ANALYSIS OF ROBUST MILTIUSER DETECTION TECHNIQUE FOR COMMUNICATION SYSTEM

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ABSTRACT

Today, in this information-hungry society, Internet traffic such as multimedia streaming applications is driving the demand for high speed data packet wireless services. Multiple access interference (MAI) limits the capacity of Direct Sequence Code Division Multiple Access (DS-CDMA) systems. Multiuser detection is an approach which uses filters for the optimization. However, the main drawback of the optimal multiuser detection is one of complexity so that suboptimal approaches are being sought. Much of the present research is aimed at finding an appropriate trade off between complexity and performance. These suboptimal techniques have linear and non-linear algorithms. The use of multiple transmit and receive antennas has been proposed for the fourth generation code-division multiple access (CDMA) wireless cellular networks in order to meet these demands. Receivers proposed for such systems thus far have been based on the assumption that perfect knowledge of the channel state information is available. Multiuser detection is an approach which uses filters for the optimization. In this work, the non-linear approach for multi user detection is applied. The grouping based on signal strength is applied on successive interference cancellation scheme. The BER is improved compared to SIC scheme.

Key Word: *DS-CDMA, GSIC, Interference Cancellation, SIC, MUD, MAI*

Introduction

Time Domain Multiple Technique (TDMA), Frequency Multiple Access Technique (FDMA) and Code Division Multiple Access (CDMA) The idea of CDMA was originally developed for military communication devices and developed by Allies in World War II. In CDMA technology every mobile station or user will be allocated the entire spectrum all of the time . It uses codes to identify each user connection. In conventional DS/CDMA system it treats each user separately as a signal and other users are considered as noise or multiple access interference (MAI).All mobile station or users interfere with all other users. These interferences added to primary (main) message signal and therefore degradation in system performance. The near/far issue is serious and tight power control, with attendant complexity is necessary to combat it. Potentially significant capacity increases and near/far resistance can theoretically be achieved if the negative effect that each user has on others can be cancelled.

To overcome these problems (of the conventional CDMA system) Multiuser Detection (MUD) is used. In this technique all users are considered as signals for each other. After 3rd generation cellular mobile communication system multi-carrier code division multiple access (MC-CDMA) networks are proposed for fourth generation (4G) system. These networks are defined by the ability to integrate heterogeneous networks, particularly radio mobile networks and wireless networks, which offers anytime anywhere access of all kind of services. The rapid growth of internet services in portable computing devices creates a strong demand for high speed wireless data services. Key issues to fully meet these evolution. perspectives are based upon the multi-carrier systems which have become popular for their spectral efficiency and robustness against frequency-selective fading and inexpensive implementation. Multi-carrier code division multiple access (MC-CDMA) is a technique that combines the advantage of multi-carrier modulation with that of code division multiple access to offer reliable high data rate downlink cellular communication services. It is used, as it has proven to be better than conventional CDMA, FDMA and TDMA networks.

- Issues in practical implementation (Limitations of MUD)
  - Processing complexity
  - Processing delay
  - Sensitivity and robustness

Related Works

A high capacity, low complexity and robust system design for a successive interference cancellation (SIC) system were proposed and analyzed. Multicarrier Code-Division Multiple Access (MCCDMA) was used to suppress multipath and to overcome or minimize the multipath channel estimation problem in single carrier SIC systems. Furthermore, an optimal power control algorithm for MC-CDMA with SIC was derived, allowing analytical bit-error rate expressions to be found for an un-coded system. Low-rate forward error-correcting codes are then added to the system to achieve robustness. It was observed that the capacity of the coded system approaches the additive white Gaussian noise capacity for SIC, even in a multipath channel fading with channel estimation error. This indicates that MCCDMA technique is very attractive for systems employing SIC. A low-complexity MC-SIC system was proposed to increase CDMA capacity in a multipath fading channel, and its analytical BER performance was derived. In addition, the optimum PC distribution for such a system was derived in the presence of channel estimation error.

