

# Properties and Elements of WIDEBAND CDMA

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## 1. Abstract

The ability to communicate with people on the move got unimaginable popularity in the past few years. Today there are uncountable users of cellular phones in the world, and the mobile communication market has grown dramatically every year. To keep up with this insatiable demand, the cellular service providers, equipment manufacturers and researchers are facing great challenge and to solve this problem they are finding multiple access techniques.

## 2. Introduction

The ability to communicate with people on the move got unimaginable popularity in the past few years. Today there are uncountable users of cellular phones in the world, and the mobile communication market has grown dramatically every year. To keep up with this insatiable demand, the cellular service providers, equipment manufacturers and researchers are facing great challenge and to solve this problem they are finding multiple access techniques.

There are three types of multiple access techniques, FDMA(*frequency division multiple access*), TDMA(*time division multiple access*) and CDMA(*code division multiple access*). In FDMA and TDMA it is observed that the channel is basically partitioned into independent single-user subchannels. The communication system design methods that was developed so far are directly applicable for these two techniques, but the problem arise in these two techniques. In other words the information transmissions from a single user are separated by periods of no transmission, where these periods of silence may be greater than the periods of transmission. In such an environment FDMA and TDMA tend to be inefficient because a certain percentage of the available frequency slots or time slots assigned to users do not carry information. Ultimately an inefficiently designed multiple access system limits the number of simultaneous users of channel. CDMA is a technique where a channel or subchannel can be shared by more than one user. In CDMA the users access the channel in a random manner and the signal transmissions among the multiple users completely overlaps both in time and frequency. CDMA is thus finding lots of research, interest and application in the mobile industries.

## 3. CDMA Concepts

In CDMA, as the name implies, each user is assigned a distinct code to encode its information bearing signal. At the receiver, if the user knows this code, the information bearing signal can be obtained by demodulation process. That can be accomplished since the correlation among the other codes of other users are too small. In encoding process, the BW of the code is much larger than the BW of information bearing signal. The encoding process enlarges the spectrum of the signal and is known as *spread spectrum modulation*. Hence the resulting signal is called *spread spectrum signal* and CDMA is often referred as *spread spectrum multiple access*.

At the receiver, the received signal is correlated with a synchronously generated replica of the spreading code to recover the original information bearing signal. This means that the receiver (a mobile station-MS, a base station-BS- or a fixed station) must know the code used to modulate the data.

## 4. Properties of Signals

### 1. Multiple Access Capabilty

When all the users send their information at the same time, the receiver must distinguish the intended data by using the crosscorrelation property among the codes. Since the crosscorrelation is nearly zero between the codes, the other SS signals are not despread and act as interference signals. The intended and thereuopn despread data then will demodulated and decoded.

### 2. Protection Against Multipath Interference

At the receiver, since the difference among the codes is more than one chip duration, only the intended data will be despread. In multipath case, signals from different paths are all coppies of the same transmitted signal with different amplitudes, phases, delays and arrival angles. If the delay is more than one chip duration, the multipath signals act as interference.

### 3. Privacy

The transmitted data can be recovered if and only if the code used to transmit the data is known at the receiver.

### 4. Interference Rejection

At the receiver, since the narrowband interference is multiplied by the wide code, the interference will be spread over the frequency band and power spectrum density (PSD) will decrease.

### 5. Antijamming Capability, Especially Narrowband Jamming

This is the same as the case 4 except that the interference is now willfully inflicted on the system. So this property is very important for military applications.

### 6. Low Probability of Interception (LPI)

We know that the spread data has a very low PSD. Due to this property, the spread spectrum signal is difficult to detect by a hostile listener.

