CDMA TECHNOLOGY

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Introduction to CDMA

This paper provides an introduction to Code Division Multiple Access (CDMA) communications, covering a Radio Carrier Station (RCS) and a Fixed Subscriber Unit (FSU).

Introduction to Spread Spectrum Communications

CDMA is a form of Direct Sequence Spread Spectrum communications. In general, Spread Spectrum communications is distinguished by three key elements:

1. The signal occupies a bandwidth much greater than that which is necessary to send the information. This results in many benefits, such as immunity to interference and jamming and multi-user access, which we'll discuss later on.

2. The bandwidth is spread by means of a code which is independent of the data. The independence of the code distinguishes this from standard modulation schemes in which the data modulation will always spread the spectrum somewhat.

3. The receiver synchronizes to the code to recover the data. The use of an independent code and synchronous reception allows multiple users to access the same frequency band at the same time.

In order to protect the signal, the code used is pseudo-random. It appears random, but is actually deterministic, so that the receiver can reconstruct the code for synchronous detection. This pseudo-random code is also called pseudo-

Three Types of Spread Spectrum Communications

There are three ways to spread the bandwidth of the signal:

- Frequency hopping. The signal is rapidly switched between different frequencies within the hopping bandwidth pseudo-randomly, and the receiver knows beforehand where to find the signal at any given time.
- Time hopping. The signal is transmitted in short bursts pseudo-randomly, and the receiver knows beforehand when to expect the burst.
- Direct sequence. The digital data is directly coded at a much higher frequency. The code is generated pseudo-randomly, the receiver knows how to generate the same code, and correlates the received signal with that code to extract the data.
- CDMA is a Direct Sequence Spread Spectrum system.
- The CDMA system works directly on 64 kbit/sec digital signals. These signals can be digitized voice, ISDN channels, modem data, etc.

Direct Sequence Spread Spectrum

Figure 1 shows a simplified Direct Sequence Spread Spectrum system. For clarity, the figure shows one channel operating in one direction only.

