IMPLEMENTATION OF CDMA IN MATLAB

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Abstract—The telecommunications industry faces the problem of providing telephone services to rural areas, where the customer base is small, but the cost of installing a wired phone network is very high. One method of reducing the high infrastructure cost of a wired system is to use a fixed wireless radio network. The problem with this is that for rural and urban areas, large cell sizes are required to obtain sufficient coverage. This result in problems caused by large signal path loss and long delay times in multipath signal propagation. Currently Global System for Mobile telecommunications (GSM) technology is being applied to fixed wireless phone systems in rural areas or Australia. However, GSM uses Time Division Multiple Access (TDMA), which has a high symbol rate leading to problems with multipath causing inter-symbol interference. Several techniques are under consideration for the next generation of digital phone systems, with the aim of improving cell capacity, multipath immunity, and flexibility. These include Code Division Multiple Access (CDMA) and Coded Orthogonal Frequency Division Multiplexing (COFDM). Both these techniques could be applied to providing a fixed wireless system for rural areas. However, each technique has different properties, making it more suited for specific applications.

Keywords—CDMA, FDMA, TDMA, DS-CDMA, FH- CDMA

I. INTRODUCTION

A. Evolution of Spread Spectrum Communication

The evolution of spread spectrum methods for communication has its root in the late 1930. In 19338n, Guavella filed a patent containing all the technical characteristics of SR-S radar. In 1940, Prof. E. Rultman was issued German patent on Chip Pulse Radar. In 1941, Claude. Shannon showed that his channel capacity was maximized by selectively spreading the signaling spectrum. Middle of 1940 saw the formulation of the match filter concept for maximum signal to noise ratio (SNR) pulse detection by North and Vanvleck and Middleton from June to August 1950, a summer study program known as “Hartwell” was commenced under the direction of Jerrold Zacharias. This project leads to the culmination of three methods of convert communication. One was Adam’s and De Rosa’s SR-SS system.

A second system, attributed to J. R. Piere of BTL, used very narrow pulses to achieve frequency spreading pulse pair spacing to carry intelligence. The third was a TR-SS system (transfer reference) where the carrier storage and synchronization problem of SR-SS system would be traded for the headache of a second channel. While closing this discussion “Hartwell” report suggested that several of these kind of system using different wideband carriers could operate simultaneously in the same bandwidth, this was one of the earliest references of CDMA technique.

B. Key elements of spread spectrum

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

- The signal occupies a bandwidth much greater than that which is necessary to send the information.
- The bandwidth is spread by means of a code which is independent of date.
- The receiver synchronizes to the code to recover the data.
- In order to protect the signal, the code used is pseudo-random.

II. TYPES OF MULTIPLEXING

There are three types of Multiplexing:-

- Frequency-Division Multiple Access (FDMA).
- Time-Division Multiple Access (TDMA).
- Code-division Multiple-Access (CDMA)

A. Frequency-Division Multiple Access (FDMA):-

It is a communications technique that divides a communications channel into a number of equally spaced frequency bands.
III. **Theory of CDMA**

The drawbacks of FDMA and TDMA are overcome in this third technique in which the users are spread across both frequency and time in the same channel. An important advantage of CDMA over FDMA and TDMA is that it can provide for secure communication. Here, unique digital codes, rather than separate RF frequencies or channels are used to differentiate subscribers. The codes are shared by the mobile station (cellular phone) and the base station, and are called “pseudo random code sequences” or “pseudo-noise code sequences” (PN-Sequence).

A PN-sequence is a periodic binary sequence with a noise-like waveform that is usually generated by means of a feedback shift register. “Pseudo” word is used, as these are not real noise. These are noise-like.

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**A. Classification of CDMA:**

1) **Direct Sequence Spread Spectrum-CDMA (DS)**: DS sequence allows each to transmit over the entire frequency spectrum all the time. Multiple simultaneous transmissions are separated using some sort of coding technique that is each user is assigned a chip sequence. The sender and receiver synchronize by the receiver locking into the chip sequence of the sender.

Binary phase shift keying (BPSK) is the most common technique used in DS system. Direct sequence is, in essence, multiplication of a more conventional communication waveform by PN sequence in the transmitter.

2) **Frequency Hopping Spread Spectrum-CDMA (FH-CDMA)**: FH-CDMA is a kind of spread spectrum technology that enables many users to share the same channel by employing a unique hopping pattern to distinguish different users transmission.

A major advantage of frequency hopping is that it can be implemented over a much larger frequency band than it is possible to implement DS-spreading, and the band can be noncontiguous. Another major advantage is that frequency hopping provides resistance to multiple-access interference while not requiring power control to prevent near-far problems. There are two basic characterization of frequency hopping:

- Slow frequency hopping, in which the symbol rate Rs of MFSK signal is an integrator multiple of the hop rate Rh that is, several symbols are transmitted on each hop.
Fast frequency hopping, in which the hop rate \( R_h \) is an integrator multiple of MFSK symbol rate \( R_s \), that is, the carrier frequency will change or hop several times during the transmission of one symbol.

