

FURTHER READING:

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

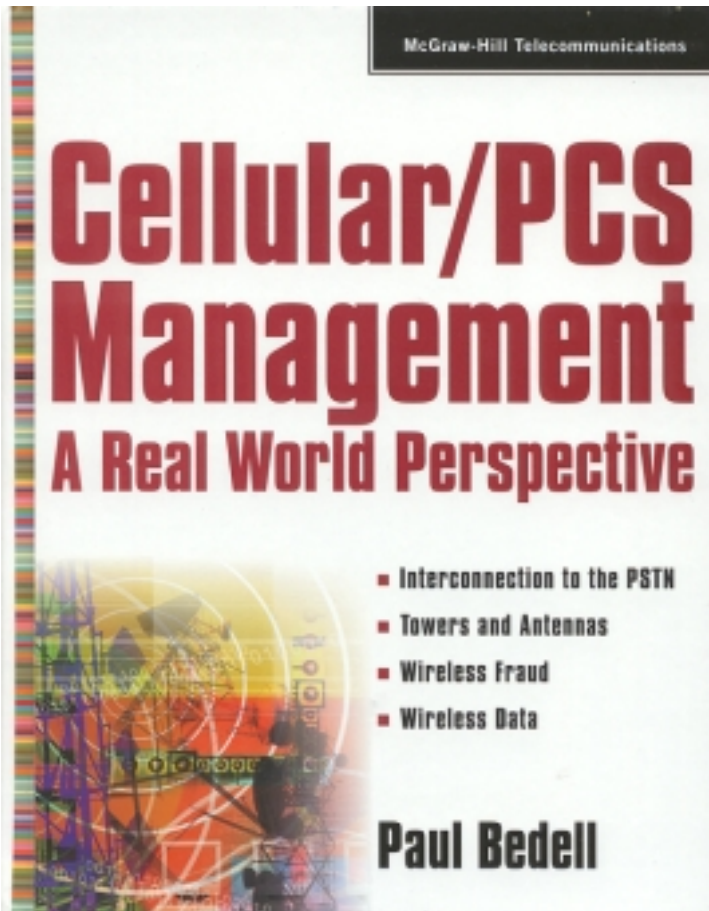
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IS-54 was the earliest standard to use TDMA technology, defining the migration path from analog to digital radio systems. The IS-54 standard, also known as the D-AMPS (digital AMPS) standard, referred to TDMA and digital radio in very generic terms and contained few references to digital radio feature sets. It focused on the migration from AMPS analog systems to digital cellular systems.

The revised, updated standard for TDMA systems, IS-136, contains information on full-featured TDMA digital systems, with references to feature sets such as caller ID and short message service (SMS), which provides text messaging.

A person who went to a cellular carrier's business store and purchased a digital phone in 1998 would actually be buying a phone that can use either the TDMA IS-136 standard or the CDMA standard. This phone would be a dual-mode phone, capable of operating in analog or one of the digital modes. TDMA/AMPS or CDMA/AMPS phones are available.

Currently, D-AMPS provides three voice calls per 30 kHz of bandwidth. Compared to the analog AMPS standard, this is a 3:1 increase in system capacity per channel.

TDMA systems can be more susceptible to interference than other radio technologies. Historically, this has been especially true in combined AMPS/TDMA systems used by cellular carriers, where calls could break up or mute. However, major improvements in vocoders since the early 1900s have allowed for vast improvements in dual-mode TDMA/AMPS transmissions.

20.5 Code Division Multiple Access

20.5.1 Overview

Code division multiple access (CDMA) is an American digital standard that was developed by a company named Qualcomm, based in California. CDMA was originally deployed as a battlefield communications system because it is very hard if not completely impossible to intercept CDMA transmissions. The CDMA digital modulation scheme is titled Interim Standard 95 (IS-95). Many of the broadband PCS license winners have selected CDMA as their official digital radio technology standard.

CDMA employs what is known as a wideband *spread spectrum* technology to carry digitized voice and data transmissions. As each voice is digitized at the mobile phone, it is assigned a unique digital code known as a *Walsh* code. This code is assigned as a pseudorandom noise code that's generated by the digital radio. At this point, the voice transmission has been encoded. This code is then transmitted back to the cell base station, where the voice is decoded, and regular call processing is completed. This process is analogous to each mobile speaking a different language and the base station interpreting each of the languages it receives. Each CDMA conversation is assigned its own separate code.

20.5.2 CDMA Architecture and Operations

Each CDMA base station can use the same 1.25-MHz carriers at the same time. The only change between each block of 1.25-MHz spectrum is the pseudorandom Walsh noise code. There are a maximum of 64 allowable pseudorandom Walsh noise codes per 1.25-MHz carrier in the CDMA modulation scheme.

Prior to the widespread deployment of CDMA systems, which were mainly spurred by the broadband PCS carriers, there were concerns that CDMA systems could not handle heavy traffic loads. This caused concerns in the industry that CDMA systems couldn't handle a huge acquisition of customers in a short period of time. Nevertheless, CDMA has many distinct attributes which make it attractive to cellular and PCS providers, as listed below.

Key: Theoretically, there can be nine 1.25-MHz CDMA carriers per cell. Some PCS carriers are successfully using eleven 1.25-MHz carriers per cell. Today, cellular carriers are using two to four carriers per cell. Theoretically, each of these 1.25-MHz carriers (channels) can handle 22 to 40 voice calls. However, today both PCS and cellular carriers obtain an average 12–14 calls per carrier. In contrast to the AMPS standard, which typically employs an $N = 7$ reuse format, CDMA employs an $N = 1$ “reuse” format because identical sets of 1.25-MHz bandwidth (spectrum) can be assigned at every base station in a CDMA system. CDMA is a spread spectrum technology because the voice transmissions, the conversations, are all *spread* over the entire swath of the 1.25-MHz carriers.

