Chapter 1

Wireless Communications Overview

1.1 Introduction

The great success of mobile cellular communication systems is probably one of the most celebrated events in the history of the telecommunication industry over the past 100 years. The convenience of mobile cellular telephony has finally made a dream come true: people can get in touch with anyone else on earth at any time and at any place. In fact, it is hard to imagine the outcome if all mobile cellular services around us disappeared.

Wireless communications have under gone rapid development since the 1970s, gives the user the freedom of mobility, and in recent years, various wireless technologies have gained popularity. This is attributable to the growth and sophistication of supporting new technologies, one of the major reasons for the continuous growth in the use of wireless communication is its increasing ability to provide efficient communication links to almost any location, at constantly reducing costs with increasing power efficiency.

At the same time, the data transmission rate through a wireless air-link has increased tremendously, from 9.6 kbps in 1995 (on, Global System Mobile, GSM) to 2 Mbps in 2005 (on Wideband Code Division Multiple Access, WCDMA, system), increasing by more than 200 times within the last 10 years. Inevitably, the growth in wireless communication has seen the development of many competing technologies, and this has led to the continuous birth, as well as near-extinction of different wireless standards.

1.2 Wireless Communication Growth

Mobile cellular systems have been developed over four key generations as shown in Fig.1.1. First generation, 1G, systems comprise voice-oriented analog cellular and cordless telephones. Second generation , 2G, voice-oriented wireless systems comprise digital cellular and PCS systems and data-oriented wireless wide- and local-area networks as well. The number of mobile phones exceeds the number of landline phones and the mobile phone penetration is approaching 100% in several markets.

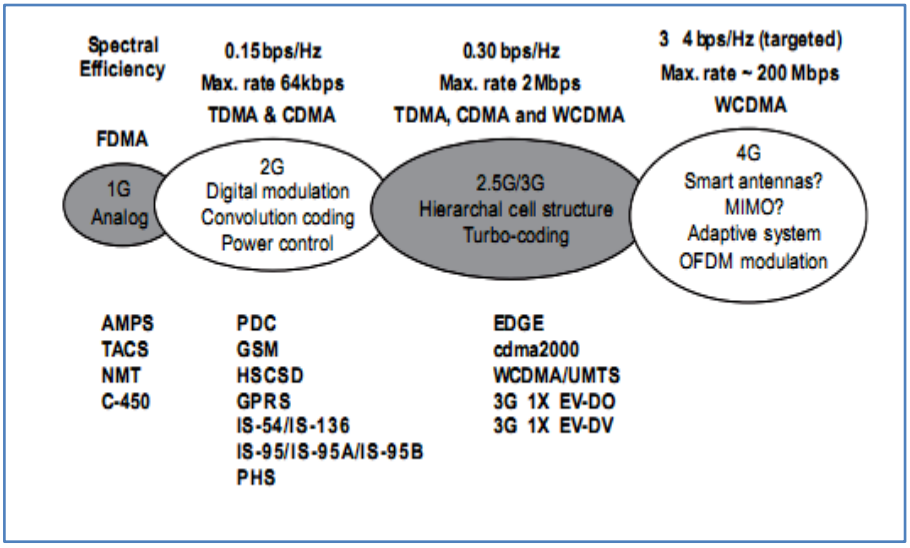

Fig.1.1 Wireless network from 1G to 4G [1,10].

The data-handling capabilities of second-generation systems are limited. Third-generation (3G) wireless networks designed to increase voice capacity and provide high speed data over 2G. Fourth generation (4G) mobile systems are intended to promote digital mobile multimedia (voice, streaming video, and data) services with data rates of up to 20Mbps or more. 4G systems will have broader bandwidth and higher data rate.

1.2.1 The first generation (1G cellular system)

The services of the first generation (1G) systems began when analog technology-based mobile telephony was first introduced in Chicago City in the 1979s. This 1G analogue mobile cellular system in the United States is also called Advanced Mobile Phone System (AMPS) system, which operated in 800 MHz and used 30 kHz bandwidth under the frequency division multiple access (FDMA) scheme. During the early 1980s, several incompatible cellular systems (TACS, NMT, C450, etc.) were introduced in Western Europe.

All of the 1G cellular systems used analog frequency modulation (FM), for which the transmission power requirement depends on the transmission bandwidth. On the other hand, power is also related to signal coverage and to the size of mobile radios. So, one can compensate for the reduction in transmission bandwidth per user by reducing the size of a cell in a cellular network. Reduction in cell size increases the number of cells and the cost of installation of the infrastructure [1].

The common characteristic features for all 1G systems around the world can be summarized as follows.