Using this distribution, it was shown that coded MC-CDMA is capable of mitigating the multipath fading channel for a SIC system, and able to nearly achieve the performance of SIC in a flat-fading channel, even with a substantial amount of channel estimation error. The derived PC distribution also allows the capacity falloff with cancellation error to be gradual relative to other IC systems, if the IC accuracy is conservatively estimated. DS-CDMA System with Linear Multiuser Detection in AWGN Channel” Direct sequence code division multiple access (DS-CDMA) technology is a popular wireless technology. In this paper a comparative study between linear multiuser detectors, optimal multiuser detector, and conventional single user matched filter in DS-CDMA system. Analysis and simulations was conducted in synchronous AWGN channel, and Gold code sequences are used as the spreading codes. Their study shows that optimal multiuser detector performs better than the conventional matched filter and linear multiuser detector in terms of BER performance. However, optimal multiuser detector suffers from complex computation and costly implementation. MMSE detector provides better error performance than the decorrelating detector, but it utilizes the estimation of the received powers.The optimal multiuser detector performs better than the conventional matched filter and also the linear multiuser detectors. However, this detector is more complex for implementation in practical DS-CDMA system. MMSE detector generally performs better than the decorrelating because it considers the background noise. As number of user increases, the performance of all detectors will degrades. This is because the density of MAI becomes higher with increasing the number of interfering users.

Problem formulation

In the CDMA wireless system the SNR is affected due to interference and noise in the channel or environment of medium due to interference the signal received with low SNR or higher BER at the receiver end and generate some delay due to successive process of signals hence performance also decrease as well, so here I am using a technique to reduce delay and improve SNR value which is known as Group Based Successive Interference Cancellation Technique (GSIC) with the help of MATLAB Tool.

Methodology

By using this technology Bit Error Rate (BER) can be reduce by processing the signals in group of certain signals simultaneously. For this work MATLAB tool is used here and investigate the received signal with different values of SNR, different length of message and PN Sequence and observe the BER and compare it with SIC for BER improvement.

MUD algorithm

Figure A Shows the hierarchical categorization of different techniques adopted for the multiuser detection. The efficient algorithm for the implementation of MUD is suboptimal methods. The recent development in these techniques further categorized in two methods, i.e. linear and non-linear. Due to simple in implementation and easy to processing nonlinear techniques are more powerful and developed algorithm. Further, the successive interference cancellation technique (SIC) and group wise successive interference cancellation technique (GSIC). Our emphasis is on finding a suboptimal method to find a combination having proper complexity and performance. In this dissertation, we study and compare the both MUD implementation techniques i.e. Successive Interference Cancellation Technique and Group based Successive.