20.5.3 Power Control

CDMA base stations control the power of all mobiles for interference reduction purposes. All mobile signals must arrive at the base station at the same power level so that the signals can be properly coded. Power control is a required operational parameter of CDMA digital system operations. For example, if a mobile station that is right next to the base station is transmitting at very high power, and a mobile station 10 mi away from the base station is transmitting at very low power, the power of the mobile next to the base station is throttled down to a given level while the power of the mobile 10 mi away from the base station is raised to a given level. Power control is *necessary* to maintain system capacity. A by-product of power control is reduced power costs at the base station, as well as increased battery life in the mobile phone.

Power control exists in AMPS, TDMA, and GSM systems, but it is simply a benefit that can be utilized to make the systems perform better. Power control in CDMA systems is a *critical* item; it is absolutely required in order for the system to operate effectively.

20.5.4 Rake Receivers

CDMA systems *thrive* on multipath radio signals. There are four “rake” receivers within each base station transceiver and three “rake” receivers within each mobile phone, so called because they resemble a lawn rake. The function of the rake receiver at both ends (mobile and base station transceivers) is to aggregate the diversity in all the received signals within each rake receiver. The direct signal at the rake receiver (i.e., the *strongest* signal) is combined with the multipath, reflected signals from the other two or three rake receivers to form the composite signal that is used to process the mobile call. The multipath signals are *additives* to the direct signal to obtain the cleanest, strongest signal possible.

20.5.5 Soft Handoff

“Soft” call handoffs are different from “hard” call handoffs in that a soft handoff allows *both* the original cell and new cells to temporarily service a call during the handoff transition. The handoff transition is from the original cell carrying the call to one or more new cells and then to the final new cell. With soft handoff, the wireless call is actually

carried by two or more cells *simultaneously*. In this regard, the analog system (and TDMA and GSM digital systems as well) provide a “break-before-make” switching function in relation to call handoff. In contrast, the CDMA-based soft handoff system provides a “make-before-break” switching function with relation to call handoff.

CDMA systems require a Global Positioning System (GPS) antenna at every cell base station. The GPS antennas synchronize all the cell sites to one timing source—the GPS. This is an absolute necessity for soft handoffs because timing is critical among the multiple sites that may simultaneously handle a call during the soft handoff process.

Analogy: The soft handoff process is analogous to a trapeze artist flying in the air between two trapeze platforms. In the analog AMPS world, the artist in the middle is transferred from the trapeze at one end to the trapeze at the other end by being flung through the air. In a CDMA world, instead of flinging the middle trapeze artist through the air, the first trapeze artist doesn't let go of the middle artist until he or she is sure that the opposite end trapeze artist has a firm grip on the middle artist.

Not only does soft handoff greatly minimize the probability of a dropped call, but it also makes the handoff virtually undetectable to the user. Soft handoffs are directed by the mobile telephone. As such, soft handoff is also known as *mobile-directed handoff*.

20.5.5.1 Soft Handoff Operations The sequence of events in a soft handoff is as follows:

- After a mobile call is initiated, the mobile station continues to scan the neighboring cells to determine if the signal from another cell becomes stronger than that of the original cell.
- When this happens, the mobile station knows that the call has entered a new cell's coverage area and that a handoff can be initiated.
- The mobile station transmits a control message to the MTSO which states that the mobile is receiving a stronger signal from the new cell site, and the mobile identifies that new cell site.
- The MTSO initiates the handoff by establishing a link to the mobile station through the new cell while maintaining the old link.
- While the mobile station is located in the transition region between the two cell sites, the call is supported by communication through both cells. This eliminates the ping-pong effect of repeated requests to hand the call back and forth between two cell sites.

- The original cell site will discontinue handling the call only when the mobile station is firmly established in the new cell.

20.5.5.2 Wideband CDMA There is currently a newer version of CDMA under development, known as *wideband CDMA* (W-CDMA). Instead of utilizing a 1.25-MHz carrier, W-CDMA will utilize a 5-MHz (or greater) carrier. This new technology is supposed to significantly step up the time frame by which CDMA systems will be able to offer voice, data, and at least half-rate motion video from CDMA handsets. This technology falls under the heading of third-generation (3G) wireless technology. The first generation is cellular, the second generation is all-digital (PCS) systems, and the third generation of wireless technologies are those technologies that the industry is trying to have standardized through national and international standards bodies.

20.6 Global System for Mobile Communications

20.6.1 Overview

Global System for Mobile Communication (GSM) is a digital wireless communications standard that was developed by a consortium of European countries. In 1992-1993, the countries of Western Europe began introducing the new GSM cellular radio system to replace the many incompatible cellular systems that were in service at that time across Europe. At the time GSM was developed, there were six incompatible analog cellular systems in operation throughout Europe. A mobile designed for one system could not be used with another system. This situation served as the impetus for the development of an all-European system.

As the European community started to dismantle its trade barriers, the mobile communications field anticipated the trend with the creation of an all-digital, pan-European mobile telephone system: the Global System for Mobile Communication, otherwise known by its popular acronym, GSM. (The GSM acronym originally stood for Group Spéciale Mobile). Over time, GSM has become a *worldwide* digital cellular standard, along with becoming the standard pan-European digital cellular system. This is evidenced by the fact that many American PCS companies chose GSM as their digital radio technology standard.