Interference Reduction in CDMA using SIC

Sukrita Swarnkar, Nipun Mishra, Mohan Awasthy

Abstract - In a code division multiple access system, multiple access interference coupled with near-far problem is one of major factors limiting system performance. To overcome these issues, various multiuser detection schemes have been proposed multiple access interference limits the capacity of Direct Sequence Code Division Multiple Access systems. In CDMA systems MAI is considered as additive noise and a matched filter bank is employed. Traditionally, multiuser detector code-matched and a multiuser linear filter are used which increases the complexity of the system due to its nature of operation. Multiuser detection is an approach which uses both these 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 tradeoff between complexity and performance. These suboptimal techniques have linear and non-linear algorithms. In this work, we introduce Successive Interference Cancellation which is a nonlinear suboptimal method of MUD and is based upon successively subtracting off the strongest remaining signal. Further analysis is to be carried out and simulations to be done for better understanding of SIC.

Index Terms - Successive Interference Cancellation, Multiple Access Interference, Multiuser Detection, Code Division Multiple Access

1. INTRODUCTION

CDMA stands for Code Division Multiple Access [1]. It is a digital cellular technology that uses spread-spectrum technique means it works by digitizing multiple conversations. It is developed by Qualcomm, Inc. and standardized by the Telecommunications Industry Association as an Interim Standard IS-95. In this several users share the share the same physical medium i.e. same frequency band at same time In CDMA every communicator will be allocated the entire spectrum all of the time. It uses codes to identify connection. A conventional DS/CDMA system treats each user separately as a signal, with other users considered as noise multiple access interference. All users interfere with all other users and the interferences add to cause performance degradation. The near/far problem is serious and tight power control, with attendant complexity is needed to combat it. All users in a CDMA system interfere with each other. Potentially significant capacity increases and near/far resistance can theoretically be achieved if the negative effect. That each user has on others can be canceled. A solution to the shortcomings of the conventional CDMA system is Multiuser Detection in which all users are considered as signals for each other.

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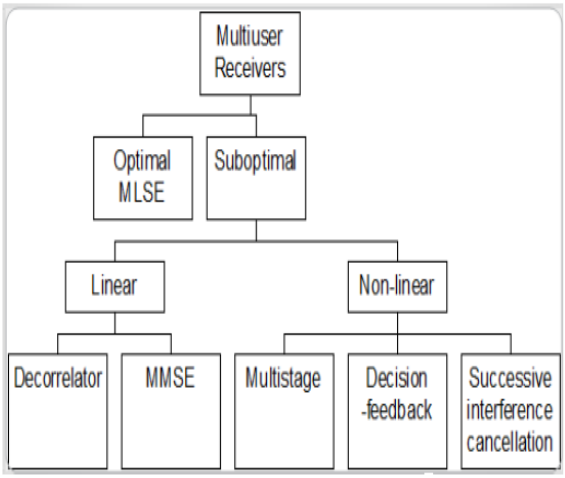
2. INTERFERENCE CANCELLATION SCHEME

Interference is the major limiting factor in the performance of cellular radio system. sources of interference include another mobile in same cell a cell in progress in a neighboring cell, other base stations operating in the same frequency band .we try to reduce the interference by various methods [2] Limitations of a Conventional CDMA System A conventional DS/CDMA system treats each user separately as a signal, with the other users considered as either interference, Multiple Access Interference, or noise[3]. The detection of the desired signal is protected against the interference due to the other users by the inherent interference suppression capability of CDMA, measured by the processing gain. The interference suppression capability is. however, not unlimited and as the number interfering users increases, the equivalent noise results in degradation of performance, i.e., increasing bit error rate BER or frame error rate. Even if the number of users is not too large, some users may be received at such high signal levels that a lower power user may be swamped out. This is the near/far effect single user receivers treat multiple access interference (MAI), which is inherent in CDMA, as if it were additive random noise. Multi-user receivers use knowledge of the spreading sequences to exploit the structure of MAI. The major difference between single-user detector and Multi-User Detector (MUD) is that in MUD, the users are jointly detected for their mutual benefit. Multi user detection is a promising approach to overcome the limitations of single user CDMA receiver and improve system capacity. Since computational complexity of multi-user detectors like optimal receivers, De correlator, Minimum Mean Square

Error receivers are computationally complex linear MUD like interference cancellation receivers are considered. In an interference cancellation scheme, the signal is first passed

through a bank of correlators and then each user's signal is re-constructed and cancelled from the received signal.



