital communications and analog-to-digital conversion methods, it has been understood that dividing the time domain into channels while all users share the same frequency spectrum would be a better option than FDMA. Therefore, the time division multiple access (TDMA) scheme has been invented, allowing multiple users to use the whole available frequency band, but by sending their respective information at different periods of time, namely, *timeslots* as shown in Figure 1.1b. Each pair of adjacent time slots is separated with a short time period as guard-time, to reduce the interference from adjacent channels. Pulse code modulation (PCM) has been a great achievement in completing this era of digital communications sending smaller amount of information, but sufficient to retrieve the sender information, over the shared medium. The PCM itself finds its development through the invention of Nyquist's sampling theorem. TDMA and FDMA both are categorized as contention-less protocols as users' transmissions are scheduled in either the time (TDMA) or the frequency (FDMA) domain, and therefore there is no contention in accessing the channel by users, as, for example, can be experienced in an Aloha multiple access scheme [8].

More recently, code division multiple access (CDMA) schemes came to be used as commercial techniques in sharing the wireless channel resources [9–12]. In a CDMA system, users' signals occupy all the frequency spectrum during the entire transmission period, but these signals are distinguished from one another according to the specific code assigned to each user, as shown in Figure 1.1c. At any given time, a subset of the users in the system can transmit information simultaneously over the common channel to corresponding receivers. The transmitted signals in the common spectrum can be distinguished from one another by the superimposing of a different pseudorandom (or pseudonoise, PN) pattern, called a *code*, in each transmitted signal. Thus, a particular receiver can recover the transmitted information intended for it by knowing the PN pattern, that is, the sequence used by the corresponding transmitter. The most popular form of CDMA is direct sequence CDMA (DS-CDMA), in which DS spread-spectrum signals occupy the same channel bandwidth, provided that each signal has its own distinct PN sequence. As we will see later, DS-CDMA is used in UMTS (Universal Mobile Telecommunications System) FDD (frequency division duplex) mode [14–18], whereas in cdma2000 [19,20], another third-generation (3G) cellular system, a multicarrier CDMA, is used (see Chapters 3 and 4 for details).

CDMA can be considered as either a contention-less or contention protocol, depending on the situation of the channel. A CDMA scheme is a contention-less protocol if the number of simultaneous transmissions on the channel or the level of multiple-access interference is under a given threshold in which all the transmissions can be handled successfully by the system. It is a contention protocol if the level of interference is above the threshold, which results in contention and loss of all simultaneous packets on air. For this reason, CDMA is referred to as a power-limited system, limited by the total power of interference from other users, different from TDMA and FDMA, which are bandwidth-limited systems.

1.1.1.2 Cellular mobile communications

Progress in radio communications, multiple access schemes, and coding algorithms brought the means for the implementation of mobile communications for personal users. So, the new era of Personal Communication Services (PCS) has started. At the same time, progress in electronic design and manufacturing made it possible to put many of the developed communication algorithms on a small electronic chip. All these achievements paved the path for mobile communications. Popularity in the use of mobile communications for voice conversation and the enormous progress in very large-scale integrated (VLSI) circuit technology forced the price of mobile communications and devices to go down dramatically during a short period of time. Therefore, even radio and television were considered as the most attractive telecommunication services, and the mobile communications found a new record in attracting the first 50-million users in just 12 years.

In the PCS systems, the concept of cellular structure has been included in order to achieve higher spectral efficiency by reusing a same frequency band in a cell far enough from another one using the same frequency band. In a seven-cell frequency reuse pattern shown in Figure 1.2, for example, the total radio spectrum allocated to the cellular communication service is divided into a maximum of seven subbands. While neighboring cells use different subbands, the pairs of cells that are far enough could use a same-frequency subband, as shown in the figure. Each number shown in one cell in this figure means a separate frequency subband used in that cell. The current cellular mobile communications systems all use a similar concept as shown in the simple example of Figure 1.2.

