An Overview of Wireless Systems

Introduction :

The cellular system employs a different design approach than most commercial radio and television systems use [1,2]. Radio and television systems typically operate at maximum power and with the tallest antennas allowed by the regulatory agency of the country. In the cellular system, the service area is divided into cells. A transmitter is designed to serve an individual cell. The system seeks to make effi cient use of available channels by using low-power transmitters to allow frequency reuse at much smaller distances. Maximizing the number of times each channel can be reused in a given geographic area is the key to an effi cient cellular system design. During the past three decades, the world has seen signifi cant changes in the telecommunications industry. There have been some remarkable aspects to the rapid growth in wireless communications, as seen by the large expansion in mobile systems. Wireless systems consist of wireless wide-area networks (WWAN) [i.e., cellular systems], wireless local area networks (WLAN) [4], and wireless personal area networks (WPAN) (see Figure 1.1) [17]. The handsets used in all of these systems possess complex functionality, yet they have become small, lowpower consuming devices that are mass produced at a low cost, which has in turn accelerated their widespread use. The recent advancements in Internet technology have increased network traffi c considerably, resulting in a rapid growth of data rates. This phenomenon has also had an impact on mobile systems, resulting in the extraordinary growth of the mobile Internet.

Wireless data offerings are now evolving to suit consumers due to the simple reason that the Internet has become an everyday tool and users demand data mobility. Currently, wireless data represents about 15 to 20% of all air time. While success has been concentrated in vertical markets such as public safety, health care, and transportation, the horizontal market (i.e., consumers) for wireless data is growing. In 2005, more than 20 million people were using wireless e-mail. The Internet has changed user expectations of what data access means. The ability to retrieve information via the Internet has been “an amplifi er of demand” for wireless data applications. More than three-fourths of Internet users are also wireless users and a mobile subscriber is four times more likely to use the Internet than a nonsubscriber to mobile services. Such keen interest in both industries is prompting user demand for converged services. With more than a billion Internet users expected by 2008, the potential market for Internet-related wireless data services is quite large. In this chapter, we discuss briefl y 1G, 2G, 2.5G, and 3G cellular systems and outline the ongoing standard activities in Europe, North America, and Japan. We also introduce broadband (4G) systems (see Figure 1.2) aimed on integrating WWAN, WLAN, and WPAN. Details of WWAN, WLAN, and WPAN are given in Chapters 15 to 20.

First- and Second-Generation Cellular Systems

The fi rst- and second-generation cellular systems are the WWAN. The fi rst public cellular telephone system (fi rst-generation, 1G), called Advanced Mobile Phone System (AMPS) [8,21], was introduced in 1979 in the United States. During the early 1980s, several incompatible cellular systems (TACS, NMT, C450, etc.) were introduced in Western Europe. The deployment of these incompatible systems resulted in mobile phones being designed for one system that could not be used with another system, and roaming between the many countries of Europe was not possible. The fi rst-generation systems were designed for voice applications. Analog frequency modulation (FM) technology was used for radio transmission.

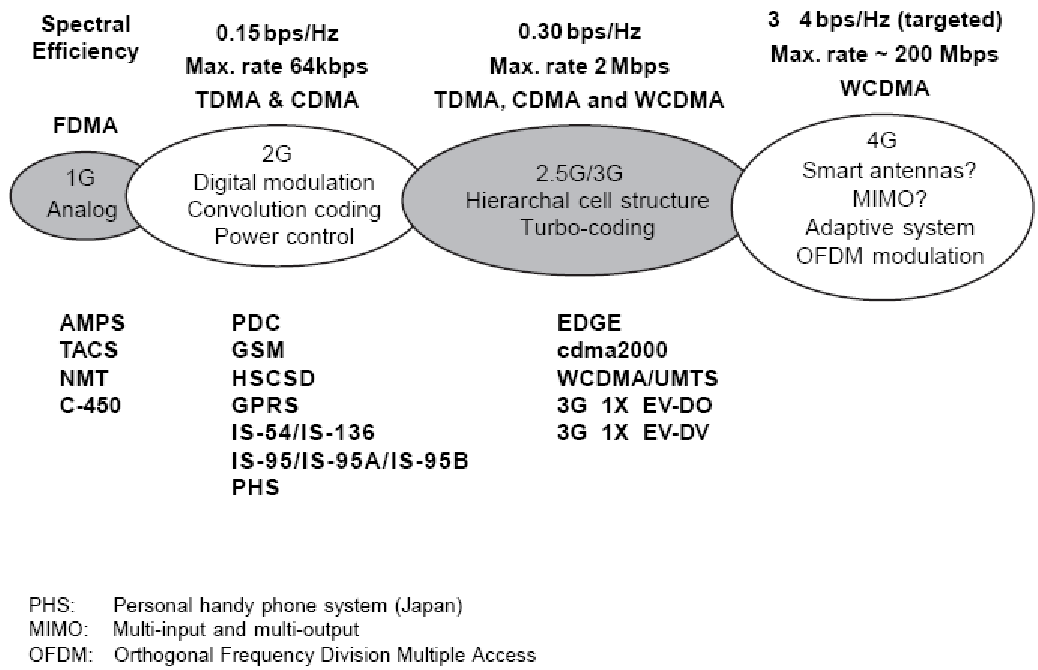

Figure 1.2 Wireless network from 1G to 4G.

