ISSN 2250-3153

Effective Technique for Mitigating the MAI in DS-CDMA System

Shrikant J. Honade[1] And Dr. P. V. Ingole[2]

[1]Lecturer ,Department of E & *TC*, G.H.Raisoni College of Engineering & *Management,Amravati*

[2]Principal ,G.H.Raisoni College of Engineering & *Management,Amravati*

Abstract- DS-CDMA system is well known wireless technology. This system suffers from MAI (Multiple Access Interference) caused by Direct Sequence users. Multi-User Detection schemes were introduced to detect the users data in presence of MAI. This paper focuses on iterative linear multi-user detection schemes used for data demodulation. Simulation results demonstrate the bit error rate performance of turbo multiuser detector in presence of MAI for different number of users with variation in signal to noise ratio.

Index Terms- Multiple Access Interference, Parallel Interference Canceller, Successive Interference Canceller, Code Division Multiple Access, Time Division Multiple Access, Frequency Division Multiple Access, Direct Sequence Code Division Multiple Access, Multiuser Detection, Base Station, Decision Feedback Equalizer, Maximum Likelihood detection, Maximum Aposteriori Probability, Linear Minimum Mean Square Error, Turbo Multiuser Detection.

I. INTRODUCTION

1.1. Multiuser DS-CDMA System

In a Direct Sequence CDMA system, the signals on all the links are transmitted simultaneously. Further, all uplink signals are transmitted in one frequency band and all downlink signals in another frequency band. The individual signals are separated by using spreading codes, with one or more spreading signals embedded within the desired signal. Because of the propagation environment, such codes are only semi-orthogonal, especially in the uplink direction where the signals originate from disparate geographical locations. The result is that the desired signal for each user is contaminated not only by the thermal noise but also by the signals from other users. This interference from other users, or multiple access interference (MAI), is a limiting factor in the capacity of CDMA systems. In simple CDMA receivers, MAI is regarded as additive noise and detection is based on the assumption that the additive noise due to MAI is Gaussian.

The amount of multiple access interference (MAI) in a CDMA system depends upon two factors: relative signal strength from individual transmitters, and the cross-correlation properties of the spreading sequences. The relative signal strengths, in turn, depend upon the transmitted power from each user in the uplink and upon their relative distances from the base station. The amount of MAI for each user may be so large that it renders the system unusable due to excessive bit error rates. Most of the undesired signal is due to MAI and very little due to thermal noise. The signal received at the front end of a receiver is the sum of the desired signal, the thermal noise, and the MAI. In a conventional CDMA receiver, the signal from each user is demodulated and detected independently while regarding the MAI in the demodulated signal as noise. This limits the capacity of a CDMA system. It is important to note that the MAI from signals within the cell under consideration has a known structure, as compared to the interference from other cells, or "unknown" MAI where the codes are generally different in that, for efficiency reasons, the cellular systems should be interference-limited rather than noise-limited. IS-95 systems, by virtue of regarding MAI as additive noise, are clearly interference-limited.

Multiuser detection is largely the process of mitigating the multiple access interference (MAI). In this paper, we consider linear multiuser detection schemes as depicted in Fig. 1. As this figure illustrates, signals from individual users, in the uplink, are first demodulated without any knowledge of other users. For each user, the demodulated signal contains MAI that, in current CDMA system, is regarded as added noise. Linear multiuser detection is a standard approach that involves passing the demodulated signals for all users through a linear filter which generates cleaner signals for the users with minimal or no MAI.

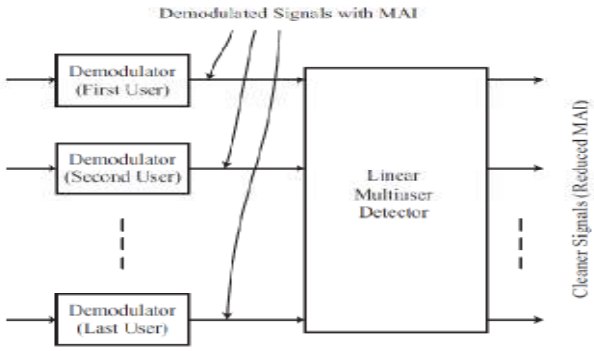

FIGURE 1: MULTIUSER DETECTION

The performance of a DS-CDMA system is limited by Multiple Access Interference (MAI) and the Near Far Problem. MAI gives rise to irreducible error even in absence of thermal noise, while near far problem arises since high power users destroy the communication of low power users. Use of orthogonal codes is not considered to be a good solution to this problem since multipath fading and delay destroys the orthogonality of the signature waveforms. Moreover, the theoretical limit on the number of orthogonal codes for a fixed spreading gain restricts the number of users in the system.

