

CHAPTER

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Realizing the mobile information society

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10.1 Introduction

The growth in the penetration of mobile phones has been tremendous—so tremendous that to many people wireless communications equals mobile phones. Soon, practically every person in developed countries will have a mobile phone—from school children to elderly people. Voice has gone wireless. Given this ubiquity, what can be new be in wireless communications? The next 20 years could be divided into three phases:

1. *Phase 1:* Voice increasingly becomes wireless, 2000–2005;
2. *Phase 2:* Development of mobile information society,¹ 2006–2010;

1. The term “information society” has been much used. Here we mean the capability of users to access any information that they want (within reason) wherever they are. This capability will likely lead to social changes, such as increased home working, and hence the term “information society.”

3. *Phase 3*: Full realization of the mobile information society, 2010–2020.

During the first phase, mobile penetration reaches its final peak, which is approximately 100% in the most developed countries.² The mobile phone has truly become the preferred phone, and the number of mobile users has exceeded the number of fixed phone users.

In the second phase, wireless data services will emerge in the mass market. Mobile users will be able to access all types of information whenever they want, wherever they want. Today's primitive and little-used data services such as wireless application protocol (WAP), iMode, and location-based services become widely used. Mobile devices in all types of form factors emerge as the primary means to access the Internet, and totally new services for mobile users are introduced.

In the third phase, seamless interaction with humans and machines through wireless devices using voice, sight, and touch will become reality. Integrated mobile devices will communicate our feelings and thoughts to other people or receive information about our environment, wherever we happen to be. Today's separate communication networks will evolve into one single, distributed network spanning the whole globe and offering the same type of service set regardless of the air interface used.

One of the key drivers for future development is the need for growth among the operators and manufacturers in the wireless industry. Wireless data is required to maintain growth of revenue for mobile operators. The growth of voice-only services will continue with saturating penetration figures once nearly everyone owns a mobile phone. The new business opportunities offered by the mobile Internet are currently driving the investments and new business innovations that will lead to the developments of the future.

10.1.1 Requirements for future communications systems

In this section, we explore the requirements for future wireless communications. This will be examined from three angles: user behavior, services, and user devices.

2. This had already occurred, for example, in Finland during 2000.

10.1.2 User behavior

Mobile phones have freed the user from physical location to make calls. This is reflected in the very natural way that humans prefer to communicate with each other regardless of the place where they happen to be at a specific moment. Voice is only one type of communications. Vision is another, and it is already emerging in wireless communications through picture messaging.

Other natural needs for humans are the need to organize things and the need to have fun. Things that make this possible to carry out anywhere have latent demand. How many times have you wished to do something useful or entertaining while waiting in line, sitting in a taxi, or commuting in a train or bus?

A newborn baby has zero tolerance and requires immediate attention and fulfillment of his needs. Although adults are more sophisticated in behavior, instant gratification is a fundamental desire for all people (i.e., all information that one wants should be delivered immediately). When you hear about the latest music hit from your friend, you would like to download it immediately to your own terminal without waiting several minutes—and how many times have you felt frustrated trying to download your e-mail while on the road? With all the attached information it takes too long.

Hence, the answer to the question of how much bandwidth is required in the end-user terminal can be derived from the user's behavior. The need for instant gratification and zero tolerance means the answer is "as much as can be delivered." For example, a user browsing a travel agent's Web pages wants the three-dimensional picture of a sunny beach delivered immediately, not after 10 seconds. It is more difficult to solve what makes economic sense.

10.1.3 Services

Describing and predicting future services is very difficult. Assume that five years ago a market study was conducted where people were asked if they would like to send text messages of up to 160 characters through their fixed phones. Most likely, nobody would have liked this type of service. SMS, however, currently accounts for approximately 10% of some operators' revenue.

Future wireless communications offers wide variety of services including the following:

- ▶ Conversational, interactive services (voice and video);
- ▶ Location-based services;
- ▶ Games and entertainment;
- ▶ Messaging services;
- ▶ Mobile Internet.