Flowchart for MUD Algorithms

3 METHODOLOGY

Successive Interference Cancellation Scheme In each iteration of SIC [2], the entire users signal is estimated and the signal with the largest power is regenerated and subtracted from the buffered received signal.

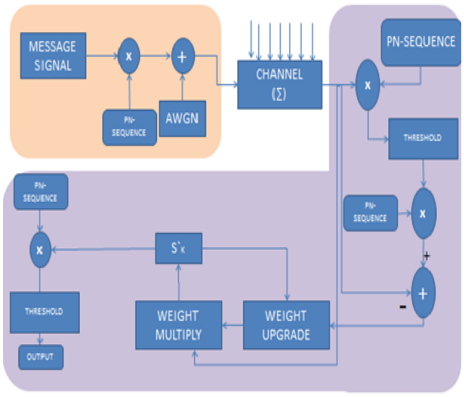


Fig1

Fig1 Sampled output of the matched filter for the kth user: The remaining signals are now re-estimated and a new largest user is selected and the process continues until all the users' signals have been recovered or the maximum allowable number of cancellations is reached. Successive interference cancellation receiver is shown in Fig.1. The SIC receiver almost has an optimal performance and is quite reliable but number of iteration to cancel out all the MAI is directly proportional to the number of users. Hence the computation time is quite large

$$y_k = \int_0^T y(t)s_k(t)\,dt$$
$$= c_k x_k + \sum_{j\neq k}^{K} x_j c_j \int_0^T s_k(t)s_j(t)\,dt + \int_0^T s_k(t)z(t)\,dt$$

In this equation to cancel the Multiple Access Interference (MAI), the factors XjCj Are needed, in addition to the cross-correlations. One of the methods could be estimating xj andCj separately. The other approach would be to estimate the product XjCj directly by using the correlator output. The strongest signal has to be cancelled 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 on that signal the strongest signal has the minimum MAI, since the strongest signal is excluded from its own MAI. An alternative called the Parallel Interference Cancellers simultaneously subtract off all of the users' signals from all of the others. It works better than SIC when all of the users are received with equal strength Decision is made for the stronger user 1:X=Sgn(y1) Subtract the estimate of MAI from the signal of the weaker user:

$$\hat{x}_2 = \operatorname{sgn}\left(y_2 - rc_1\hat{x}_1\right)$$
$$= \operatorname{sgn}\left(c_2x_2 + rc_1\left(x_1 - \hat{x}_1\right) + z_2\right)$$

All MAI can be subtracted from user 2 signal provided estimate is correct. MAI is reduced
and near/far problem is alleviated.
Parallel Interference Cancellation Scheme
In contrast to the SIC receiver, the PIC [3] receiver shown in Fig. 2 estimates and subtracts out all of the MAI for each user in parallel. The initial estimates of the transmitted data of the nth user are achieved by dispreading the received signal r(K) with the respective modified sequences Zn(j, j,2)(K) leading to

$$X_{n,0}^{(1,2)}(i) = \sum_{j=t_p}^{k-1-t_p} r(i-L+l) - Z_n^{(1,2)}(L-\tau_n)$$

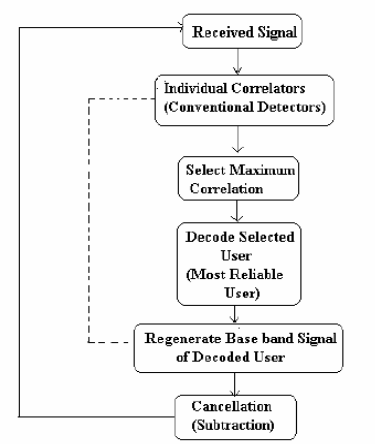


Fig2 Successive Interference cancellation scheme

4 SIMULATION RESULTS

When the transmitted signal and the received signal compared (shown in Fig 3 and 4), we get zero error because of higher SNR. So both the figures are same.

