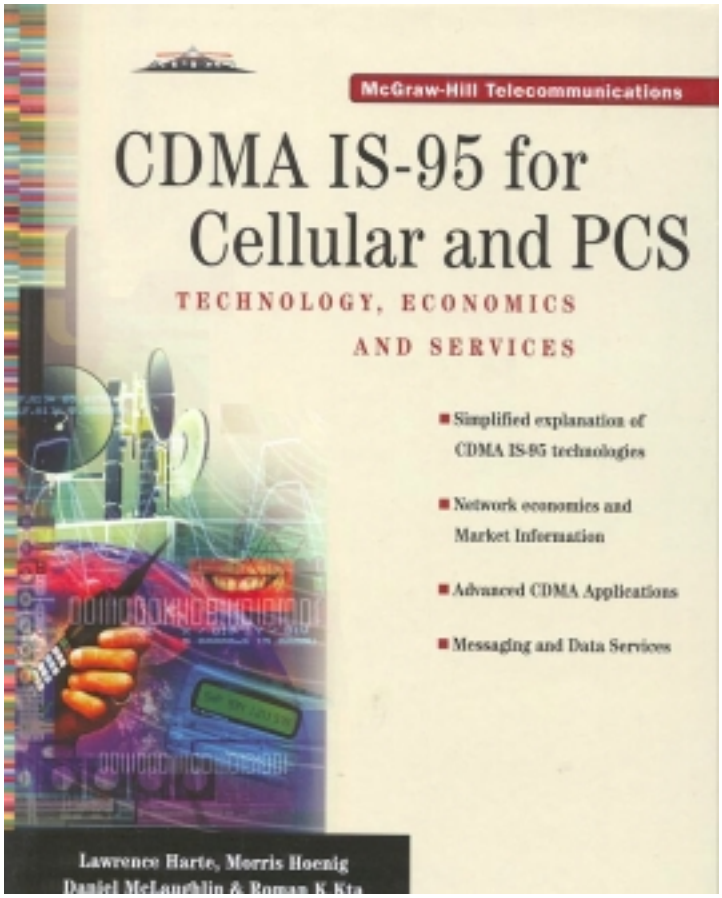
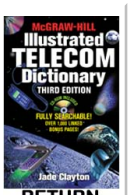
FURTHER READING:

As a preview for further reading, the following reference has been provided from the pages of the book below:

Title: CDMA IS-95 for Cellular and PCS
Author: Harte, Hoenig, McLaughlin, Kta
Publisher: McGraw-Hill

ISBN: 0070270708





Chapter 1

Introduction to IS-95 CDMA

IS-95 CDMA (commonly called "CDMA") is a digital cellular radio system that is used in over 35 countries throughout the world. The IS-95 digital cellar system optionally combines analog cellular communications network with digital CDMA radio technology. In 1998, there were over 23 million CDMA phones in use [1] and projections show that by the year 2002, there will be over 106 million CDMA phones [2].

The CDMA network provides for mobile voice communication as well as many new advanced services like mobile fax and text messaging. This book explains in both simple language and in detail how CDMA and its applications work. The authors hope that it will be useful to those new to telecommunications as well as those somewhat experienced in the field.

This book is intended for persons having a general familiarity with cellular and PCS networks, and a particular interest in CDMA and PCS-1900 technology. The technical background level expected from the reader is minimal.

What is CDMA

CDMA is the abbreviation for Code Division Multiple Access communication. CDMA is a form of spread spectrum communications. Spread spectrum communications is the transmission of a radio signal over a radio channel that is much wider than necessary to transmit the original information signal. Because the signal is

spread over a very wide bandwidth, interference from other users within that bandwidth is minimal. This allows multiple users to share the radio channel at the same time.