The conventional decoder treats the signals of all the other users as noise and tries to suppress it. Thus, conventional decoding requires that the interference from other users should

be minimal. This places the entire burden of performance on the cross correlation property of the spreading codes of the users. However, the interference suppression capability of such system deteriorates as the number of users grows in the system. A better detection strategy is to jointly detect multiple users, where the additional structure of the MAI is exploited rather than considered as noise. Multiuser Detection deals with the demodulation of the digitally modulated signals in the presence of MAI. The optimal maximum likelihood (ML) receiver for multi-user detection (MUD) was found by Verdu. It showed an improvement over conventional decoder by orders of magnitude. However, the practical implementation of such scheme is limited by the decoding complexity which grows exponentially with the number of users.

A class of linear receives and suboptimal receiver is the trade-off between complexity and performance. The main idea is to use some appropriate linear transformations on the outputs of a matched filter bank. This scheme makes too many assumptions about what is known at receivers (signature and timing information of desired user and interferer, received amplitudes etc). This can be implemented in uplink channels but it is not practical in downlink channels. The downlink receiver is generally limited in terms of power, complexity and memory and since a downlink receiver needs to detect the bits of only a particular user, joint detection is not energy efficient.

It was shown that the blind implementation of some linear MUD schemes is possible which require knowledge no more than that required by a conventional detector (only desired user's waveform and its timing).

With this motivation, the theory of Multiuser detection (MUD), existing algorithms and current implementation issues is studied.

II. DESIGN METHODOLOGY

Let us consider channel-coded CDMA systems operating over multipath fading channels whose channel state information is unknown to the receiver. To demodulate and decode such systems, the turbo principle is applied to both channel estimation and multiuser detection. The iteration will be initialized with training symbol based channel estimation and a non-iterative multiuser detection. The paper is focused mainly on the performance analysis of such structures using Bit Error Rate Performance and is carried out on large number of users. This analysis will be used to describe the decoding process as an iterative mapping

III. IMPLEMENTATION OF MULTIUSER DETECTION SYSTEM

This part introduces the actual wireless communication model and the direct sequence code division multiple access (DS-CDMA) transmission environment, and develops models of different components in a generic DS-CDMA system. The single user direct sequence spread spectrum communication system is described as a basis for understanding of multiuser direct sequence spread spectrum communication system. Single user end-to-end systems consist of three components: a spread spectrum transmitter, a spread spectrum receiver, and a communication channel through which the spread spectrum signal propagate. A multiuser system is introduced as a superposition of multiple single user systems describes the spreading sequences for DS-CDMA system simulations presented in this dissertation.

A single user DS spread spectrum system can be extended to a multiuser system. In fact, both single user and multiuser spread spectrum systems have similar transmitter and receiver structures and the multiuser channel is just the superposition of many single user channels. At the base station, detection of a particular user's signal assumes that signals from the other users can be regarded as additive noise. This assumption is based on the fact that direct sequence spreading results in frequency components with diminished amplitudes, and that the spectrum of a spread spectrum signal resembles additive noise. Commercial CDMA systems are multiuser DS spread spectrum systems. Since the multiuser detectors developed in this paper are designed for DS-CDMA systems, detailed construction of the transmitter and the receiver for such systems is described in fig.2. and fig. 3.