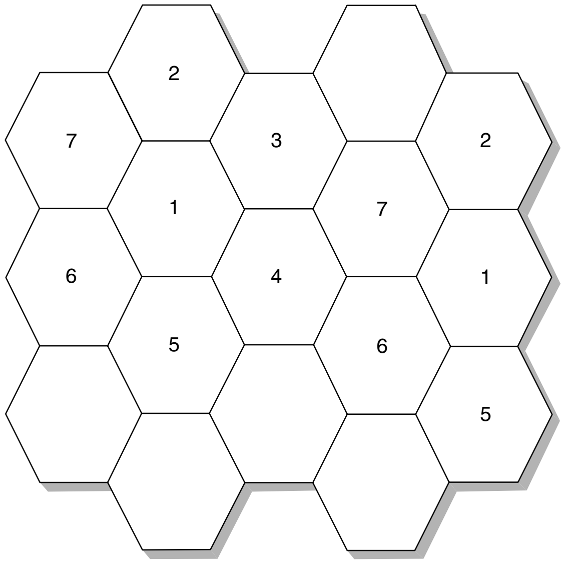

Figure 1.2 Basic concepts of cellular mobile communications and frequency reuse

The cellular concept discussed here can be used in FDMA systems, so the same sets of frequency bands can be used more than once in groups of cells far enough from one another. It can be used also in CDMA systems so that the multiple-access interference from users of adjacent cells is reduced, resulting in higher system capacity. It can be used in TDMA systems to provide a higher capacity system, accommodating more users, through combination of TDMA and FDMA techniques.

1.1.2 Internet: Fixed, wireless, and mobile

By that date, broadcasting using radio and television and voice communications using wired and mobile phones were considered as the complete set of services for the telecommunications industry. This was the case until personal computers (PCs) became available, replacing many traditional office and home equipments. Invention of hypertext transfer protocol (HTTP) and hypertext markup language (HTML) brought the Internet as the new media for telecommunications. PCs have been connected to each other and have started exchanging information data. Soon people found out that the computer and the Internet could replace many traditional means of communications that they knew until then, including the radio, the television, and even the telephone. The dramatic decrease in the price and the huge increase in the processing capability of personal computers made it possible that anyone could have a computer at home and then connect it to the Internet. The services provided by the computer and the Internet were so exciting that the Internet created a new record by attracting a 50-million market, that is, in just four years. Figure 1.3 illustrates the market achievement of the different telecommunication technologies discussed above.

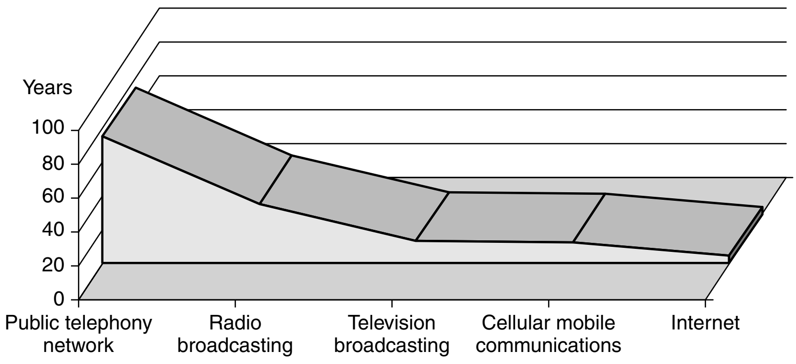

Figure 1.3 First 50-million users market period for telecommunications technologies

It seems that we achieved all that we could not even imagine just a few decades ago. We have good voice and video transmissions in our offices and on the road and can get any up-to-date information from the Internet with a click of a mouse. Then what is left? The answer is simple when we think about the progress in telecommunications. When voice communications could become mobile, why should the Internet access be restricted to geographically fixed locations. If the Internet plays an important role in our daily life, why should we not be able to use it whenever we want and wherever we want. So the mobile Internet is the next step (albeit a huge one as we will see soon) in the development of the telecommunications industry, and this book is all about it.

Mobile Internet in general is defined as an architecture in which a user can have access to the global Internet network and its usual services regardless of the current point of attachment to the network. Such definition implies that the mobile Internet is much broader than the wireless Internet. In wireless Internet, the user physical connection to the network is composed of wireless medium through RF channels. But mobile Internet provides access to the network through not only the radio channels but also through a wired network such as Ethernet and dial-up connections wherever available. An example of wireless Internet is the wireless local area network (LAN) in which an access point is the base station serving several mobile computing devices in an indoor environment and within a limited geographical area and connecting them through a wireless LAN server to a wired LAN and eventually to the global Internet. The mobile Internet however may include the wireless LAN as one of its several segments. A user in a mobile Internet network may be connected to the Internet through high-speed Ethernet access and at another moment may change his connection to a wireless LAN through a wireless LAN access card and then be connected to the cellular network through a cellular modem. Different from a nomadic user who has to disconnect from one network (for example, Ethernet) before connecting to another network (for example, wireless LAN or dial-up), a user in a mobile Internet network moves around, and his connection is changed seamlessly without any connection interrupt.