Even though voice is already now a saturated service in many markets, there might be new developments that will further accelerate the migration from fixed to mobile networks. Wideband codecs using double the sampling rate of normal voice codecs are currently in the standardization process. This means that instead of normal 3.6-kHz voice band used in all fixed networks and in mobile networks, a 7.2-kHz sampling rate is used. These codecs will deliver clearer sound than traditional codecs, and therefore could bring the voice quality of mobile networks to above that of fixed networks.

Wireless video is one of the most touted new services for third-generation mobile systems. It should be remembered, however, that the video phone was first introduced in 1927 by AT&T and has often since been predicted as the next major commercial success. In the mobile world, it might finally succeed since it fulfills one of the basic needs of human beings, to express feelings using all senses. Not only can you deliver your own picture, which might not be the most interesting part, but also the picture of your environment, perhaps a nice beach while on holiday or a repairman sending an image of a machine that he is working on to the service center for further instructions.

Location-based services make use of the location of the mobile terminal. For example, your mobile terminal can locate where you are and then deliver information that is relevant to your current location such as a local map or restaurants in the neighborhood.

Games and entertainment will most likely account for the majority of future wireless services as they do in the fixed Internet. The personal nature of the mobile phone and the fact that people usually carry it with them makes it ideal to deliver entertainment services. The first network games for mobile users are already emerging.

SMS has been widely successful in some markets, for example, in Scandinavia. Applications of SMS include delivery of different types of information such as weather and stocks. It is also possible to buy a can

of Coke by dialing a certain number or sending a short message from your mobile to a given number. You can also pay for a car wash using your mobile phone. This is a simple but very tangible example of mobile commerce (m-commerce)—a new way of purchasing. Picture messaging and multimedia messaging are the next steps in the messaging services.

The mobile Internet enables access to information regardless of location. This is an advantage that should be the basis for service development because those services that are driven by the development of wireline networks face the problem of bandwidth in the wireless networks. In the fixed network, for example, DSL technology has been a significant breakthrough in recent years, and, consequently, broadband access to the Internet has become a reality for those consumers able to receive it and willing to pay the premium often charged. This has enabled, for example, high-resolution, three-dimensional graphics to be delivered into the home. Mobile Internet will face problems in trying to match the wireline data rates and service level. Therefore, the unique advantage of location information should be utilized.

10.1.4 User devices

Today, we have primarily one type of form factor for mobile devices. Moreover, mobile phones have been referred to as clumsy devices to access the Internet. Small, black and white screens and tiny keyboards have made it difficult to implement really fancy applications.

This picture will change dramatically in the future. Miniaturization of the core components such as chips and radio frequency parts will enable these to be built into almost any form factors, as opposed to the current situation where the form factor is somewhat limited by the need to package all the components that comprise a cell phone. Already, wristwatch mobile phones are a reality. High-resolution color displays that can even show a movie will become a reality in the near future. Looking forward to the next 20 years, it is not hard to imagine that there will be 3-D displays in mobile devices.

Completely new types of user devices and user interfaces will emerge in the form of wearable computers. For example, the screen will be integrated into eyeglasses and user commands entered using a voice recognition system. It will become possible to create virtual reality around the user and through this communicate with other users as if they were present. There will be many attempts to find the right form factor for different types of terminals such as videophones, Internet access devices, and wireless game consoles. In particular, the next few years when

third-generation networks and wireless data will emerge will be a very fruitful time for all kind of trials with new types of form factors. After the trial-and-error period, however, for each device category, a de facto standard will emerge, as has happened for almost all consumer electronic devices.

Currently, we carry a number of various devices for different purposes with us: for example, a mobile phone, a digital camera, an MP3 player, and an electronic calendar. The convergence of devices, however, is changing all this. In the future, our personal trusted device will contain elements from all of these devices enabling faster, more effective, and easier ways of doing business.