Interference Cancellation Technique

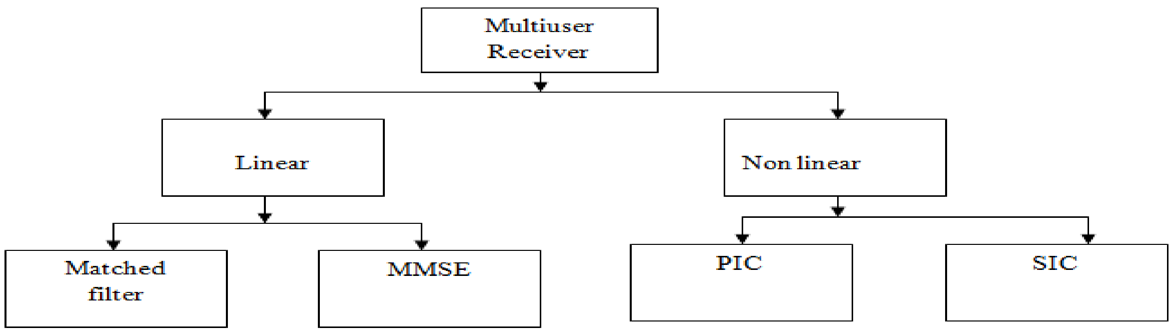

Figure A : MUD algorithm in flowchart form

Group based Successive Interference Cancellation

Group wise Successive Interference Cancellation Technique (GSIC) Group based multiuser detection has recently emerged as a effective solution for multiuser detection, since GSIC provides interference cancellation in groups instead of individual user signal, and the groups can be straightforwardly formed by considering users that have equal transmission rates. Within a group, any type of detectors can be implemented, although the simplest, most common choice is to use matched filter receivers. Group wise successive interference cancellation (GSIC) performance analyses and iterative power control schemes have been presented in for a simplified case that considers perfect interference cancellation among groups and matched filter receivers within groups.The performance of a DS-CDMA system is limited by multiple access interference (MAI) and near-far effect. Such problem arises from the use of the conventional single-user detector, which ignores the existence of other available users. As a consequence, whenever the number of active user’s increases to a certain level or some user’s signals becomes extremely strong, weak users with the conventional single-user detector may lose communication because of the overwhelming MAI.

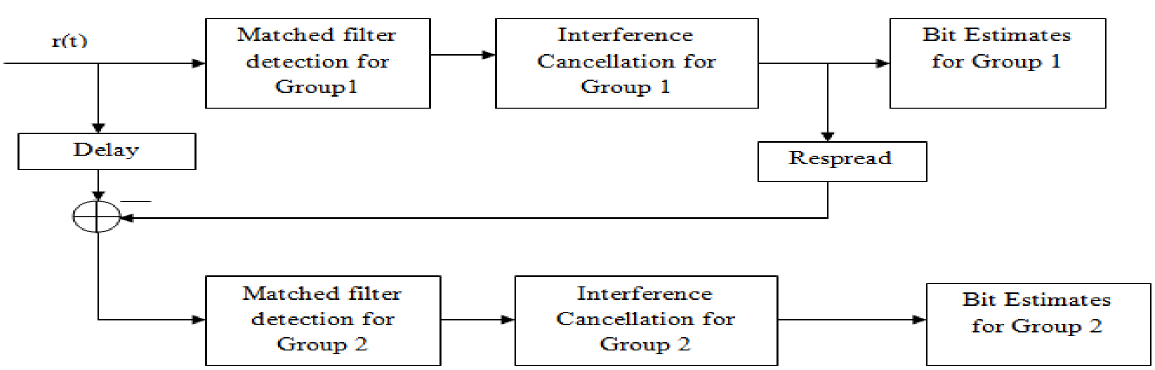

Figure B : Block diagram of Group based SIC

Figure B shows the system block diagram of GSIC based DSCDM system for the multi-user detection. Baseband signal of p^{th} user is given by,

$$u_p(t) = \sum_{i=0}^{\infty} a_p(i) \bullet c_p(i) \bullet s_p(t - iT - \tau_p)$$

Received signal is given by,

$$b(t) = \sum_{p=1}^{P} u_p(t) + z(t)$$

Output of matched filter is

$$b_p = \int_0^T b(t) s_p(t) dt$$

$$= c_p a_p + \sum_{j \neq p}^{P} a_j c_j \int_0^T s_p(t) s_j(t) dt + \int_0^T s_p(t) z(t) dt$$

- the factor xjcj are introduces to cancel the **Multiple Access Interference** (MAI). Two approaches are used for the determination of xj and cj. In first method, the xj and cj are estimated separately. In second method, the product of xjcj is estimated using the correlator output. The strongest incoming signal has to be cancelled out before the detection of other signals because it is most negative. The best estimate of signal strength is from the strongest signal because the best bit decision is made from that signal; further the strongest signal has least MAI, since the strongest signal is excluded from its own MAI. The optimal maximum likelihood (ML) detector that jointly detects all active users' signals eliminates the MAI and provides substantial increase in system capacity. However, the complexity of the optimal ML detector is exponentially proportional to the number of users, so it is impractical for implementation, and was discussed in prior sections. Therefore, new version of SIC is proposed. This extension of SIC try to approach the performance of the optimal ML detector with reduced computational complexity. As a sub-optimal multi-user detector, the group-wise successive interference cancellation (GSIC) receiver was considered for CDMA system. In the GSIC receiver for the CDMA system, user signals are divided into groups according to data rates and interference from each group is estimated and subtracted successively from the received signal in an order of decreasing data rate. The strongest outputs with similar signal strength are re-spread with the appropriate chip sequences, after which the group they belong to is cancelled. This process is repeated until the weakest group is demodulated.