Realization of the mobile Internet is not as straightforward as what we have experienced in voice and telephony communications. There are many parameters in the way of such realization that could make it very challenging. In the case of voice communications, the problem was merely (at least in the beginning) to make a means of transmission of analog in nature signals using electromagnetic waves. As long as the communications can be established within a reasonable delay and the voice is recognizable, there would be no complaint from a subscriber using the mobile voice service. Short interruption or signal corruption in voice communications is acceptable to the human ear, and as long as the signal-to-noise ratio (SNR) of the received signal is above some flexible level, the signal can be regenerated at the receiver and delivered to the speaker. For the data communications such as the Internet, however, even very short interruption in data transferring could damage the whole data file and may be difficult to recover. Therefore, there is a need for more research and development until a reliable mobile Internet network is available. In this book, we will explain the requirements for realization of wireless and mobile Internet and detail current activities and progress in cellular wireless systems and similar telecommunication segments.

1.2 TRENDS TOWARD WIRELESS INTERNET

Before introducing technological requirements and worldwide activities for mobile and wireless Internet, in this section we try to explain why such a network is needed in the first place. The logical question that arises is "what are the evidences that a mobile Internet network is necessary as being part of the global telecommunications infrastructure" and must be answered before trying to solve the problem of how to realize it. The discussion given here, thus, more or less continues the introduction given in the previous section but with several statistical figures.

1.2.1 Access technology: Fixed and mobile

In order to understand the need for mobile and wireless Internet in the near future, it is wise to look at the trends in telecommunications in the past few years and how the industry has evolved from its first years in a comparably short period of time. The first significant trend that is visible in the telecommunications industry is the change from fixed access communications to mobile communications. It is not necessary to go back to the very old days to understand this trend. As shown in Figure 1.4, the increase in worldwide subscriber number for fixed telephone lines has been very smooth since 1996 at around 650 million and it would reach one billion by the year 2005 [21]. The graph illustrating this increase has shown signs of saturation or a very small increase after the year 2005. On the other hand, the increase in the number of mobile subscribers, shown on the same figure, is exponential with no sign of a stop or a slowing down of the increase rate. The figure illustrates a very natural and easily understandable phenomenon; that is, people want to have at most one or two fixed telephone lines at home used by the whole family but prefer to have one or two mobile phones for each member of family, for example, one for business and one for personal use. Continuous decrease in the cost of mobile handsets

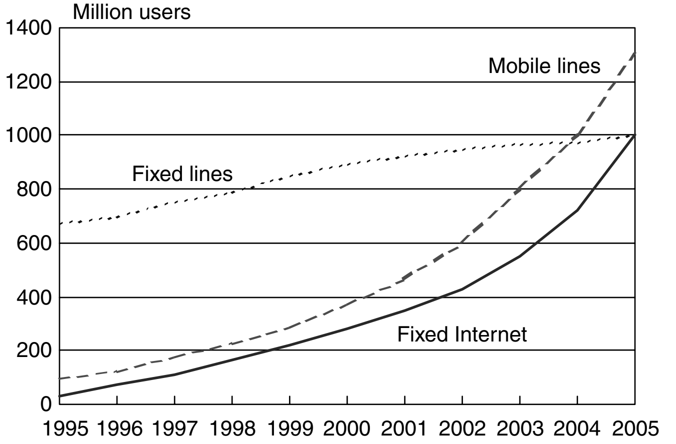

Figure 1.4 Increase in user population in fixed and mobile communication systems

and mobile usage charge tariffs is also accelerating this increase to an unknown future. Maybe the only slowing parameter in this trend would be the limited available spectrum in the future to be shared by billions of users.

The growth in the number of fixed Internet access is also shown for comparison [21,22] in Figure 1.4. As observed from this figure, Internet growth has a very similar pattern with the mobile cellular network market growth. Mobile Internet services, as we will see in Chapter 2, have been started in the second phase of the second-generation (2G) cellular networks, such as the General Packet Radio Service (GPRS) [23–25], the successor of the worldwide Global System for Mobile communications (GSM) cellular network [26]. If we add the number of users of such mobile Internet services with the fixed Internet figures, we will even see a sharper increase.

1.2.2 Increase in Internet usage

Although the Internet has been in place since the 1980s, its usage was limited to file transfer, remote access to computers, and simple mail transfer in the form of a file transfer until 1995. The Internet has started gaining popularity after the invention of HTML and HTTP, that is, the starting age of web browsing. Figure 1.5 shows the Internet growth usage over the last two decades. The web browsing has really revolutionized the Internet and is considered as the main factor in the popularity of the Internet. After invention of web browsers such as Netscape and Internet Explorer, and new email management programs that include browsing capabilities, ordinary people without a deep understanding of the computer could use PCs connected to the Internet in their daily lives, and thus a huge increase in the Internet subscription happened. The wireless Internet will be the next revolutionizing factor in the Internet usage growth, as it will provide freedom with respect to the user location and access to the Internet. In the near future, every mobile

