Performance Evaluation of MMSE filter and Matched filter based Multiuser Detectors

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***Abstract*— CDMA is very useful technique for modern communication system. There exist problem of interference due to other users accessing the channel at same time. Multi user detectors can cope up with MAI. The performance of MUD varies with number of users. The performance of two multiuser detectors is compared by varying the number of users. The MMSE filter based MUD has better response than Matched filter based MUD.**

Keywords- CDMA; MultiuserDetectors; Multiple Access interference; MMSEfilter; Matched filter

I. INTRODUCTION

In the broad sense the term communication means sending, receiving and processing of information by electronic methods. The communication started with wire line telegraphy in around 1840's. In telegraphy there is transmission of information using Morse code through wired network. After few decades there was invention of telephone. With the invention of telephone the communication became fast and there is real time communication between source and destination. With the invention of transistors, integrated circuits and other semiconductors, the radio communication came into existence. With radio frequency communication, we can communicate without using wires. All this made long distance communication very economical. Few decades ago there was invention of satellite communication. Fiber optics communication is also an important step in making communication more reliable and wide spread. In optical systems the information is transmitted in the form of light with an increased emphasis on computer and other data communication.

II. MULTIPLE ACCESS SYSTEMS

The channel bandwidth is a very limited resource. So, in order to save the bandwidth various multiple access techniques are implemented. In multiple access technique several transmitters share the same channel in order to communicate with same receiver. This is multipoint to point communication. Multiple access schemes define how the users map their data onto common channel. The various types of multiple access systems are discussed below

A. Random Multiple Access

This is a kind of bursty transmission, whenever a user has a data packet, it transmits. Due to random transmission of data collisions usually occurs.

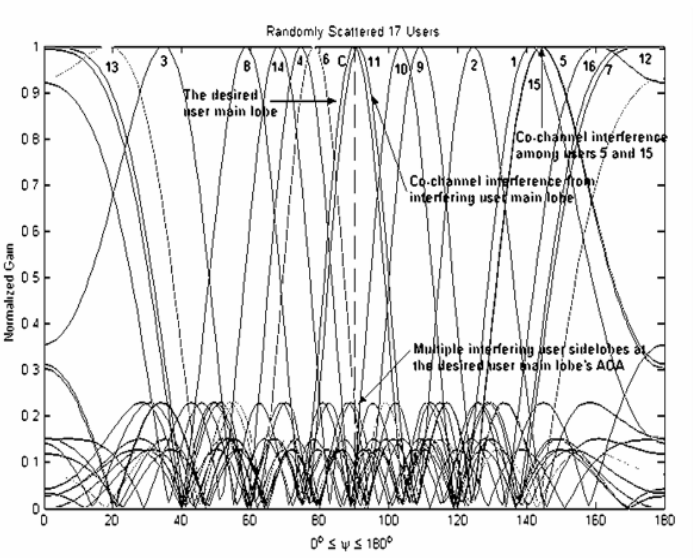

Fig1: - Random Multiple Access pattern

B. Slotted Random Multiple Access

In this scheme, the starting and ending transmission times are defined. In this multiple access system collisions are comparatively less than that of Random multiple access system

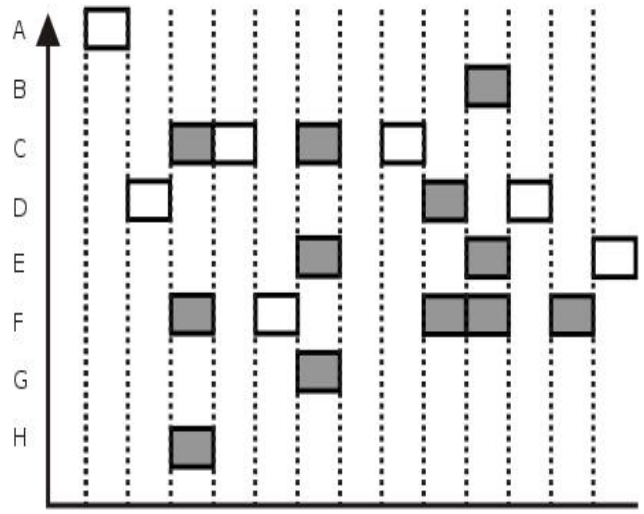

Fig2: - Slotted Random Multiple Access

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C. Time Division Multiple Access

TDMA is a channel access/ multiplexing technique, it allows the several users to share frequency channel by allocating the channel to different users on different time slots. The users transmit very rapidly one after another. TDMA is very useful in implementation of GSM, PDC and DECT techniques.