So far, computational power in the mobile phones has been limited. This might be a problem for applications such as games. In the near term, a solution could be to locate computational power in the network and only the results are delivered to the mobile device. In the longer term, more efficient computers will emerge and could solve the problem. For example, quantum computers with computing power of thousands of times more than today's fastest computers could be reality within the next 20 years.

10.2 Air interface development

The need for more bandwidth and the cost pressures calling for higher spectrum efficiency drives the development of new air interface technologies. The higher the throughput in the network, the better from the end user's perspective. On the other hand, the spectrum efficiency determines how efficiently the bandwidth can be delivered to the end user and is of primary concern for the mobile operator.

To increase the throughput, existing air interfaces will be stretched as far as is technically and economically possible. Figure 10.1 depicts this development. Common features for all of these developments are the evolution of the standard using a change of modulation technique. Limiting factors have been receiver complexity and transmitter linearity requirements. Mobile systems have three standard carrier bandwidths: 200 kHz, 1.25 MHz, and 5 MHz, using time division multiple access (TDMA) and code division multiple access (CDMA) techniques.

The US-TDMA system, also known as digital advanced mobile phone system (DAMPS) and interim standard (IS) IS-136, first evolved within a 30-kHz carrier bandwidth using multislot and higher order modulation

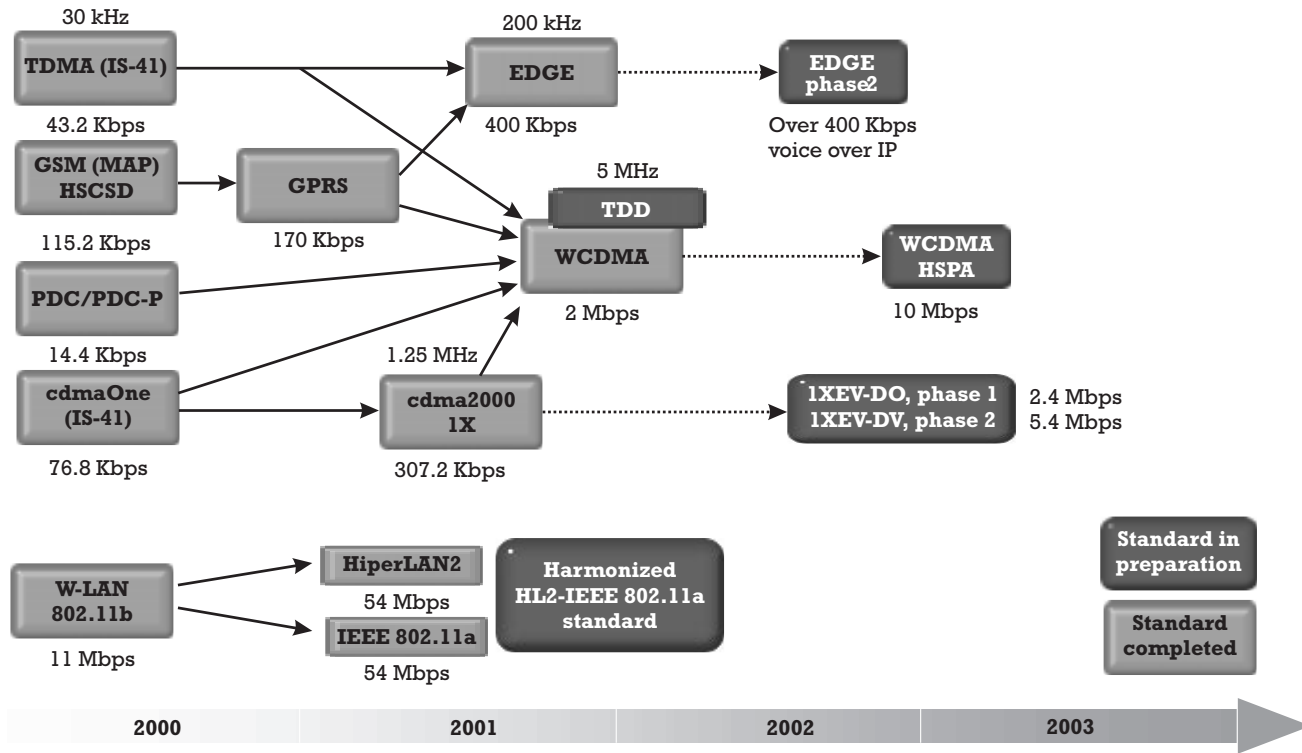


Figure 10.1 Evolution of mobile radio standards.