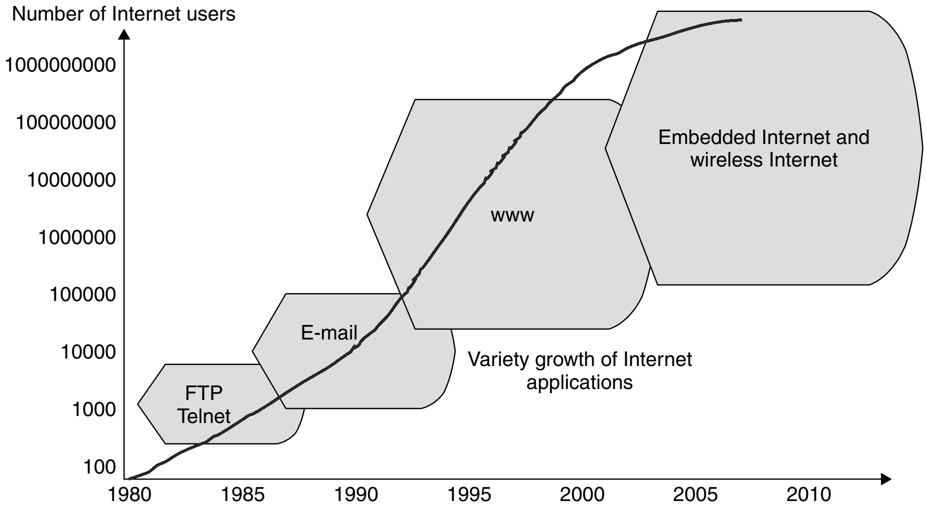

Figure 1.5 The exponential growth in the Internet usage

phone, refrigerator, air conditioning system, and other household appliances will have an Internet protocol (IP) address and will be connected to the Internet. The new usage of the Internet, called *embedded Internet*, will boost the usage of the Internet in fixed and mobile domains, generating billions of new virtual subscribers. Although the Internet started as a communication means for people, it will soon connect devices and connect people and devices. All these will require major enhancement in the Internet infrastructure and the new segments. Wireless Internet will play a major role in providing the access to these new users and devices.

1.2.3 Telecommunication services for everyone

Mobile cellular users are distributed very evenly in all parts of the world. Although this has happened for the voice communications, it would most probably be the case for mobile Internet and thus it shows that the scalability feature of the Internet will not be damaged when it becomes mobile. Figure 1.6 illustrates the worldwide mobile subscriber distribution since 1995 with an expectation for up to year 2010 [18]. The Asia Pacific region with China and other populated countries will have a major share in global mobile communications. The Internet usage is also considered to have similar distribution because of the number of people who live in this region, and thus many multinational companies consider China as the main market for future Internet. North American and European Union countries occupy the second major part of the mobile market, and other countries in Middle East and Africa show major growth for mobile usage. The figure shows a huge market in all parts of the world for the wireless Internet if a reliable and affordable network can be implemented.

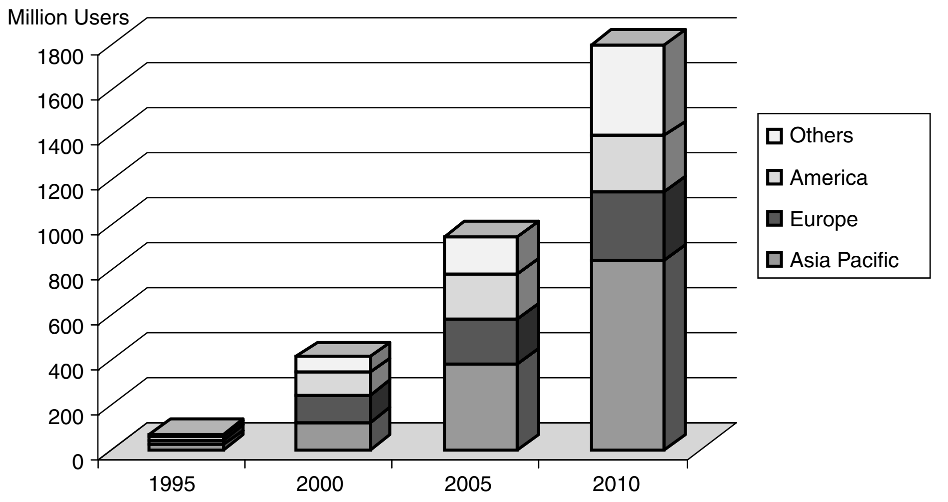

Figure 1.6 Distribution of the mobile communication subscribers around the world

1.2.4 Mobile cellular technologies coverage

Looking at the mobile cellular technology distribution worldwide, shown in Figure 1.7, we see a major part occupied by the GSM. (Cellular technologies will be explained in Chapters 3 and 4.) The advanced technologies used in the GSM network as well as the security and the portability provided by this system utilizing the subscriber identity module (SIM) made it one of the most successful mobile systems in the world compared to its counterparts in Japan and in the US. We will review these technologies later in the book, but here we want to emphasize the potential role of the GSM in future wireless mobile Internet. The successor of GSM, GPRS, has started some mobile Internet services, and 3G systems will use the GPRS as the core network. The future of mobile and wireless Internet thus will be very much related to the success of the GSM and its successor networks.