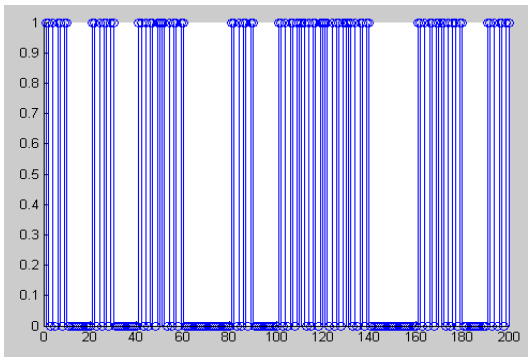


Fig3 Transmitted signal (WHEN ERROR=0) i.e. SNR=100

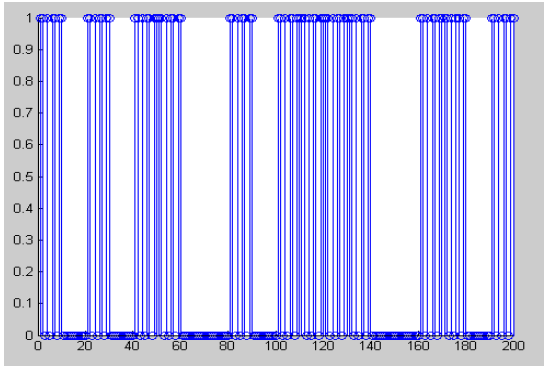


Fig4 Received signal (WHEN ERROR=0)i.e SNR=100

Applying the successive interference cancellation (SIC), the comparison of conventional plot of BER vs. Number of users and SIC plot of BER vs. Number of users, for different bits as been performed by MATLAB simulation.

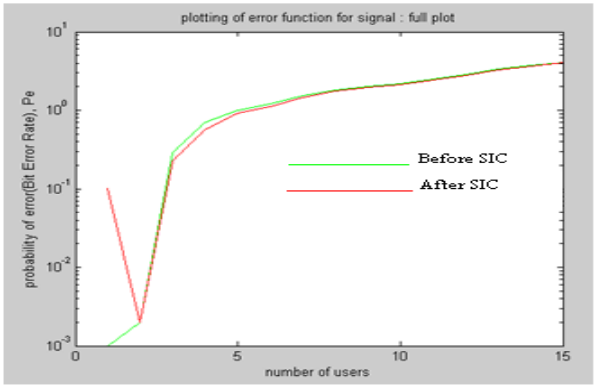


Fig 5 simulated output

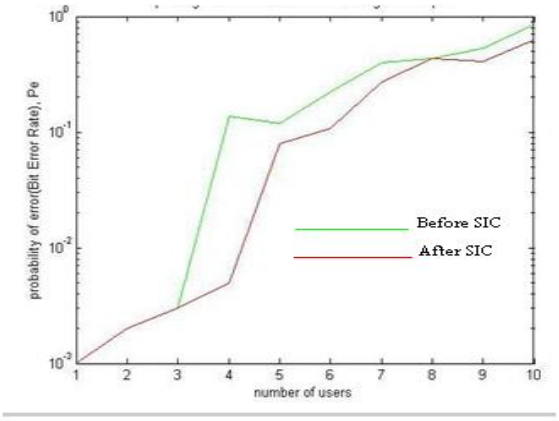


Fig 6 simulated output

Fig (5,6) It gives the plot for BER VS Number of Users taking 100000 information bits, red curve indicates BER after SIC and green curve indicates BER without SIC, in both the cases the SNR is 20 db.It is clear from the above plot that the BER decreases when SIC technique is applied. This result shows a significant improvement in the process of Multiuser detection for CDMA systems

5 CONCLUSION

The inclusion of SIC in a CDMA receiver can significantly improve its performance relative to that of conventional CDMA receiver where no interference cancellation is attempted. SIC appears to be more resistant to fading than PIC, and achieves better result with regards to BER and capacity performance, it suffers mightily from a high processing delay.

6 REFERENCES

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