(8-PSK—phase shift keying) techniques. After the evolution of the 30-kHz channel became too difficult, the US-TDMA community selected EDGE as its future air interface evolution. GSM also used multislot techniques [high-speed, circuit-switched data (HSCSD) and general packet radio service (GPRS)] and higher order modulation (8-PSK, EDGE) to evolve the 200-kHz carrier. The next step could be multicarrier EDGE.

The main third-generation standard is wideband CDMA, commonly known as WCDMA. WCDMA high-speed packet access (HSPA), intended to be used in the downlink, uses higher order modulation to increase the maximum data rate from 2 Mbps to 10 Mbps. WCDMA time division duplex (TDD) will be used in the so-called unpaired frequency bands allocated to third-generation networks.

The IS-95A standard, also known as cdmaOne, evolved into IS-95B, which uses parallel CDMA codes to create high-speed data services. The next step in the IS-95 evolution is cdma2000 1X (1X means that the carrier bandwidth is the same as in the IS-95 standard, namely, 1.25 MHz), which adds coherent detection into the uplink in order to increase radio performance and higher data rates. 1X-EV (evolution), in addition to parallel CDMA codes, uses higher order modulation techniques to further increase the maximum data rates to 5 Mbps.

Among the various W-LAN proposals, the IEEE 802.11b standard, originally providing 2-Mbps and now 11-Mbps data rate, has emerged as the mainstream standard in the 2.4-GHz frequency band. It is evolving further to support even higher data rates up to approximately 20 Mbps. In the 5-GHz frequency band, IEEE 802.11a and HiperLAN2 standards provide a maximum data rate of 54 Mbps, and this will be pushed higher.

Bluetooth provides short-range wireless connectivity and can be positioned as a cable replacement. It will be used to connect different devices into the mobile phone. There are also studies that investigate the possibility to use Bluetooth as a public access method. The next-generation Bluetooth, which is currently under development, will provide higher data rates than the existing 700 Kbps.

In addition to the above-mentioned mainstream techniques, there is a large number of different types of air interface proposals and products that are variations from the above-mentioned schemes, as well as new types of air interfaces. One very interesting new scheme is ultra-wide band (UWB), also called impulse radio, which sends very short impulses and thus spreads the information over a very large bandwidth on the order of several hundreds of megahertz up to few gigahertz. It has

been proposed that UWB systems could be overlaid with current radio systems.

At the dawn of deployment of the third-generation networks, the research community has started to discuss fourth-generation networks. Key targets are:

- ▶ Higher data rates without compromising cell range (i.e., coverage);
- ▶ Increased spectrum efficiency.

It is questionable, however, whether a new air interface would be required to achieve these targets. For example, the WCDMA air interface can be stretched toward this goal with new innovations.

Radio is only about 100 years old. At the time of its invention, who could have predicted that a major part of mankind would use it by 2000? Given the accelerated technology and innovation cycle, we predict that totally new technology for communications, not the evolution of the current radio technology, will be invented within the next 20 years.

10.3 Network development

Cost and flexibility are drivers for transition of current circuit-switched mobile networks into packet-switched, IP-based networks. Until today, there have been separate networks for voice and data; digital convergence, however, will create only one IP-based network to provide all these services. This development will bring IP, and the end-to-end philosophy and modularity, into the telecommunications world. The new generation of IP protocol, IPv6, will be essential in implementing the next-generation mobile networks. IPv6 provides huge IP address space, excellent scalability, and integrated security support. The challenge in developing the IP-based networks is how to bring the telecommunications-like functionality (for example, reliability) into the IP world.