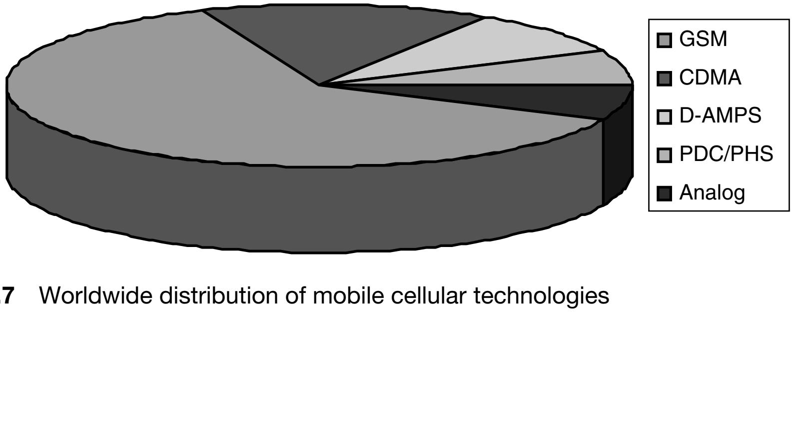

Figure 1.7 Worldwide distribution of mobile cellular technologies

1.2.5 Telecommunication traffic: voice, data, and multimedia

Figure 1.8 illustrates another trend in the telecommunications industry, that is, a service change from voice service to data service. The popularity of the Internet in recent years has been the main influence on this trend. On the one hand, the traffic load generated by the voice users had a very smooth and almost flat increase over the past few years. On the other hand, new multimedia and Internet applications, including email, web browsing, Internet telephony, and Internet videoconferencing, are pushing more data traffic into telecommunications networks in an exponential rate. In several developed countries in the world, the data traffic load has already taken over the voice traffic. In many situations, techniques such as voice over IP has made it possible to send voice information over the Internet, making the data and Internet traffic to increase even more rapidly. 500-million Internet subscribers are generating the major part of the traffic load of telecommunications networks. When the mobile Internet finds its role in the telecommunications network, this rate will increase even more rapidly. Current 2G systems such as GSM that provide short message service (SMS) have already shown huge data traffic generation from mobiles. It is expected that the 3-million mobile data users will increase to 77 million by the year 2005, that is, a 70% annual increase [21,22,27]. The traffic load on future communication networks will be composed of mainly data, and therefore new traffic management techniques are required to handle that traffic. We will discuss these important issues in realization of mobile and wireless Internet in the second part of this book.

1.2.6 Mobile internet traffic

The mobile Internet applications consist of not only those applications that have a mobile nature but also the traditional wired Internet applications. This makes another accelerative

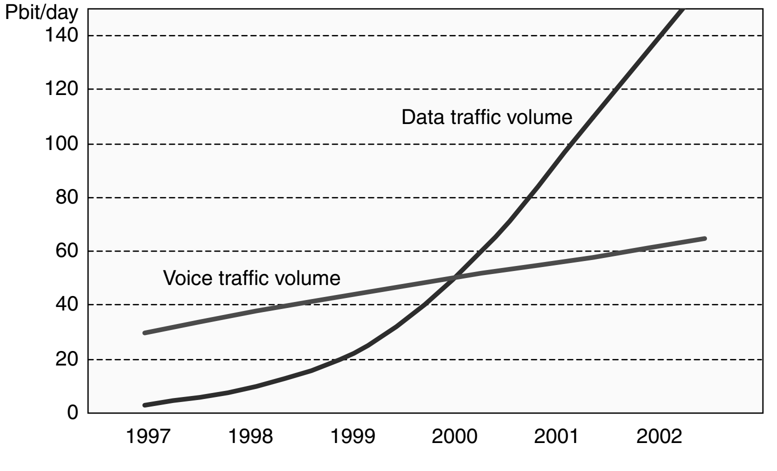

Figure 1.8 Changing the telecommunications network traffic from voice to data

factor in the wireless mobile Internet compared to its successor, the wired Internet. Mobile video and audio conferencing and navigation services are, for example, included in the wireless mobile Internet list of applications, which is already flooded with numerous applications that have migrated from the wired Internet network.