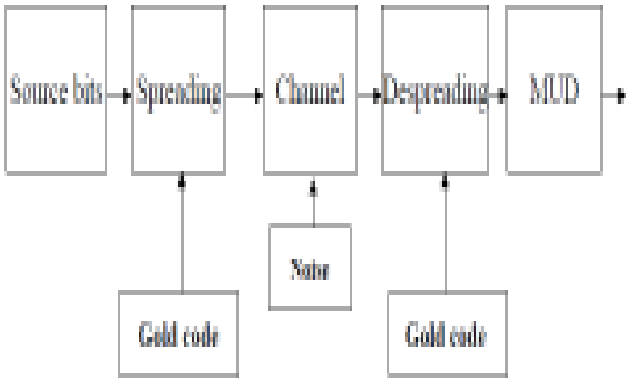

FIGURE 2: Block Diagram of single user DS-CDMA system

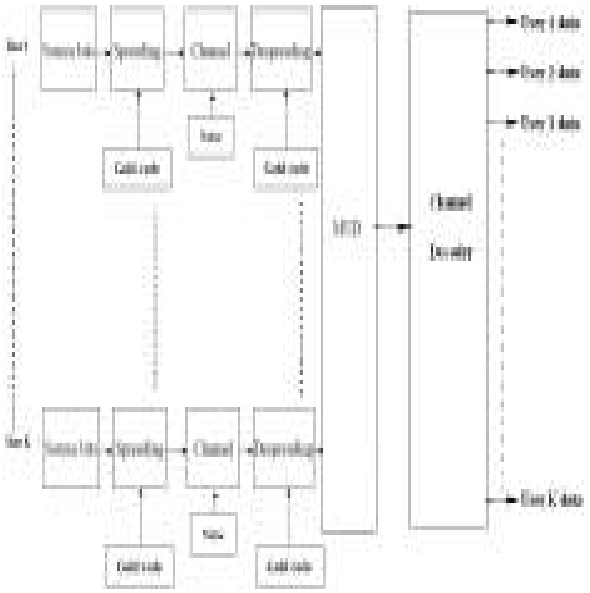

FIGURE 3: Block Diagram of Multi- user DS-CDMA system

IV. RESULT AND DISCUSSION

Fig.4, Fig. 5 and Fig. 6 shows the performance of multiple users operating over multipath fading channel whose channel state information is unknown to the receiver.

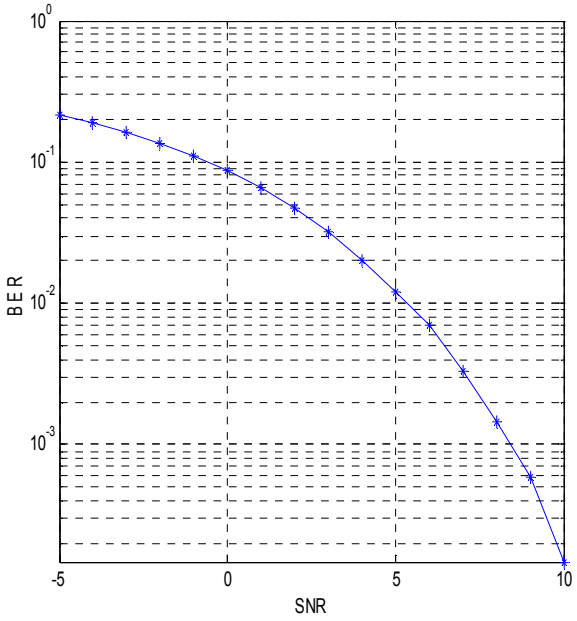

FIGURE 4: Bit Error Rate Performance for Multiuser Detection with 3-users and SNR of -5:1:10(dB)

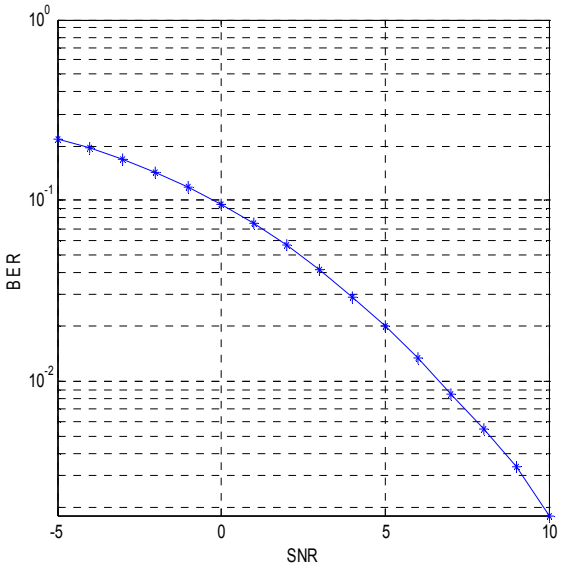

FIGURE 5: Bit Error Rate Performance for Multiuser Detection with 5-users and SNR of -5:1:10(dB)