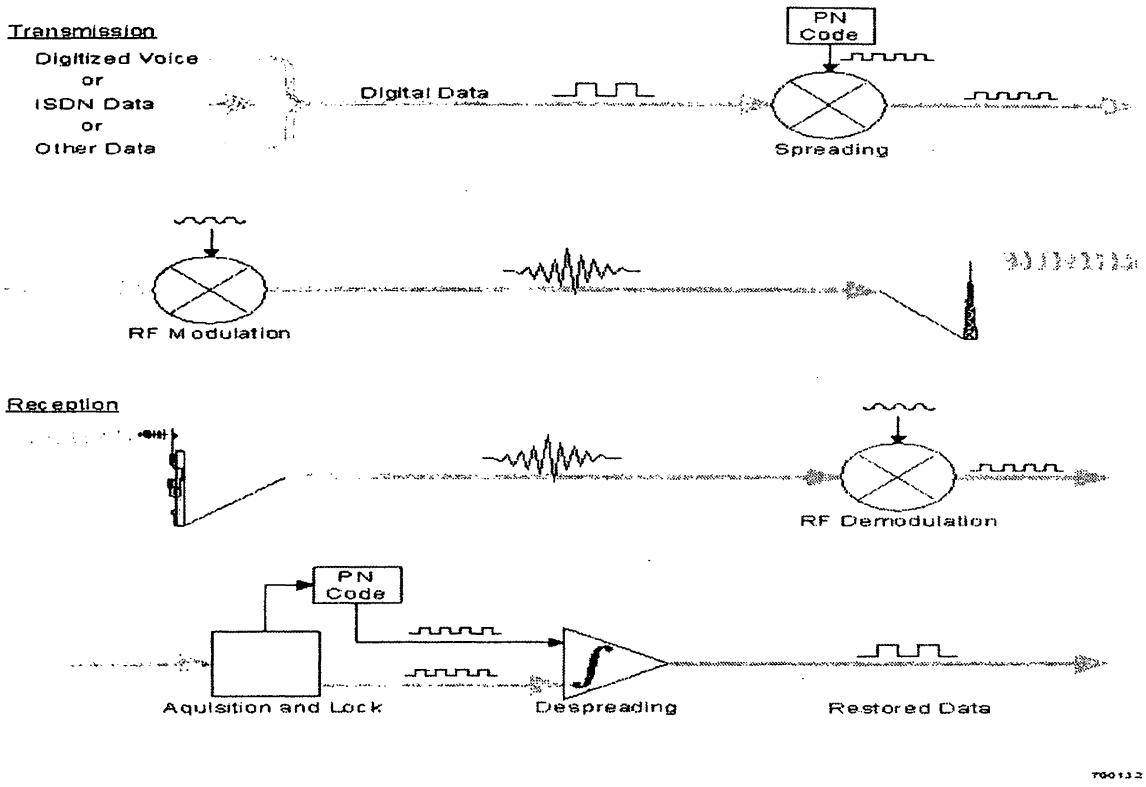

Figure 1. Direct Sequence Spread Spectrum System

Signal transmission consists of the following steps:

1. A pseudo-random code is generated, different for each channel and each successive connection.
2. The Information data modulates the pseudo-random code (the Information data is "spread").
3. The resulting signal modulates a carrier.
4. The modulated carrier is amplified and broadcast.

Signal reception consists of the following steps:

1. The carrier is received and amplified.
2. The received signal is mixed with a local carrier to recover the spread digital signal.
3. A pseudo-random code is generated, matching the anticipated signal.
4. The receiver acquires the received code and phase locks its own code to it.
5. The received signal is correlated with the generated code, extracting the Information data.

A Brief History of CDMA

The second technology standard to consider is CDMA, which stands for Code Division Multiple Access. When the world's first cellular networks were introduced using analog radio transmission technologies such as Advanced Mobile Phone System (AMPS) in the early eighties, it became clear that a higher level of network capacity required accommodating more user traffic within a tighter radio spectrum.

To accomplish that, the industry developed a new set of digital wireless technologies-Time Division Multiple Access (TDMA) and Global System for Mobile-that used a time-sharing protocol. In essence, these technologies allocated milliseconds of time to all users accessing the wireless network. The move to digital network access, though, made segmenting network usage by code rather than time feasible. Under CDMA, all mobile network users received a unique code that allowed them to access the network continuously rather than intermittent, timed access.

But CDMA's road was not a simple one. In fact, a panel of the world's leading engineers reportedly met in Japan in the early 1990s to discuss the development of wireless CDMA technology as a standard. They concluded, however, that it was impossible.

To the founders of Qualcomm, however, "impossible" simply meant that several thorny technical issues needed to be overcome. With unstoppable entrepreneurial spirit, Qualcomm's team solved them all, establishing CDMA as a legitimate wireless communications standard (and patenting it to ensure their ownership).

Launched commercially in 1995, the first CDMA networks provided roughly ten times more capacity than analog networks, and far more than TDMA or GSM. Besides supporting more traffic, CDMA brought mobile carriers and consumers better voice quality, broader coverage and stronger security, among other benefits. CDMA now has over a hundred million subscribers worldwide.

The Applications to CDMA Wireless Technology

A cellular telephone system is designed to serve a large number of users who may be in the same geographical area, and may be attempting to talk at the same time. The term "cellular" refers to the fact that a very large service area is divided up into "cells", where each cell has a relay tower to pick up and forward calls from its local region. For mobile users (e.g, someone talking on a cell phone while driving), the system must provide a way to "hand off" this user from one cell to another, preferably without the user being aware that this transition is even occurring. (It is called a "soft handoff" if the user is communicating with both the old and the new base station before the old one is released.) With simultaneous users in a limited geographical region, the obvious problem is the interference of the calls with each other. The earliest proposed systems addressed this problem either by assigning different radio frequencies to the various users (called *frequency division multiple access*, or *FDMA*), or by assigning different time slots (necessarily recurring soon enough to maintain call continuity) to different users (called *time division multiple access*, or *TDMA*). However, by nearly universal agreement, a superior approach, used in some "second generation" (2G) cell phone systems, and planned or already implemented in virtually all "third generation"(3G) systems, is known as *code division multiple access*, or *CDMA* for short.

