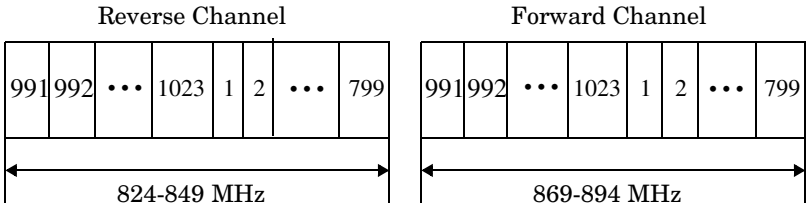

	Channel Number	Center Frequency (MHz)
Reverse Channel	$1 \le N \le 799$	$0.030N + 825.0$
	$991 \le N \le 1023$	$0.030(N - 1023) + 825.0$
Forward Channel	$1 \le N \le 799$	$0.030N + 870.0$
	$991 \le N \le 1023$	$0.030(N - 1023) + 870.0$

(Channels 800–990 are unused)

Figure 1.2 Frequency spectrum allocation for the U.S. cellular radio service. Identically labeled channels in the two bands form a forward and reverse channel pair used for duplex communication between the base station and mobile. Note that the forward and reverse channels in each pair are separated by 45 MHz.

currently allocated for U.S. cellular telephone use. Cellular radio systems operate in an interference-limited environment and rely on judicious frequency reuse plans (which are a function of the market-specific propagation characteristics) and frequency division multiple access (FDMA) to maximize capacity. These concepts will be covered in detail in subsequent chapters of this text.

In late 1991, the first US Digital Cellular (USDC) system hardware was installed in major U.S. cities. The USDC standard (Electronic Industry Association Interim Standard IS-54 and later IS-136) allowed cellular operators to replace gracefully some single-user analog channels with digital channels which support three users in the same 30 kHz bandwidth [EIA90]. In this way, U.S. carriers gradually phased out AMPS as more users accepted digital phones. As discussed in Chapters 9 and 11, the capacity improvement offered by USDC is three times that of AMPS, because digital modulation ($\pi/4$ differential quadrature phase shift keying), speech coding, and time division multiple access (TDMA) are used in place of analog FM and FDMA. Given the rate of digital signal processing advancements, speech coding technology will increase the capacity to six users per channel in the same 30 kHz bandwidth within a few years, although Chapter 2 demonstrates how IS-136 will eventually be replaced by wideband CDMA technology.

A cellular system based on code division multiple access (CDMA) was developed by Qualcomm, Inc. and standardized by the Telecommunications Industry Association (TIA) as an Interim Standard (IS-95). This system supports a variable number of users in 1.25 MHz wide channels using direct sequence spread spectrum. While the analog AMPS system requires that the signal be at least 18 dB above the co-channel interference to provide acceptable call quality,

CDMA systems can operate at much larger interference levels because of their inherent interference resistance properties. The ability of CDMA to operate with a much smaller signal-to-noise ratio (SNR) than conventional narrowband FM techniques allows CDMA systems to use the same set of frequencies in every cell, which provides a large improvement in capacity [Gil91]. Unlike other digital cellular systems, the Qualcomm system uses a variable rate vocoder with voice activity detection which considerably reduces the required data rate and also the battery drain by the mobile transmitter.

In the early 1990s, a new specialized mobile radio service (SMR) was developed to compete with U.S. cellular radio carriers. By purchasing small groups of radio system licenses from a large number of independent private radio service providers throughout the country, Nextel and Motorola formed an extended SMR (E-SMR) network in the 800 MHz band that provides capacity and services similar to cellular. Using Motorola's integrated radio system (MIRS), SMR integrates voice dispatch, cellular phone service, messaging, and data transmission capabilities on the same network [Fil95]. In 1995, Motorola replaced MIRS with the *integrated digital enhanced network* (iDen).

Personal Communication Service (PCS) licenses in the 1800/1900 MHz band were auctioned by the U.S. Government to wireless providers in early 1995, and these have spawned new wireless services that complement, as well as compete with, cellular and SMR. One of the stipulations of the PCS license was that a majority of the coverage area be operational before the year 2000. Each PCS licensee was able to "build-out" each market well in advance of this deadline. As many as five PCS licenses are allocated for each major U.S. city (see end of Chapter 11).

1.3 Mobile Radio Systems Around the World

Many mobile radio standards have been developed for wireless systems throughout the world, and more standards are likely to emerge. Tables 1.1 through 1.3 list the most common paging, cordless, cellular, and personal communications standards used in North America, Europe, and Japan. The differences between the basic types of wireless systems are described in Section 1.4, and are covered in detail in Chapter 11.

The world's most common paging standard is the Post Office Code Standard Advisory Group (POCSAG) [CCI86], [San82]. POCSAG was developed by the British Post Office in the late 1970s and supports binary frequency shift keying (FSK) signaling at 512 bps, 1200 bps, and 2400 bps. New paging systems, such as FLEX, ReFLEX, and ERMES, provide up to 6400 bps transmissions by using 4-level modulation and are currently being deployed throughout the world.

The CT2 and *Digital European Cordless Telephone* (DECT) standards developed in Europe are the two most popular cordless telephone standards throughout Europe and Asia. The CT2 system makes use of microcells which cover small distances, usually less than 100 m, using base stations with antennas mounted on street lights or on sides of buildings. The CT2 system uses battery efficient frequency shift keying along with a 32 kbps adaptive differential pulse code modulation (ADPCM) speech coder for high quality voice transmission. Handoffs between base stations are not supported in CT2, as it is intended to provide short range access to the PSTN. The DECT system accommodates data and voice transmissions for office and business