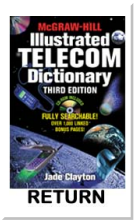
There are two basic types of spread spectrum communications: frequency hopping and code division. Frequency hopping multiple access (FHMA) is an access technology that allows mobile radios to share radio channels by transmitting for brief periods of time on a single radio channel frequency and then hopping to other radio channel frequencies to continue transmission. Each mobile radio is assigned a particular hopping pattern and collisions that occur randomly occur and only cause a loss of small amounts of data that may be fixed through error detection and correction methods. CDMA technology is called a wideband spread spectrum system as compared to earlier narrowband wireless systems. A wideband spread spectrum system spreads the radio signal over a frequency bandwidth that is much wider than is necessary to transfer the information signal (typically voice). By spreading the radio signal over a wide frequency bandwidth, this reduces the interference to other users operating in or near the radio channel bandwidth. Code division multiple access (CDMA) allows multiple users to share a single radio channel frequency at the same time by assigning a unique code sequence to each mobile radio.

History of CDMA

Development of CDMA technology originated in the United States in 1989 as a result of the CTIA next cellular generation technology requirements. In September 1988 the Cellular Telecommunications Industry Association (CTIA) laid out the User Performance Requirements (UPR) for the next generation of wireless service. The requirements were for a digital technology that would include:

- Tenfold increase over analog system capacity
- Ability to introduce new features
- Higher voice quality
- Voice and Data Privacy
- Ease of transition and compatibility with existing analog system

In 1989 the Telecommunications Industry Association (TIA) adopted time division multiple access technology (TDMA) as the radio interface standard. With the support of infrastructure equipment, MS manufacturers, and carriers, a company called QUALCOMM developed a CDMA system compliant with the CTIA requirements. In December 1991 QUALCOMM along with participating carriers and man-



ufacturers, presented the results of the CDMA system field trials. In 1992 the CTIA Board of Directors adopted a resolution requesting TIA to prepare structurally to accept contributions regarding wideband systems. TIA unanimously adopted the motion and recommended that the TR45 Committee address standardization activities regarding wideband spread spectrum digital technologies. In July 1993 TIA voted on and accepted IS-95 as the CDMA air interface standard (radio specifications). CDMA systems based on the IS-95 standard and related specifications are referred to as cdmaOne? systems.

The first commercial network began operation in Hong Kong in 1995. Since then commercial service has begun in both cellular and PCS bands throughout the world. CDMA is the fasted growing technology in wireless communications. Figure 1.1 illustrates the time between the deployment of the first Advanced MS Phone Service (AMPS) network, CTIA's UPR announcement and acceptance of TDMA, and IS-95 CDMA.

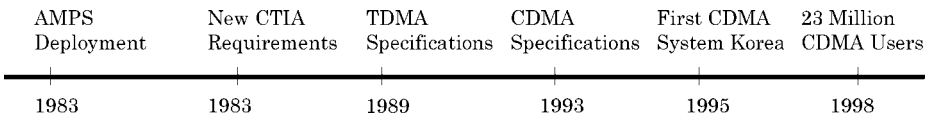
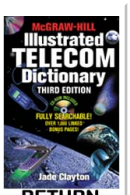


Figure 1.1, Wireless Development Timeline

Forms of CDMA

cdmaOne™ is a trademark of the CDMA Development Group and refers to the family of standards that define the CDMA technology. IS-95 specifies the AMPS and CDMA operation in the 800 MHz cellular frequency band. The IS-95 specification is a dual mode technical standard that incorporates both IS-553 AMPS and CDMA functions into one standard.



RETURN

This standard defines the mobile station (MS) and base station (BS) compatibility requirements for CDMA and analog operational modes. A revision of the standard (IS-95A) was voted on and accepted in 1995. This standard adds additional features to the original CDMA system.

New features and capabilities became available but were not available for inclusion into IS-95A. The features and capabilities were for a new voice encoder/decoder and extended messages. The extended messages and features are defined in TSB-74.

In 1998 revisions to the standard were accepted. The new standard is called TIA/EIA-95. The standard now incorporates IS-95A, TSB-74, and ANSI J-STD-008. The analog portion of the standard has been removed and referenced where needed. In addition to combining everything into one standard, there are several new enhancements and corrections. Among the new features are enhancements to the access process, Traffic Channel handoff process, support for medium data rate services, position location, and subscriber addressing.