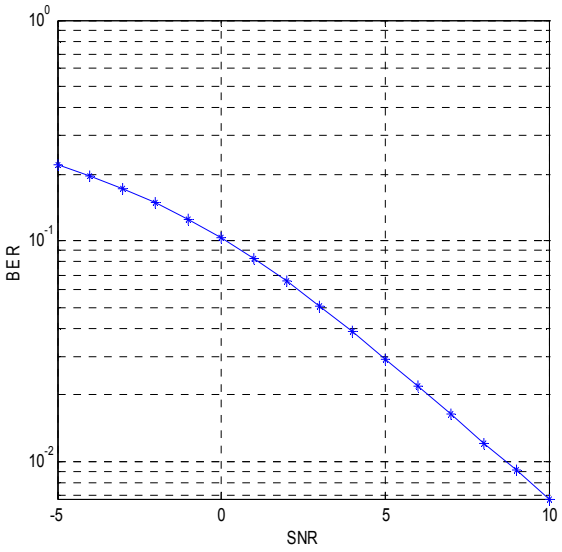

FIGURE 6: Bit Error Rate Performance for Multiuser Detection with 7-users and SNR of -5:1:10(dB)

From the bit error rate performance of multiuser detection, it is observed that even though if the number of users increases, still we get almost same BER. All the multiuser detection schemes offer substantial improvement over the conventional detector especially in the case of high cross correlation. Moreover, the proposed algorithm performs nearly same as the optimal MUD especially in the case of high cross correlation where curves are nearly indistinguishable. The conventional receiver is found to perform very badly in presence of a dominant interfere with average error

probability reaching 0.5 while the performance of other schemes are almost constant. The proposed algorithm performs much better than a decorrelating and MMSE detector showing that it has high near far resistance.

Therefore, in other word we can say that multiuser detection is a better strategy of mitigating the effect of Multiple Access Interference (MAI) in DS-CDMA system effectively thus improving the system performance.

V. CONCLUSION

This paper explores the use of detection techniques to mitigate the effects of the uplink MAI. These techniques reduce the BER for the individual users in addition to improve the overall system capacity. From the work carried out in this paper and from summarized results it can be concluded that,

- A low-complexity iterative receiver structure for decoding multiuser information data in a convolutionally coded asynchronous multipath DS-CDMA system is a better strategy of mitigating the effect of multiple access interference (MAI) in DS-CDMA system thus improving the system performance iteratively.
- Simulation results demonstrate that, in asynchronous multipath fading channels, the proposed turbo multiuser receiver outperforms significantly than the conventional non-iterative RAKE receiver within three iterations.
- Moreover, at high signal-to-noise ratios, the performance of the multiuser receiver in a multiuser environment is even better than that of a single-user RAKE receiver in a single-user environment.

Simulation results demonstrate that the proposed low-complexity turbo multiuser receiver offers performance approaching that of the single-user channel with a high efficiency at a larger rate.

ACKNOWLEDGMENT

The author sincerely thanks to Prof. Nitin N. Mandaogade, Prof. S.R. Hirekhan, and Prof. Rahul D. Ghongade for their valuable suggestion, criticism and time to time encouragement.

The author also expresses his warm appreciation to his Brother Amol, for his help in editing this article.

REFERENCES

[1] S. Verdu, “Minimum probability of error for asynchronous gaussian multiple-access channels,” *IEEE Trans. Inform. Theory*, vol. 32, p. 8596, Jan. 1986.

[2] R. Lupas and S. Verdu, “Linear multiuser detectors for synchronous code-division multiple-access channels,” *IEEE Trans. Inform. Theory*, vol. 35, p. 123136, Jan. 1989.

[3] R. T. S. Z. Xie and C. K. Rushforth, “A family of suboptimum detectors for coherent multiuser communications,” *IEEE J. Select. Areas Commun.*, p. 683690, May 1990..

[4] U. M. M. Honig and S. Verdu, “Blind adaptive multiuser detection,” *IEEE Trans. Inform. Theory*, vol. 41, p. 944960, 1995.

[5] T. C. Yang and W.-B Yang. "Interference Suppression for code division multiple-access communications in an underwater acoustic channel,".J . Acoust. soc. Am 126(1), 220-228, July 2009.

[6] ccccS. Moshavi, “Multi-User detection for DS-CDMA Communications,” IEEE Commun. Mag., Oct. 1996.

[7] P. Alexander, A. Grant and M. C. Reed, “Iterative detection of code-division multiple-acess with error control coding,” European Trans. Telecommun., Vol. 9, pp. 419–426, Aug. 1998.

[8] P. Alexander and A. Grant, “Iterative channel and information sequence estimation in CDMA,” Proceedings of IEEE Sixth International Symposium on Spread Spectrum Techniques and Applications, pp. 593–597, Parsippany, NJ, Sept. 2000.

[9] U. M. M. Honig and S. Verdu, “Blind adaptive multiuser detection,” *IEEE Trans. Inform. Theory*, vol. 41, p. 944960, 1995.