By the discussions and statistics provided previously in this section, it should be clear that the future of telecommunications networks will be very much dependent on the Internet, as the Internet will occupy the major capacity of the network. Data communications and, in particular, the Internet is the determining factor in future telecommunications networks, and the mobility provided by the wireless technology will be desired enormously. The mobile Internet will thus be the main topic before the researchers in the academia and the industry. Implementation of a mobile Internet network will not finalize these researches because the quality of service (QoS) for the telecommunications networks in general and for mobile Internet in particular need to be provided in future networks. We will discuss QoS and other important topics throughout this book.

1.3 WIRELESS INTERNET REQUIREMENTS

As we proceed through this book, each chapter discusses details of requirements and specifications of an efficient wireless mobile Internet network. In this section, we will go through a few general requirements of wireless Internet. Therefore, in this section we try to answer the question of ‘what would be an ideal wireless Internet and what aspects should be included in such an architecture?’

1.3.1 Extension of Internet with mobility features

Mobile and wireless Internet, as its name specifies, should provide a seamless transition from a geographically fixed domain into a mobile environment. By seamless transition, we mean that there should be no sensible change for a user who is connected to the Internet while moving from a fixed domain into a mobile domain. In a broad sense, this could be the case even when a user moves from a wireless network domain to another one. In technical terms, the Internet access for the user should be independent of the access technology used for the Internet services.

Let us simplify this definition by an easy example. Although the current computer operating systems (OS) and the Ethernet do not support more than one Internet access at any instant, imagine that your computer is connected to an Internet service provider (ISP) through a 100-Mbps 100-Base-T Ethernet [1] card of a wired LAN and an 11-Mbps IEEE802.11b wireless LAN [28–30] card simultaneously. The backbone network of both is assumed to be the same, for example, a bus LAN. Your imaginary (or ideal) OS is assumed to be capable of choosing between the two connections in accordance to the connection speed, for example. So when you are sitting in front of your desk in your office, your computer OS chooses the 100-Mbps Ethernet and ignores the alternative wireless LAN connection. Now you are going to a meeting. You unplug the 100-Base-T cable from your computer and then your computer OS switches all your Internet connections to the wireless LAN. Assume that while this physical movement is happening, you are in the middle of downloading a large file from an FTP (file transfer protocol) server. If the process of downloading is continued without any interruption and you really have not felt the change of speed between the two connections, we can say that your connection has seamlessly transferred from one access network to another. The main point of being seamless here, of course, is the fact that the FTP session has not been interrupted while you moved from one (wired) domain into another (wireless) domain. But if the change in the downloading bit rate is not sensible for the Internet user as a human being, then the process is even more seamless.

The example above should clarify the difference between a seamless mobile Internet system (that this book is all about) and a nomadic Internet. A nomadic Internet user in the previous example has to unplug the 100-Base-T cable, insert a wireless Internet card and reconnect to the Internet. If there was an ongoing FTP connection, for example, it has to be interrupted and restarted after changing to the new network connection. All data transferred before the network access interruption will be lost. Therefore, there is a clear difference between the two cases. We will not discuss the nomadic Internet in this book. The above example could be extended to the case that the Internet access is provided partly through cellular mobile networks.

1.3.2 Internet connection specifications and QoS

The example given in the previous section of one computer and two Internet accesses should clarify some of the changes required in the realization of the mobile Internet. We mentioned connection speed as the determining factor in choosing between available connections by the OS. Indeed, this is the case in any seamless transition from one access network to another. In a mobile Internet system, the user should not feel a dramatic change in the QoS for the application currently being used. The most humanly sensible quality measure is the connection speed or data bit rate, which is logically, followed by the delay requirements. We will discuss QoS parameters comprehensively in Chapter 5.

1.3.3 Change in Internet protocols

The simple example given above shows a major change in requirements for the protocols that govern the Internet. Change in protocols goes into all layers of the network protocol stack. Link layer (Layer 2) has to be modified in order to concurrently establish two or more connections via different access networks supported by the physical layer (Layer 1). This change in the link layer protocol has to be incorporated with the computer OS so that, for example, two Internet connections can be set up and maintained at the same time.

At the physical layer, mobile devices have to be equipped with multiple interfaces to different access networks (wired such as Ethernet cable and dial-up modem as well as wireless such as wireless LAN, infrared, and cellular modems). The physical layer has to include several interfaces to Layer 2 in order to manage the best connection to higher layers, and if one connection cannot provide the required quality to the application, a combination of two access networks can be granted.

At the network layer (Layer 3), IP needs major changes so that it can handle the routing and other tasks of the network layer in wired and wireless environments. Mobility of the Internet IP address should be accommodated into the future mobile Internet. Signaling requirement of the IP layer protocol has to be simplified to provide more spectrum efficiency in future wireless access network. IP addressing and global address translation between heterogeneous networks must be performed in protocol change at Layer 3.