Simulation Results and Discussion

In successive interference cancellation scheme interference is removed successively. Sic consumes more time for processing. So delay is introduced. In Group based SIC the received signal is divided in the form of groups based on strength of signal. So the time consumption is reduced in GSIC . Also, BER is decreased in GSIC compare to SIC.

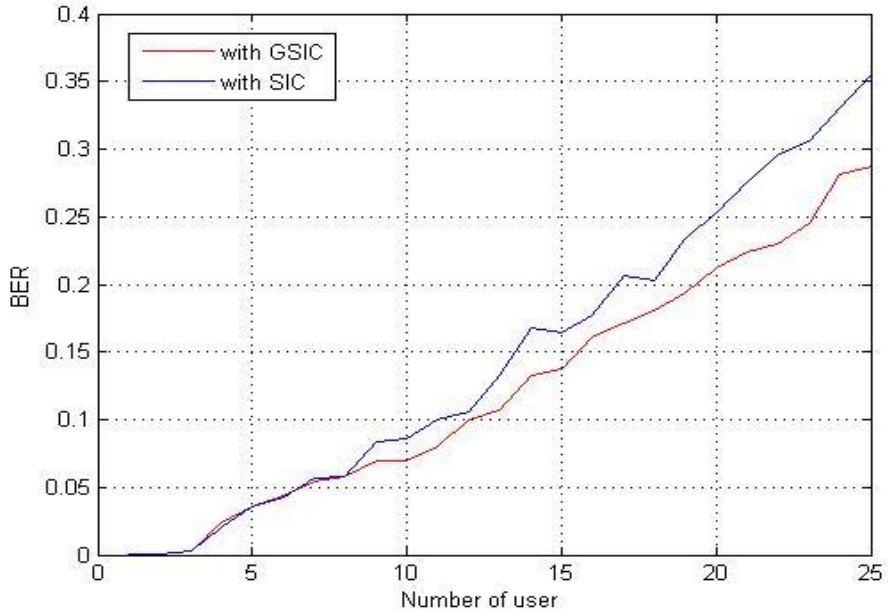

Figure C: BER for 25 users with SNR=15dB

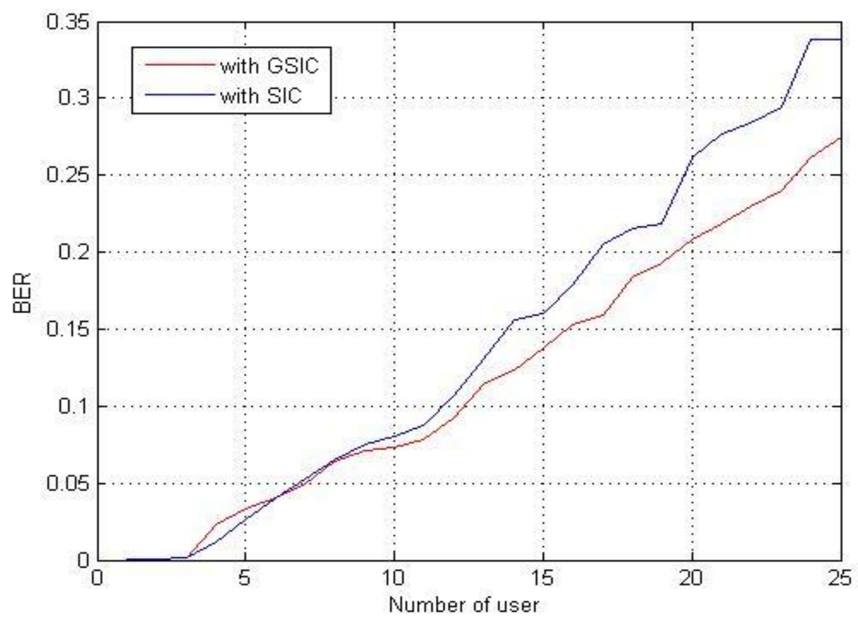

Figure D : BER for 25 users with SNR=20dB

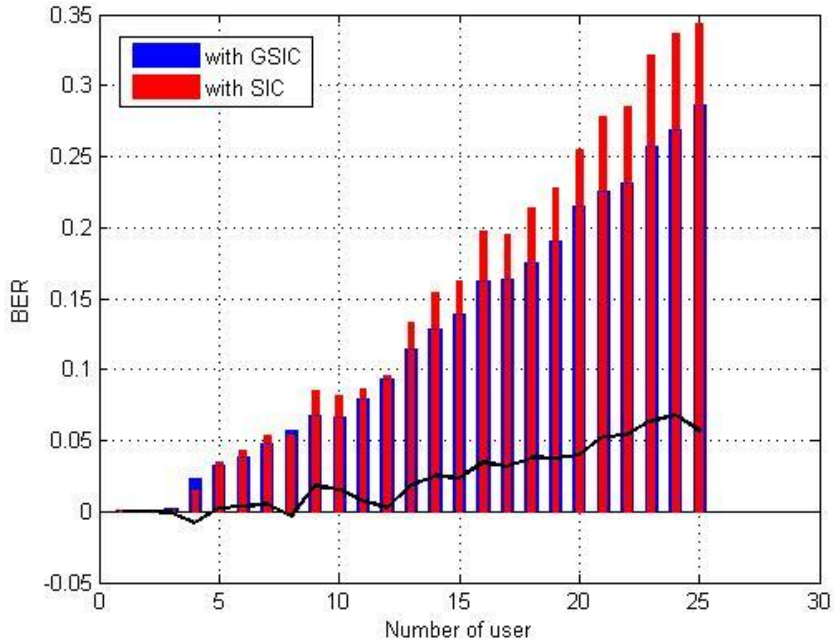

Figure E : Analysis Chart of Improvement in BER between GSIC

Improvement in Bit Error Rate is shown in below table of Group based SIC with SIC.

NO. OF USER	SIC	GSIC	BER IMPROVEMENT
10	0.0800	0.0732	0.0068
11	0.0876	0.0780	0.0096
12	0.1068	0.0928	0.0140
13	0.1304	0.1136	0.0168
14	0.1564	0.1236	0.0328
15	0.1600	0.1380	0.0220
16	0.1788	0.1528	0.0260
17	0.2052	0.1596	0.0456
18	0.2156	0.1832	0.0324
19	0.2188	0.1928	0.0260
20	0.2616	0.2080	0.0536
21	0.2764	0.2188	0.0576

22	0.2836	0.2300	0.0536
23	0.2944	0.2404	0.0540
24	0.3384	0.2612	0.0772
25	0.3389	0.2744	0.0645

Conclusion and future work

The inclusion of GSIC in a CDMA receiver can significantly improve its performance relative to that of conventional CDMA receiver where no interference cancellation is attempted. GSIC appears to be more resistant to fading than SIC, and achieves better result with regards to BER and ability performance, it is due to extremely from a high processing delay. While doing practical execution, problem occurred due to sensitivity, robustness and processing delay. In determining overall capacity, Capacity improvements only on the uplink would only be partly used anyway. Doing multiuser detection Cost must be as low as possible so that there is a performance/cost trade off advantage. Using better channel estimation technique the performance of the GSIC can be improved further. For delay, one of the way is to limit the number of cancellation also Group wise SIC (GSIC) has proposed to deal with delay it may degrade the routine. Study of GSIC and comparison it to PIC and EGSIC could be left for some future work.

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