TIA/EIA-95 is the minimum compatibility requirements for the MS and BS. The standard defines the modulation scheme for the six code channels, power control, call processing, handoffs, and registration techniques. A CDMA network includes the same basic subsystems as other wireless systems, including a switching network, controller, Base Station (BS), and Mobile Station (MS).

Figure 1.2 shows how the CDMA standard was developed. This diagram shows that the features, services and requirements were created by standards organizations using many proven technologies. This is why CDMA is called a “second generation” cellular system.

The different revisions of CDMA technology can make use of the same digital radio channel structure that set up handover and end the connection. These digital signals are sometimes referred to as the “base band” waveforms, and the part of the hardware that processes these is sometimes called the base band hardware. While the base band hardware can be absolutely identical in mobile stations and handsets that use CDMA standards, they can operate on different frequency bands. Only the radio portion of the handsets and base stations are substantially different in hardware, and in some cases the differences are very minor indeed. Thus, the CDMA standard can be implemented at 800 MHz in one location, and then at 1900 MHz in the another location. Even though the technology is the same, because the frequency of the network determines the frequency of the hardware required, a single mode 800 MHz CDMA handset will not function in an 1900 MHz CDMA network. However, some manufacturers produce handsets that can operate on either fre-

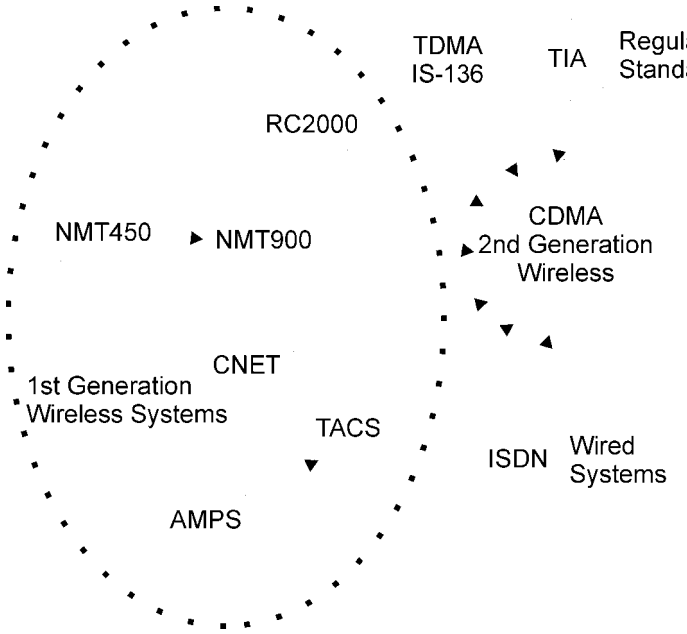
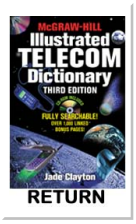


Figure 1.2, Development of CDMA Standard

quency band (dual band handsets).

All CDMA networks use a specific radio frequency band for signals from the base transmitter to the mobile receiver (called the forward or downlink channel) and a second distinct radio frequency band for the signals from the mobile transmitter to the base receiver (called the reverse or uplink channel).

In CDMA, the separation "on the radio dial" between adjacent radio carrier frequencies is 1.25 MHz (megahertz). A pair of radio carrier frequencies is loosely referred to (matching uplink and downlink) as "a frequency." In both documentation and in control signals sent between the base and mobile stations, each distinct matching carrier frequency pair is designated by an identification number such as 1, 2, 3 and so forth. To clarify the terminology, CDMA documents consistently distinguish between the words "carrier" and "channel." In CDMA, a carrier frequency is divided by means of codes into 64 individual channels. Each channel carries the information related to a separate and distinct conversation in digitally coded form. In some cases, an individually coded channel carries signals related to the beginning of a connection. Confusion sometimes arises when discussing older analog fre-



quency division multiplex (FDM) systems, in which each pair of carrier frequencies can carry only one conversation. In FDM systems, a channel is synonymous with a carrier. In spread spectrum systems such as CDMA, one carrier carries several channels.