The transport layer on top of the IP layer may be considered as the main part of the modification for future mobile Internet networks. The legacy design of this layer for wired networks avoids efficient use of the radio channel capacity and thus major modification and extensions are required at the transport layer with dominant transmission control protocol (TCP) and user datagram protocol (UDP). Chapter 9 will discuss these changes for IP and TCP protocols.

1.3.4 Authentication, authorization, and accounting

In a mobile Internet, the mobile user does not see any difference between the currently available service providers at a given time and location, and it is assumed that a user may access the Internet regardless of his point of attachment to the network and the supporting access and core networks. Therefore, a system for the authentication and the authorization of users when moving across different networks must be established.

Authentication provides the proof of identity of a user to the network that the user is going to access. This process is usually performed through an authentication function procedure. Authorization certifies what type of services may be provided to an authenticated user. Therefore, it is not sufficient that a user is in a capacity to connect to a network but the user has to be subscribed for a list of services that he is going to receive from the connecting network. Accounting, as the third A in the network AAA (authentication, authorization, and accounting), provides a history of what and when a user used a particular service while connected to a network.

In the existing communication networks, every service provider keeps a database for its users and their profiles in order to perform the related AAA procedure. In some situations, two or more service providers might share a common database or have access to their partner providers' databases so that some type of portability of users among these networks is possible. In the future mobile Internet, however, this database is required to become more globally available so that users can easily switch their access networks and still can get appropriate services from the Internet and be charged accordingly. Maintaining the database in an efficient way and with minimum conflicts among different service providers will be important issues that are to be resolved before a mobile Internet can be realized. Billing and charging users for the services they have used by appropriate operators are among issues involved in this process. The system must be designed also to prevent the release of personal information to unauthorized entities and the misuse of the services by users who are not subscribed to receive those services.

1.3.5 Resource management

Mobile Internet is going to stay among different telecommunication technologies and hence need to share the limited available resources. A sophisticated resource management thus would be vitally necessary to share these resources among all coexisting technologies. Resource management schemes such as bandwidth managements, admission control, congestion control, and so on will guarantee reliable performance of the network as well as a fair allocation of resources to all eligible users. We will address this issue in several occasions within the chapters of this book.

1.3.6 Changing the network architecture

The current network architectures used in either the wired Internet or the cellular networks would not be appropriate and efficient for future wireless mobile Internet, even if we assume that the cellular networks will provide the major infrastructure of the mobile Internet. In recent years, many literatures have discussed this issue and how it is possible to change the network architecture to be utilized for the mobile Internet [31–37]. One major issue is making the core network independent of the underlying access technology. In Chapter 4, we will discuss this issue in detail and provide some solutions from the industry as well as other related research communities.

The exponential increase in both the Internet and the wireless cellular domains is expected to produce a huge market for the wireless Internet as a technology that covers existing and new subscribers of both the technologies. This expectation is shown in Figure 1.9. By that

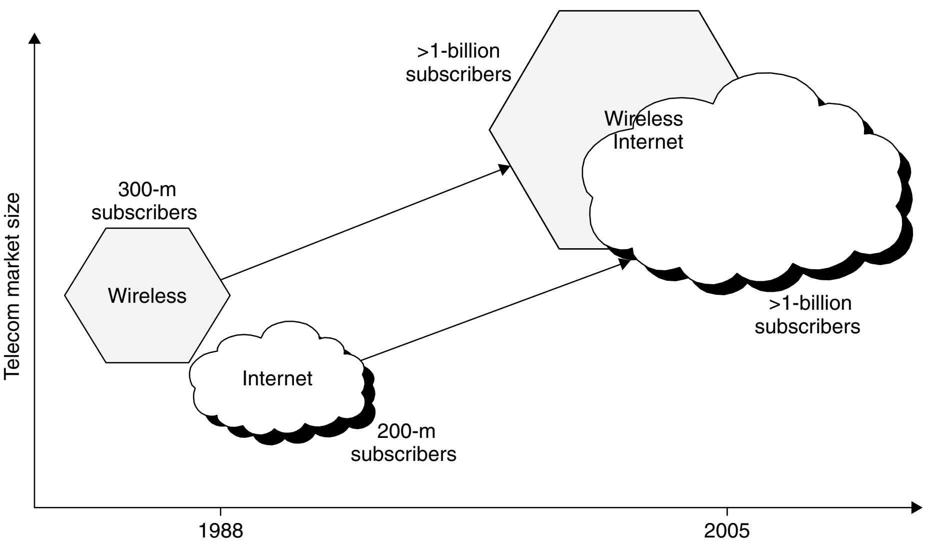

Figure 1.9 The wireless and Internet growths

time, the wireless should become an integrated part of the Internet and not just another access technology for it.