The GSM (renamed Global System for Mobile communications) initiative gave the European mobile communications industry a home market of about 300 million subscribers, but at the same time provided it with a signifi cant technical challenge. The early years of the GSM were devoted mainly to the selection of radio technologies for the air interface. In 1986, fi eld trials of different candidate systems proposed for the GSM air interface were conducted in Paris. A set of criteria ranked in the order of importance was established to assess these candidates

Two digital technologies, Time Division Multiple Access (TDMA) and Code Division Multiple Access (CDMA) (see Chapter 6 for details) [10] emerged as clear choices for the newer PCS systems. TDMA is a narrowband technology in which communication channels on a carrier frequency are apportioned by time slots. For TDMA technology, there are three prevalent 2G systems: North America TIA/ EIA/IS-136, Japanese Personal Digital Cellular (PDC), and European Telecommunications Standards Institute (ETSI) Digital Cellular System 1800 (GSM 1800), a derivative of GSM. Another 2G system based on CDMA (TIA/EIA/IS-95) is a direct sequence (DS) spread spectrum (SS) system in which the entire bandwidth of the carrier channel is made available to each user simultaneously (see Chapter 11 for details). The bandwidth is many times larger than the bandwidth required to transmit the basic information. CDMA systems are limited by interference produced by the signals of other users transmitting within the same bandwidth 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 fi rst 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.

Traffic Usage:

A traffi c path is a communication channel, time slot, frequency band, line, trunk, switch, or circuit over which individual communications take place in sequence. Traffi c usage is defi ned by two parameters, *calling rate* and *call holding*.

Calling rate, or the number of times a route or traffi c path is used per unit time; more properly defi ned, the *call intensity* (i.e., calls per hour) per traffic c path during busy hour.

Call holding time: or the average duration of occupancy of a traffi c path by a call. The *carried* traffi c is the volume of traffi c actually carried by a switch, and *offered* traffi c is the volume of traffi c offered to a switch. The offered load is the sum of the carried load and overfl ow (traffi c that cannot be handled by the switch).

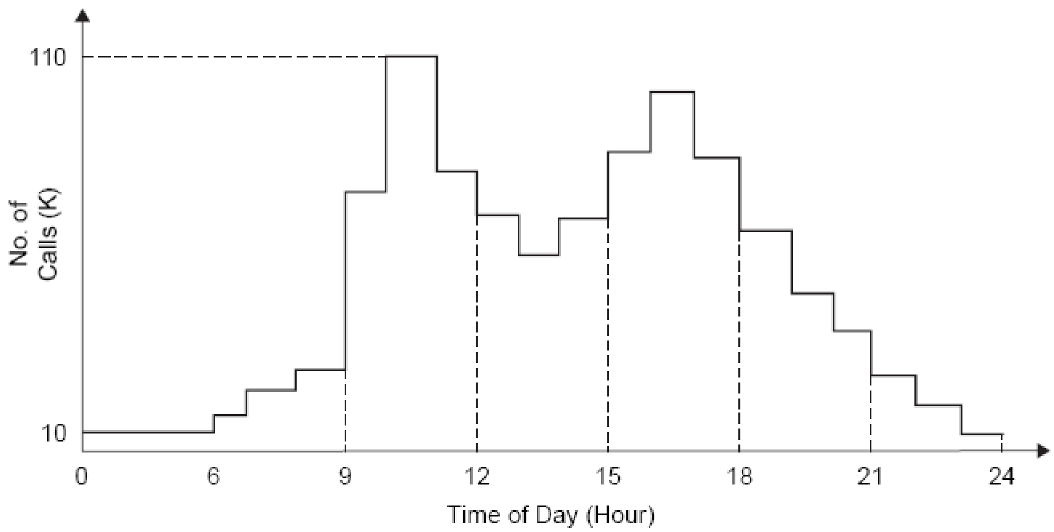

Figure shows a typical hour-by-hour voice traffi c variation for an MSC. We notice that the busiest period — the *busy hour* (BH) is between 10 A.M. and 11 A.M. We define the busy hour as the span of time (not necessarily a clock hour) that has the highest average traffic load for the business day throughout the busy season. The peak hour is defined as the clock hour with highest traffic load for a single day. Since traffi c also varies from month to month, we define the average busy season (ABS) as the three months (not necessarily consecutive) with the highest average BH traffic load per access line. Telephone systems are not engineered for maximum peak loads, but for some typical BH load. The blocking probability is defined as the average ratio of blocked calls to total calls and is referred to as the *GoS*.

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