800 MHz CDMA

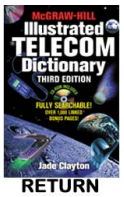
CDMA technology can be used in existing cellular frequency bands and the new personal communications service (PCS) frequency band. When used in the cellular system, CDMA operates in same radio spectrum allocation for cellular systems. It maintains a separation of forward and reverse channels in cellular band is 45 MHz. The MS transmit frequency band is 824-849 MHz. The BS transmit frequency band is 869-894 MHz.

In the CDMA cellular network, some radio carrier frequencies are defined for CDMA use. Not all of these frequencies are used for CDMA transmission. The FCC requires that analog radio transmission (AMPS) continue to operate. In the late 1990's, almost all the 800 MHz CDMA phones that were produced were capable of operating on CDMA or AMPS radio channels. This is called dual mode operation.

1900 MHz CDMA (PCS)

Some CDMA systems operate in the new Personal Communications System (PCS) frequency bands. PCS is primarily available in North America on the 1900 MHz frequency band, where it is called PCS-1900. Because of the commonality of the base band signals, some manufacturers make dual band CDMA handsets that can operate on both the 800 MHz and 1.9 GHz bands. When the base CDMA networks in the same region operating on these two bands are properly linked, it is possible for a subscriber to obtain service from either or both such systems if their handset is equipped for dual frequency band operation.

When used in the PCS frequency band, CDMA is specified for operation under the ANSI J-STD-008 specification. This standard is an up-banded version of IS-95A and TSB-74 but without the analog compatibility requirements. CDMA operation complies with the frequency structure of the PCS band. The separation of forward and reverse channels in the 1800 MHz PCS band is 80 MHz. The MS transmit frequency band for is 1850-1909 MHz. The BS transmit frequency band for is 1930-1989 MHz.



CDMA Parts

A CDMA network is comprised of several major portions: a mobile radio part, subscriber information part, a radio network, a switching system and network intelligence (primarily databases). Figure 1.3 shows a basic CDMA network. The mobile phone is called a mobile station. There are several types of mobile stations in CDMA. High-power mobile phones can be used in vehicles and people typically carry low-power mobile phones (handhelds). Mobile stations communicate with nearby radio towers called base stations. Base stations convert the radio signal for communication to a switching system. The switching system connects calls to other mobile stations or routes the call to the public telephone network. The switching system is connected to several databases that hold customer information. These databases include phone numbers, electronic serial numbers and authorized feature lists (features the customer has subscribed to).

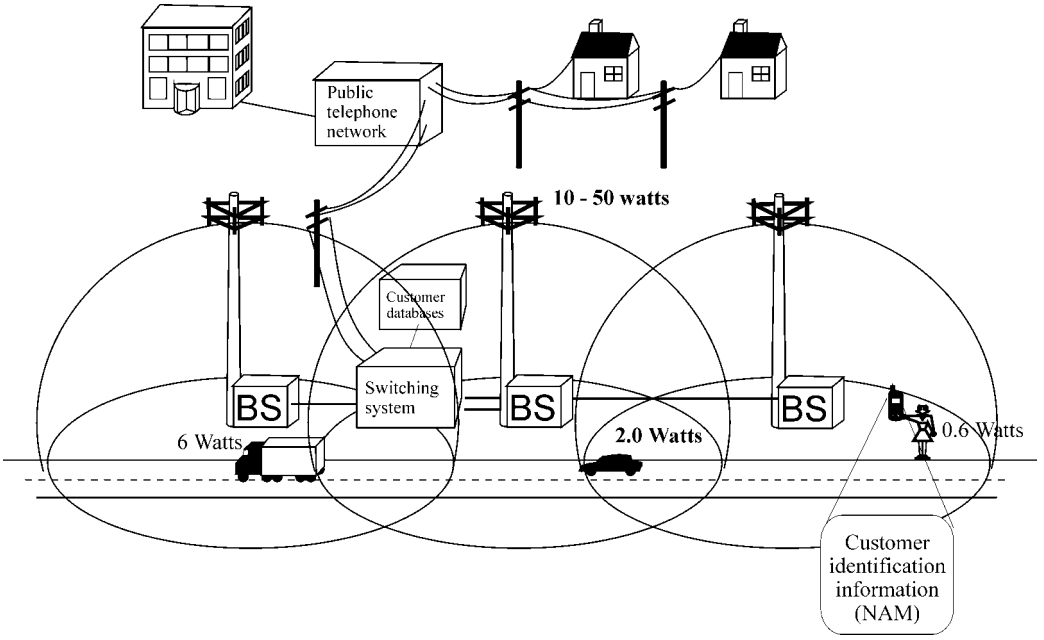
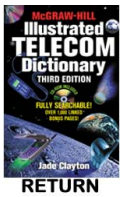