D. Frequency Division Multiple Access

FDMA is a channel access technique. It allows the several users to share a common channel by allocating an individual user a specific frequency band. In FDMA all users share the channel at same time. The major advantage of FDMA is that it can be used with both analog and digital signals

E. Code Division Multiple Access

CDMA permits all users to utilize all time and frequency resources simultaneously. Users distinguish themselves by modulating their information onto a user-specific spreading sequence. By selecting mutually orthogonal spreading sequences, each user is perfectly separated at the common receiver. Since each user is assigned a unique spreading code to spread the narrow band information over the whole bandwidth. The most common CDMA methods are frequency hopping and direct sequence. In FH-CDMA system, the carrier hops from one frequency to another in a Pseudo random hopping pattern controlled by the spreading code. For DS-CDMA system, the spreading code is pseudo random in nature, usually binary sequence, with a large bandwidth than the transmitted information signal. The information is multiplied by the spreading code to introduce rapid phase transition and accordingly increase the signal bandwidth.

III. MULTI USER DETECTION

The issue in present wireless communication system is to share resources, especially to share frequency spectrum. The multiple access techniques are useful in sharing frequency band. In wireless communication system the receiver deals with interferences and noise produced in the channel at that instance. But in CDMA systems, we also have interference produced by other users accessing the channel at the same time. The signal processing techniques used to solve the problem of interference caused by multiple users is known as multi user detection. This technique is exclusively applied on CDMA systems [1].

In CDMA each user is assigned a unique signature sequence called code word. Codes are assigned in both electrical as well as optical domain. Intelligent design of code word is the key to success of CDMA system. However codes [-1, +1] designed for electrical domain cannot be applied in optical domain because in optical domain signal cannot be negative. 5[1,2] Multi user interference is the key limit of CDMA based system performance. Multi user interference increases with the increase in number of users [2].

The performance of DS-CDMA system is limited by multi user interference and near-far problem. Multi user interference gives rise to irreducible error even in the absence of thermal noise, while near –far problem arise since high power users destroy the communication of low power users. Use of orthogonal codes is not much beneficial as multipath fading and delay destroys the orthogonality of the signature waveform. The focus of conventional decoder is towards user of interest only and it treats the other signals as noise and tries to suppress it. This is the basic requirement of conventional decoder that the interference from other users should be least. If we detect multiple users jointly then the process is known as multiuser detection. Multi user detection deals with the demodulation of the digitally modulated signals in the presence of multi user interference [3].

Multiuser detection provides the first comprehensive treatment of the subject of multiuser digital communication. Multiuser detection deals with demodulation of the mutually interfering digital streams of information that occurs in areas such as wireless communication, high-speed data transmission, satellite communication, digital television and magnetic recording. The development of multiuser detection techniques is one of the most important recent advances in communication technology.

A. Single User Detector

$$Y=SAb+n$$

Where

A: - Signal Amplitude

S: - Unit energy spreading sequence

$$S^H S=1$$

b □ (-1, +1) Data signal

B. *Multiuser Detector*

The optimum detector, that maximizes signal to noise ratio at its output is the matched filter detector. Matched filter is a linear filter with impulse response S(Ts – t) sampled at t=Ts
The output of matched filter is

$$S^H Y = S^H SAb + S^H n$$

Matched filter achieves minimum error probability among all detectors
Multiple Users in the Channel

$$Y = SAb + n$$

Where $A = diag\{A_1, A_2, \ldots\ldots A_k\}$

$$S = [S_1, S_2, \ldots\ldots S_k]$$

Output of the k^{th} users matched filter

$$S^H{}_k y = A_k b_k + \sum_{J=K} S^H{}_K S_J A_J B_I + S^H{}_K n$$

$$S^H{}_K S_J = 0$$

If sequences are orthogonal MAI=0, everything stays the same as in single user case

$$S^H{}_K S_J \neq 0$$

If the sequences are not orthogonal, MAI exists and the performance of Matched filter detector decreases. Near – far problem exists.
Matched filter is suboptimum in the presence of MAI. [4]

IV. PRESENT WORK

- In this work the DS CDMA signal is generated using spread spectrum technique. It spreads the bandwidth of the data uniformly for the same transmitted power. The signal is generated by performing XOR operation between data and PN- code. Each user in a CDMA system uses a different code to modulate their signal.
- A modulator is designed. It transmits the coded output of XOR gate on to a channel using Binary phase shifted signal.
- Noise signal is also generated and is mixed with the signal in the channel. It deteriorates the message signal
- Matched filter based multiuser detector is implemented and the original signal is recovered.
- BER of the received signal is measured.
- E_b/N_o of the received signal is measured.
- Graph between BER & E_b/N_o is ploted.
- Procedure is repeated using MMSE filter based detector.