1.4 OUTLINE OF THE BOOK

This book is organized so that it could cover a broad range of audiences including senior-level undergraduate university students, postgraduate students, research engineers, system developers, and telecommunications managers. Different set of chapters of this book could be used as a text for different course levels, targeting the subject of wireless IPs. The first part, which includes Chapters 1 to 4 provides a comprehensive text to the definition of wireless Internet and its enabling access and core network technologies. The second part, consisting of six chapters, discusses basic requirements and issues toward the realization of wireless Internet. The last part, including three chapters, provides several advanced topics on wireless Internet and its generalization on a global basis. The book as a whole, therefore, can be used as a comprehensive text on the subject of wireless mobile Internet, its requirements and implementation, whereas its parts individually can be customized and used as the text for a more specialized course in the field.

Each chapter has a final section summarizing the main topics discussed in it followed by additional conclusions to those topics. A complete set of references cited within the text at the end of each chapter provides the reader access to the most relevant literature. A list of all abbreviations given throughout the book is provided at the end, which can help the reader in locating the meaning of numerous abbreviations used in related literature. To simplify customizing this book for different target audiences, a summary on each chapter is provided in this section.

In the first chapter some basic trends toward wireless Internet have been identified. These trends include ones within the telecommunications technology as principles and ones within the Internet applications. Several statistics have been provided to justify the need for wireless Internet implementation and related filed studies. A general understanding on the requirements of wireless Internet has also been included in this chapter.

Chapter 2 starts the discussion on practical wireless Internet architectures by reviewing the most promising solutions originally created over the second-generation wireless cellular systems and more recent systems such as Wireless Application Protocol (WAP) and Japan's i-mode. The discussions provided in this chapter could formulate the future wireless Internet architectures so as to avoid the drawbacks and the shortcomings of the predecessor systems. A summary of who is who in the standardization of telecommunications networks and the Internet has been included in the chapter to introduce appropriate locations that the reader needs to search for relevant information for wireless Internet.

In Chapter 3, a comprehensive review on the third-generation UMTS family has been provided after introducing its predecessor systems including GSM and GPRS. The UMTS will have a major role in the establishment of underlying technology for future wireless mobile Internet and hence such a review is considered as significant for the subject of this book.

Chapter 4 completes the discussion started in Chapter 3 on third-generation systems, by first looking at the cdma2000 system and giving a comparison of that system with the UMTS. A new trend toward harmonization of 3G systems has been followed and then the proposed functional layered network architecture for future wireless mobile Internet has been presented.

In Chapter 5, as the start of the second part of this book, the quality-of-service requirements and establishments in telecommunication systems and in particular for mobile networks has been presented. QoS progress in both Internet and cellular networks has been reviewed in this chapter. This chapter could be also considered as a self-complete literature on QoS for telecommunications networks.

Chapter 6 looks at the traffic nature in telecommunications data networks and future wireless Internet systems. Mathematical representations of several traffic models used in different telecommunications systems have been presented.

In Chapter 7, traffic management techniques have been discussed as a major contributor to the solution of the problem of limited telecommunication resources. In particular, admission control techniques have been described with numerous numerical result presentations.

Chapter 8 outlines the mobility characteristics in wireless networks. User mobility patterns and models have been discussed in detail. The problem of finding a user within a network in order to achieve an efficient network management, usually referred to as location management, has been detailed in this chapter together with a comprehensive discussion on paging schemes in mobile networks.

In Chapter 9, the selection of an appropriate transport protocol for future wireless Internet has been addressed. The traditional TCP has been reviewed first to give the reader some fundamental aspects in performance evaluation of the transport layer protocol. This discussion has been followed by up-to-date activities toward implementation of transport protocol over the error-prone wireless channel, detailed discussions on one of the modification techniques for transport protocol, and several numerical results and discussions.

Chapter 10 looks at the IP as the enabling function of the future wireless Internet systems. After describing the existing IP and its next-generation model, the issue on how the fixed-IP address allocation of the Internet needs to be modified to migrate into the wireless Internet has been discussed.

The third part of this book begins with Chapter 11, in which some Internet perspectives for the future wireless Internet have been outlined. The chapter discusses the initiatives from the cdma2000 core network for such wireless Internet realization.

Chapter 12 provides a concise but comprehensive discussion on wireless LANs, the mobile ad hoc networking using the wireless LAN, and future challenges within the mobile ad hoc networking, as partial implementation of the wireless Internet.

Discussions on advanced topics for wireless Internet have been finalized in Chapter 13, in which the globalization of mobile Internet has been addressed through the usage of satellites. The chapter starts with a comprehensive discussion on narrowband and broadband satellite systems, followed by the issues on the inclusion of the satellites as an important element in future wireless mobile Internet on a global basis for home and business users.

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