Figure 1.3, Basic CDMA Network



Mobile Station

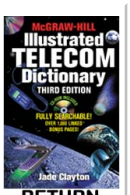
The mobile station (MS) is the subscriber's interface with the CDMA network. In the 800 MHz CDMA network, both hand-held MS units having a low-power radio transmitter and vehicle-mounted MS units are permitted. For PCS versions of CDMA, a low-power MS transmitter is the rule and handsets are only nominally used. Although, some handset manufacturers provide specific adapters for vehicle use which give coupling to an antenna outside the vehicle and, in some cases, extra mobile transmit power as well.

Most handsets use a rechargeable battery (called a secondary cell) for power. Rechargeable Nickel Cadmium or Lithium cells are typical. Some models can use disposable (called primary cells) batteries as a temporary source of power as well. Primary cells are readily available as they are widely used for flashlights, toys, etc. Most handsets come with a recharging device for the rechargeable cells, operating from either alternating current wall outlet (mains) power in a building, or a convenience outlet in a vehicle, or both. Several aspects of the CDMA design, explained in later chapters, help to give long stand-by time and long talk time with minimal battery drain.

All CDMA handsets built to date have voice capability, with a microphone and an earphone to speak and listen. The user does not need to operate a push-button to change from talk to listen, as in some older radio systems. The speech is digitally coded for transmission over the radio link. The digital speech compression process is performed by a codec. The acronym "codec" is a contraction of the first part of the two words: coder and decoder.

There are two types of digital speech coding used in the CDMA system. The original speech coding systems used 8 kbps speech coding and the later versions use 13 kbps speech coding. The 13 kbps speech coder was developed to offer higher speech quality.

Unlike other digital cellular systems, the CDMA system uses variable rate speech coding. As the speech activity varies (e.g. talk and silence), the data rate of the speech coder changes. This results in a data transfer rate that is lower for compressed speech signals (typically 40% of the designed data rate).



CDMA handsets also have an array of push buttons for dialing and for originating and answering calls. The numeric dial buttons can also be used to produce "touch tone" or dual tone multi-frequency (DTMF) tones while connected to a voice line, so that a user can operate such devices as remote control answering machines or the like.

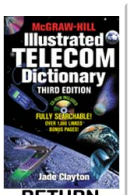
Some CDMA handsets have electrical connectors for use with an external fax machine or data terminal. The basic data transmission rate for a CDMA radio channel is 9.6 kbps. High-speed data services have been developed to allow several CDMA communication channels to be combined to achieve data rates of over 56 kbps.

Each handset contains a radio receiver and transmitter (the combination is sometimes called a transceiver), and a radio antenna. The radio and other parts of the handset are controlled by a microprocessor. The technical details of these parts of the set will be described in a later chapter.