The whole procedure is repeated by varying the number of users and the comparison is made between these two detectors

V. RESULT

The graph is plotted between BER & Eb/No by varying the number of users

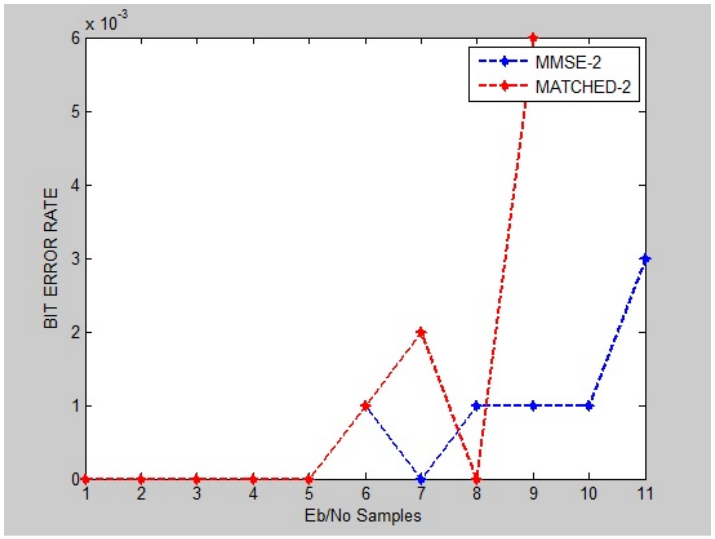

Fig 3: - BER vs E_b/N_o for 2 users

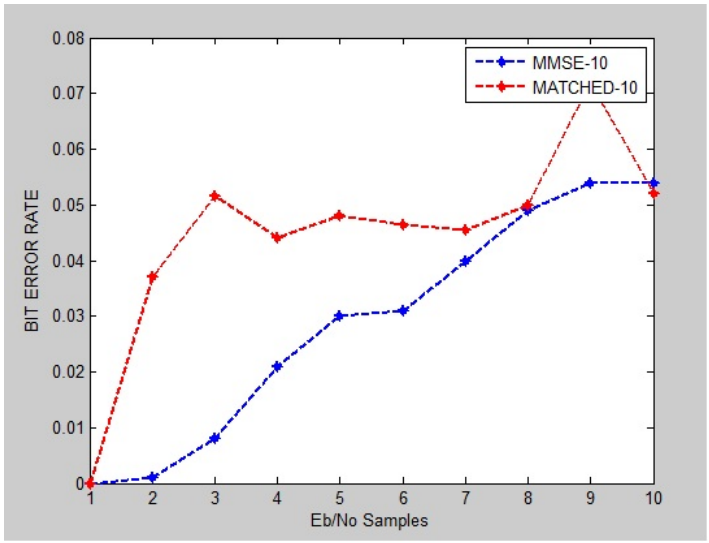

Fig 4: - BER vs E_b/N_o for 10 users

VI. CONCLUSION

DS-CDMA is most commonly used CDMA system for third generation of mobile communication system. It has many advantages. It also suffers from the problem of Near-far Effect and Multiple Access Interference. To overcome these problems multiuser detector is used.

There are many optimum Multiuser detectors. But they are very complex to implement, their complexity increases exponentially with increase in number of users. However, the linear multiuser detectors are still better in terms of complexity. Their complexity increases linearly with increase in number of users. The MMSE linear detector is one of such linear detector.

The matched filter based de-correlating detector eliminates the multiple access interference regardless of the AWGN. However MMSE linear detector can perform between background noise and the interference of other users.

In this work the comparison was made between the performances of matched filter based multiuser detector and MMSE filter based multiuser detector by varying the number of users. BER of matched filter based detector as well as MMSE filter based detector increases with increase in number of users. Irrespective of the number of users the BER of MMSE filter based detector is less than that of Matched filter based detector. Hence the performance of MMSE filter based multiuser detector is better than matched filter based multiuser detector irrespective of the number of users.

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AUTHORS PROFILE

Gaurav Juneja received the B.Tech in Electronics & Communication Engineering from Punjab Technical University Jalandhar and pursuing M. Tech from same university. His research interest include wireless communication systems.

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