The ultimate goal is to be able connect all the types of radio access networks, both WANs such as EDGE and WCDMA and LANs such as Bluetooth and W-LAN, into a common all-IP network. Scalability of the network solution is essential to implement this goal.

How many times have you thought, "If I only had performed backup of my essential information in time," after having lost hours of work

while working with a personal computer? Similar problems will start to emerge in mobile devices when they are transformed into personal trusted devices. Digital convergence will put more and more functions into the mobile device. What happens if your mobile terminal gets lost or it breaks down? The key, of course, is to have a synchronized version of your information stored in another place. Also, the fact that there will be lots of information in your device that might be useful for other people makes it important to have it up to date. Current synchronization schemes are manual and require specific action from the user. Synchronization of user information should not require user attention but should be automatic. Technologies to do this will emerge in the near future. This will also create lots of machine-to-machine communications in the network in the form of exchange of information between different databases.

With the Internet model everything becomes addressable, and a user's information can be located in different places in the network. Therefore, the importance of security will increase dramatically. Guaranteeing that your own information remains private and inaccessible to other users without your permission will be critical. Without solving the security problem, the development of mobile information society will be much slower than predicted.

10.4 Future scenarios

We predict that the future of wireless communications will be centered around one of the following two scenarios:

- Cellular dominance with further evolution;
- A distributed network paradigm.

In the first scenario the traditional cellular paradigm dominates. Networks will be built starting from wide area coverage, and maximizing bit rates and coverage at the same time is desired. Transition from second-generation to third-generation networks (from GSM, US-TDMA, and EDGE to WCDMA) will happen within 10 years from the launch of 3G networks. Drivers for this transition will be better service capabilities and spectrum efficiency. Second-generation networks, however, will

still have a significant number of cellular subscribers by 2010. Complementing technologies such as W-LANs will be integrated into cellular networks. A seamless service offering is driving this scenario.

In the second scenario new technologies such as W-LANs, wireless mesh networks, ultrawide-band radio, or some new radio technology emerge as separate networks and obtain mass-market scale. Some new service tailored for these new networks might drive this scenario. Initially, networks will emerge as islands of coverage. Imagine that each electronic device could be a wireless router connecting it into surrounding nodes. Wireless devices can connect into these routers. Gradually, the density of the network will increase and roaming capabilities will emerge. Understanding how to make a worldwide network based on this concept and be able to provide adequate quality of service remains a key challenge. The demand for high bandwidth could drive this second scenario. Traditionally built, hierarchical networks could ultimately be too limited to support huge bandwidth requirements in all the places that users want them. A more distributed network structure is required.

The book *The Innovator's Dilemma* [1] describes the development of mills, mainframe computers, and cranes. In all cases, a distributed, smaller architecture took over the earlier paradigm of centralized, "the bigger, the better" architecture. This would support the latter distributed network architecture paradigm.

10.5 Concluding remarks

In this chapter we have explored the future of wireless communications. Human nature, characterized by zero tolerance and the need for instant gratification, is driving the development of wireless communication systems to add more functionality and higher bit rates. User devices will enable communications using more senses: hearing, vision, and perhaps touch. New services, not possible to predict today, will emerge, encouraged by open platforms provided by IP-based networks. Air interface development will be based on the evolution of currently known waveform structures. Future network architectures will be centered on two scenarios: hierarchical versus distributed, where the distributed architecture will emerge as the dominant one. Finally, as the most exciting vision, within the next 20 years a new technology for communications, not based on currently known radio, will emerge. This is something that

is as impossible to imagine today as the current use of mobile phones was 100 years ago.

Reference

- [1] Christensen, C. M., *The Innovator's Dilemma*, Cambridge, MA: Harvard Business School Press, 1997.