Base Station Subsystem (BSS)

The radio parts of the CDMA network equipment are contained within the Base Station Subsystem (BSS). The Base Station Subsystem is divided into two main parts: the Base Transceiver Station (BTS) and the Base Station Controller (BSC). The BTS comprises several base radio transceivers. Each transceiver consists of a transmitter and a receiver which has a duplicated "front end" to match up with the two receiving antennas used in the base antenna assembly. The BSC comprises a control computer (typically a microprocessor central processing unit with memory), data communication facilities, and multiplexing and de-multiplexing equipment. The BSC can control the radio power levels of the various transceivers in the BTS, and also can autonomously control the mobile stations' radio transmitter power levels as well. The BSC passes certain types of control messages between the BTS and the Mobile Switching Center, and handles certain types of control messages itself under appropriate conditions. A single BSC can control several BTS radio equipment transmitters. The BSC can be located in a base station or at another remote site.

Figure 1.4 shows a basic diagram of a CDMA base station sub-system. The BTS consists of transmitters, receivers, antenna assembly, power supplies and test circuits. In this diagram, the BSC is located at the base station. Each transmitter operates on a different radio carrier frequency. Each radio carrier is divided into time slots and frames. For typical CDMA handsets (called full rate), this allows a maximum



of 64 different communication channels. Because some of these communication channels are dedicated as control channels and some are simultaneously assigned to mobile radios that are transferring calls to other cell sites, up to 40 users can share a single radio carrier channel.

One (or more) radio carrier codes (communication channels on a single RF carrier) is used as a control channel. The control channel coordinates mobile station alerting and access to the CDMA network. A special version of control channel called the paging channel sends out the paging messages to alert mobile radios of an incoming call.

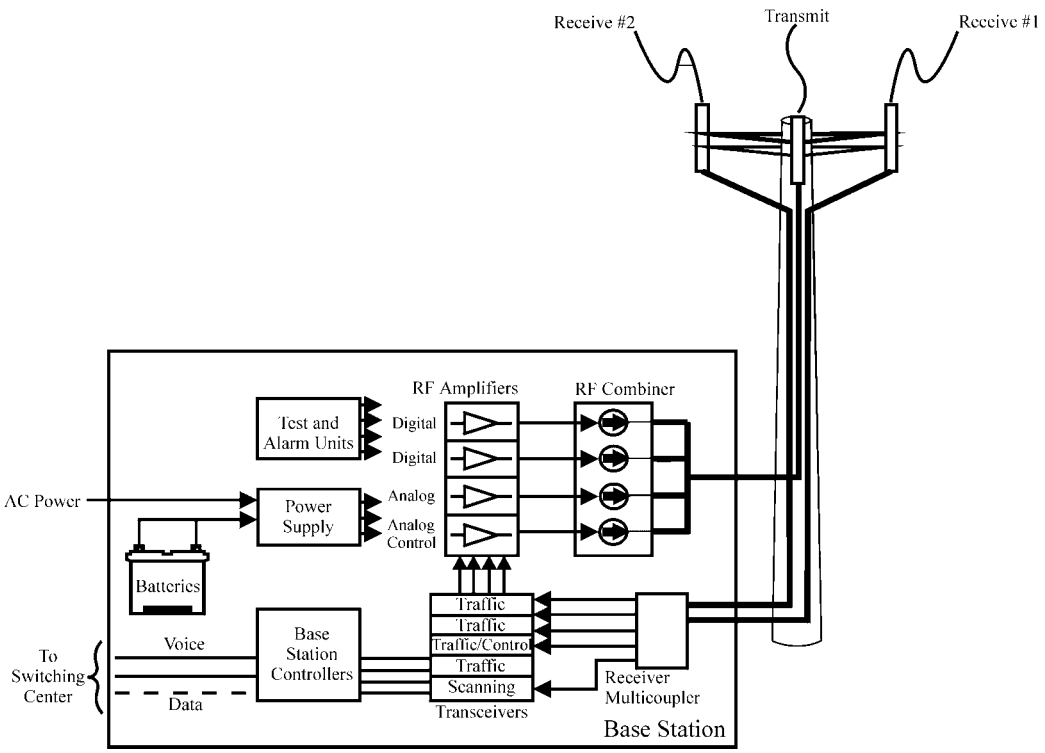


Figure 1.4, CDMA Base Station Subsystem