IV. CDMA TECHNOLOGY IN MOBILE COMMUNICATION

- Availability of very low cost, highly dense digital integrated circuits, which reduce the size, weight and cost of the subscriber station to an acceptably low level.
- Realization that optimal multiple access communication requires that all user stations regulate their transmission power to the lowest that will achieve adequate signal quality.

V. BASIC IDEA

A. Frequency Reuse

The number of radio channel frequencies is limited. The concept of frequency reuse is based on assigning to each cell a group of radio channels used in a small geographic area. Cells are assigned a group of channels that is completely different from neighboring cells. The coverage area of cells is called the footprint. This footprint is limited by a boundary so that the same group of channel scan be used in different cells that are far enough away from each other so that their frequencies do not interfere. [2]

B. Handoff

Handoff means switching a cellular phone transmission from one cell to another as a mobile user moves into a new cellular area. It is so called because the radio link with the previous sector is not broken before a link is established with a new sector; this type of handoff is described as “make before break”. In CDMA, due to this soft handoff there is no interruption of call even at the border of the cell site which means more number of customers can be accommodated; automatically increasing the capacity of the cell site. This is make before break technology. [2]

C. Multipath Fading

In a mobile environment a mobile station will receive one direct signal from the base station and multiple signals which are reflected from obstructions like buildings and towers. Each signal would have travelled a different length and would be displaced in time. Due to this, when they are combined at the mobile handsets, it will cause interference resulting in poor signal quality, this is known as fading. This problem is handled in a very good way in CDMA. A receiver that implements the above principle is known as a RAKE receiver. [3]

D. Near Far Problem

SNR for the farther transmitter is much lower. If the nearer transmitter transmits a signal of higher magnitude, then the SNR for the farther transmitter may be blow detectability and the farther transmitter may not transmit. This effectively jams the communication channel. In CDMA systems, this is commonly solved by dynamic output power adjustment of the transmitters. That is, the closer transmitters use less power so that the SNR for all transmitters at the receiver is roughly the same.

VI. SYSTEM ARCHITECTURE

An illustrative iterative MUD scheme is shown. At the transmitter side, the data from user-\( k \) is first encoded by a forward error correction (FEC) code \( C \) followed by an interleaver \( k \). A spreading operation is then applied to produce the transmitted signal. At the receiver side, the received signal is passed through a bank of correlators. A turbo process is then applied involving two functions: an elementary multiuser detector(EMUD) and a bank of \( K \) soft-in-soft output decoders (DECs) based on \( C \). In the receiver two constraints must be consider: (a) the FEC code \( C \) and (b) the correlation among signature sequences. Finding a joint optimal solution is usually computationally prohibitive. The turbo processor takes a sub- optimal approach by decomposing the task into two parts. The EMUD processes constraint (b) and ignores (a). The DECs process (a) and ignore (b). A global iterative process is then applied to refine the results.

Generally speaking, the DEC complexity per user is independent of the simultaneous user number \( K \). For example, the complexity of the well-known MMSE technique is \( O(K^2) \).
per coded bit per user. This can be a concern when K is large. Hence, we may want to minimize the EMUD cost without seriously affecting the DEC cost. A potential method is to move the spreading operation into FEC coding so as to reduce the EMUD cost related to spreading.

VII. PROCESSING GAIN

Noise signals are add non-coherently, this means instead of an amplitude basis Noise signals sum on a power basis. Thus, 6 dB louder than the signal out of each loudspeaker alone. Coherent addition of sinusoids and non-coherent addition of noise can be used to obtain any desired signal to noise ratio in a spectrum analysis of sinusoids in noise. Specifically, for each doubling of the period gram block size in Welch's method, the signal to noise ratio (SNR) increases by 3 dB (6 dB spectral amplitude increase for all sinusoids, minus 3 dB increase for the noise spectrum).[1]

\[ G_p = f_i / f_c \]

Where,
- \( G_p \) is the processing gain
- \( f_i \) is Chipping Frequency (the bit rate of the PN code).
- \( f_c \) is Information Frequency (the bit rate of the digital data).

VIII. SYSTEM CAPACITY

System capacity refers increase the number of users. The capacity of system can be increase by two ways:

- Reducing the interference
- To operate in a discontinuous transmission mode (DTX)

The capacity of a system is approximated by:

\[ C_{max} = \frac{G_p}{E_s / N_0} \frac{1}{1 + \beta} \]

Where,
- \( C_{max} \) is the maximum number of simultaneous calls
- \( G_p \) is the processing gain
- \( E_s / N_0 \) is the total signal to noise ratio per bit
- \( \beta \) is the inter-cell interference factor. [2]

IX. ADVANTAGE

- Increased capacity.
- Improved voice quality.
- Eliminating the audible effect of multipath fading.
- Enhanced privacy and security.
- Reduced average transmitted power.
- Reduced interference to other electronic devices.

X. DISADVANTAGE

- Low receiver cost
- De-centralized (asynchronous) control
- Simple treatment of ISI
- Cross- cell interference mitigation
- Diversity against fading
- Power efficiency
- Multimedia services
- High user number
- Spectral efficiency

REFERENCES


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