- They operated in the FDMA scheme, in which all voice channels are separated by different frequency carriers with a relatively narrow bandwidth (usually about 30–50 kHz).
- They were based on analogue transmission and processing technologies.
- Each system only covered a country or a relatively small region.
- The capacity of all those 1G mobile cellular systems was small due to their low bandwidth efficiency.

1.2.2 The second generation (digital cellular systems)

The characteristic features of the 1G mobile cellular system have motivated the research and development of the second generation (2G) mobile cellular standards, mainly initiated by two different groups, one in the United States and the other in Europe.

The 2G systems proposed by the United States took two different approaches, one leading to a new Time Division Multiple Access (TDMA) based technology, digital AMPS (D-AMPS) standard (the IS-54B and its enhanced version, IS-136 standard); and the other using the Code Division Multiple Access (CDMA) technology, the IS-95 standard .

At almost the same time, Europe proposed a pan-European 2G mobile phone standard; Group Special Mobile which was later called Global System for Mobile Communications (GSM), the GSM system uses TDMA technology and can operate in three different bands (800 MHz, 900 MHz and 1.8 GHz) around the world. The very different marketing approaches used by Europe have made the GSM system the single most popular digital mobile cellular system in the world today.

GSM is moving forward to develop cutting-edge, customer-focused solutions to meet the challenges of the 21st century and 3G mobile services. When GSM was first designed, no one could have predicted the dramatic growth of the Internet and the rising demand for multimedia services. These developments have brought about new challenges to the world of GSM.

For GSM operators, the emphasis is now rapidly changing from that of instigating and driving the development of technology to fundamentally enable mobile data transmission to that of improving speed, quality, simplicity, coverage, and reliability in terms of tools and services that will boost mass market take-up. New technology that is more advanced than 2G, but which does not meet the requirements for 3G. (2.5G) technology is added to a 2G network to

provide packet data service and data rates that range from 20 to 40 Kbps. In practice, 2.5G is synonymous with the GPRS (General Packet Radio System) networks.

1.2.3 2.5G Cellular Mobile Networks

A serious limitation of the 2G cellular systems is that data can only be transferred once a connection has been set up. This is not efficient whenever a user wants to transmit just a small amount of data or data is transmitted in bursts. The so-called 2.5G cellular systems allow a cellular handset to be always "connected." It means that at any moment it is possible to send and receive a packet data. In this way, the user does not incur in the cost of establishing a connection for sending/receiving small amounts of data. This allows efficient transfer of small amounts of data, without the overhead of establishing a connection for each transfer. Currently, there are two major 2.5G enhancements to second generation cellular systems: GPRS and EDGE [2].

1.2.3.1 General Packet Radio Service

GPRS is the first implementation of packet switching within GSM, that is, it only utilizes the network whenever there is data to be sent. It will complement existing services based on circuit switching and the SMS. The upgrade of a GSM network to GPRS will allow a GSM operator to eventually migrate to a third-generation network, as universal mobile telecommunications system (UMTS) is based on packet switching.

In GPRS, users can send and receive data at speeds up to 115 kbps. The deployment of GPRS networks provides several advantages to GSM network operators. It allows integrating the IP (Internet Protocol) protocol to the GSM network, and, consequently, the TCP/IP protocol suite. Furthermore, GPRS is efficient in its use

of the spectrum and allows GSM operators to offer new data services, mainly those based on data communication such as e-mail, Web access, and similar applications using mobile handheld devices and laptop computers. In practice, GPRS enables the connection to different public and private data networks. Service and application development and deployment should be easier to make since the faster data rate means that a middleware needed to adapt applications to the slower speed of wireless systems will be no longer needed [2].

1.2.3.2 Enhanced Data Rates for GSM Evolution

As its name suggests, EDGE is a faster version of GSM networks designed to provide data rates of up to 384 kbps. The goal is to enable and deliver multimedia and other broadband applications to cellular phones and mobile handheld devices. The EDGE standard reuses the carrier bandwidth and time slot structure of GSM, but it is not limited to be used in GSM cellular systems only. In fact, EDGE provides a generic air interface for higher data rates [2].

EDGE enhances data service performance over GPRS in two ways. First, it replaces the GMSK radio link modulation used in GSM with an 8-PSK modulation scheme capable of tripling the data rate on a single radio channel. Second, EDGE provides more reliable transmission of data using a link adaption technique, which dynamically chooses a modulation and coding scheme (MCS) in accordance with the current transmission conditions on the radio channel. The EDGE link adaptation mechanism is an enhanced version of the link adaptation mechanism used in GPRS.

1.2.3 Third generation mobile communication systems

Third generation wireless systems, or simply 3G, are a generic term used for a new generation of mobile communications systems