The basic idea of CDMA is to use a wide frequency band common to all the users, whose signals are made distinguishable by assigning mutually uncorrelated code modulation patterns to the various users. Communication systems for point-to-point military communications using this basic type of code modulation had been in use since the 1960's, and were known as *direct sequence spread spectrum* systems; but CDMA was invented to handle the multi-user situation with many telephones transmitting simultaneously.

We have previously mentioned a number of ways to obtain fairly large sets of binary sequences with mutually (pairwise) low cross-correlation values. However, the first CDMA standard to be implemented was the IS-95 standard, introduced by QUALCOMM, INC., where the modulation was based on the use of m-sequences. Specifically, if a particular m-sequence of period $2n$ ¡ 1 is used, each of its $2n$ ¡ 1 cyclic shifts are very nearly uncorrelated with one another. It is these shifted versions of the same underlying sequence that provide the set of mutually non-interfering signals for the IS-95 standard and in many of its successors, such as CDMA2000. (Actually, with a spreading sequence of period 242 ¡ 1, true orthogonality is not achieved over the short integration period involved. The cross-correlation achieved in practice averages on the order of $1=pm$, where m is the number of terms in the integration period.)

Observe that for this approach to work, it is necessary to maintain overall communication *coherence*. If the signals of different users are allowed to drift

Advantages of CDMA technology

There are many reasons CDMA is the technology of choice for next generation digital wireless communications products and services:

- Outstanding Voice and Call Quality CDMA filters out background noise, cross-talk, and interference so you can enjoy crystal-clear voice quality, greater privacy, and enhanced call quality. QUALCOMM's CDMA variable rate vocoder translates voice into digital transmissions, zeroes and ones, at the highest translation rates possible (8kbps or 13kbps). This allows for crystal clear voice and also maximizes your system capacity. .
- Packet Data CDMA networks are built with standard IP packet data protocols. Other networks require costly upgrades to add new data equipment in the network and will require new data phones. Standard cdmaOne phones already have TCP/IP and PPP protocols built into them.
- Improved Security and Privacy CDMA's digitally encoded, spread spectrum transmissions resist eaves dropping. Designed with about 4.4 trillion codes, CDMA virtually eliminates cloning and other types of fraud.
- Greater Capacity CDMA allows the largest number of subscribers to share the same radio frequencies, helping service providers increase their profitability. CDMA uses spread spectrum technology which can provide up to 10-20 times the capacity of analog equipment and more than three times the capacity of other digital platforms. With dual-mode phones, CDMA is compatible with other technologies for seamless widespread roaming coverage.
- Reduced Background Noise and Interference CDMA combines multiple signals and improves signal strength. This leads to the near elimination of interference and fading. Both electrical background noise (computer noise) and acoustic background noise (background conversations) are filtered out by using narrow bandwidth which corresponds to the frequency of the human voice. This keeps background noise out of your conversations.

Disadvantages to CDMA

1) Your handset can only be used with the provider that you got the phone from. Should your phone brake Under contract but out of warranty, getting a new phone from the provider will automatically extend your contract another 2 years.

2) CDMA is limited to North America and a few other places, GSM is worldwide. If you like to travel oversea's, for the most part, leave your CDMA phone at home.

3) GSM phones can be unlocked meaning that they can be used with any GSM provider. If my GSM phone brakes, I can get a cheap replacement phone without having to extend my contract. When I travel oversea's, I can continue using my service, better yet, I can use a local sim card for the country I am in and make and receive calls at a much lower rate.

The future of a CDMA technology

It all depends how you look at it. Now we have a 3G revolution of CDMA iPhone access, something we didn't worry about a few years ago. There is talk of 4G and beyond. This is pretty slick already and the tech is based on CDMA. We have EVDO, GSM, WCDMA, UMTS/HSDPA, and even VOIP.