## 5. Basic CDMA Elements

### 1. Rake Receiver:

In multipath channels, the original transmitted signal is reflected from some obstacles such as buildings, trees, mountains etc. and the copies of this signal with different delays, amplitudes and phases occur. Such kind of signals are called "Multipath Signals". If a signal arrives more than one chip duration than the other, the receiver can reject them. Hence, each multipath signals are considered to be interference signal from the view of the other. However, more benefits can be obtained if used a Rake receiver. If needed to explain in frequency domain why we need a Rake receiver, the frequency content of the message is affected partly if the message BW is larger than the coherence BW of the channel which is reciprocal of multipath spreading of the channel. That event is called "frequency selective fading". To overcome this problem, a Rake receiver is needed.

### 2. Power Control:

In the uplink of a DS-CDMA, the transmitted signals share the same BW at the same time. However, the received power level of a user closer to the base station will influence the others which are not close to the base station. The influence comes as interference. This phenomena is called "Near- Far Effect". The problem must be removed by a power control unit applied to each user to obtain the same mean power at the base station.

Another useful contribution of power control is against to the fading dips. In case of no fading dips, the channel will turn to the Gaussian channel.

There are two types of power control:

- *Open Loop Control:* Since this method measures the interference conditions for the channel and adjust the transmitter power level on average , this is the best worst case. So closed loop control loop may be needed.
- *Closed Loop Control:* In this case, the system measures the signal to interference ratio (SIR) and commands the transmitter to arrange its power level. More of them will be mentioned later.

### 3. *Soft Handover:*

In the casual CDMA cellular systems, when the received power level of the neighboring base station exceeds the threshold level, the mobile station offers handover. So handover process should allow the mobile station to connect into a cell (namely a base station) whose power is the highest (the lowest pathloss). Such kind of handover is called "hard handover".

In soft handover, since a mobile station can connect more than one base station simultaneously, its power level can be controlled by the base station from which the mobile station receives the highest power level. A mobile station enters the soft handover state when the signal level from a neighboring cell is over a threshold level but it is under the level of the current base station's signal level. In the downlink two or more base stations' signal can be received by a mobile station. However, the mobile station combines all of the received signal using the feature of Rake receiver.

Besides them, a separate pilot channel is used for the signal level for handover purpose.

### 4. *Interfrequency Handover:*

The 3G Systems are to have multiple frequency carriers in each cell, a mobile station will be measuring the signal level and quality of the other carrier frequency without disconnecting the current carrier frequency.

### 5. *Multiuser Detection:*

Since the current CDMA systems use Rake receiver which is interference limited, some performance degradation can happen. How?

When another user or interferer enters the network, the other users using the same system will be affected and the service quality will go below the acceptable level.

In order to combat this problem, multiuser detection (MUD) provides a means of reducing the effect of MUD interference, hence increasing the system capacity.

## **5. Some Advantages and Disadvantages of CDMA And Futuer of CDMA**

1. Generation of codes is easy. Modulator is a simple multiplier.
  2. Since only one carrier frequency has to be generated, the frequency synthesizer (carrier generator) is simple.
  3. Coherent demodulation is possible.
  4. No synchronisation among users is necessary.
    - Difficult to produce a locally generated code sequence at the receiver. Synchronisation must be kept within a fraction of one chip duration.
- Near-Far Effect. Since the power of a user closer to the base station is more than the user far away the base station, the first user will interfere the second. Hence, some algorithms to control the power are necessary, but very difficult.

CDMA was first tried in military field and navigation systems. In 1950 De Rosa-Rogoff proposed a DS-SS system and introduced the processing gain and noise multiplexing idea. In 1956 Rake concept was proposed by Price-Green. Among 1961 and 1978, cellular application spread spectrum system was suggested. In 1980 DS-CDMA was proposed by Qualcomm.(Later they would offer 2<sup>nd</sup> generation

CDMA radio network. In 1993 July, IS-95 standart and narrow band CDMA were introduced. Commercial applications of IS-95 and multiuser detection and MLSE (maximum likelihood sequence estimation) concept in AWGN channel were formulated in 1996 by Verdu . During 1990 wideband CDMA of bandwidth of 5 MHz or more have been studied.

### **References**

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