ISSN 2230-7850 Impact Factor : 4.1625 (UIF) Volume - 6 | Issue - 6 | July - 2016

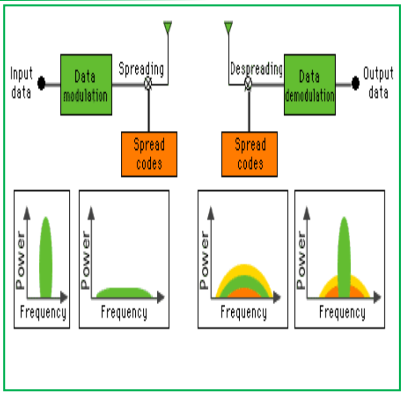
Indian Streams Research Journal
International Recognized Multidisciplinary Research Journal
ISSN No : 2230-7850 Impact Factor : 4.1625 (UIF) [Yr. 2016]

ISRJ Indian Streams Research Journal

"DESIGN AND SIMULATION OF BASE BAND DS-CDMA MULTIUSER RECEIVER DETECTORS OVER NOISY CHANNEL"

R. G.Koli[1] , S.K.Parchandekar[2] ,Jagdish Prasad[3] and Atul Pawar[4]
[1]M.Tech. Scholar of Department of Engineering, in Walchand college of Engineering Sangli, India.
[2]Associate Professor Department of Electronics Engineering Walchand college of Engineering Sangli, India.
[3](Scientist 'E'),Department of DLSPD, DOFI , Research Centre Imarat, DRDO , Hyderabad.
[4](Scientist 'F') ,Head of Department of DLSPD, DOFI , Research Centre Imarat, DRDO , Hyderabad.

ABSTRACT—
In present day wireless communication systems the resigned for high transmission data rates supporting large number of users. The available bandwidth is limited and costly, therefore, the requirement of new technologies that utilize the available spectrum more efficiently. The main contribution of this master thesis is development of algorithms for simulation of Multiuser Detection



and channel interference cancellation, which offer an essential improvement in bit error rate performance. The proposed method could be used to increase the number of users in systems with fixed available bandwidth. The Spread spectrum technology has come into bud from a military technology into one of the fundamental building blocks in today (current) and 3rd, 4th, 5th generation wireless systems. The spread-spectrum technology provides anti-jam capabilities through a processing gain that results from using a wide band (large bandwidth) signal and it also provides capacity enhancement and ruggedness against noise. This thesis presents the design and implementation of a direct sequence spread spectrum (DS-CDMA) system. The up growing communication system always needs a system which is simple but more reliable for security applications. To fulfill these Simulation and Development of DS-CDMA Multiuser Detection Technique can play an important role. The main objective of my project is to Simulation and Development of DS_CDMA Multiuser Detection Technique which provides a security for data transmission. The conventional matched filter DS-CDMA detector follows a single user detection strategy in which every each user is detected separately without regard for the all users. Better strategy is multi-user detection and information about multiple users is used to improve detection off each individual all user, Reduced Multiple Access interference travel to capacity Increase of the system. It also solves the near/far problem.

Index Terms—*DS-CDMA, MAI, MUD, SIC, PIC, BER.*

I. INTRODUCTION

A CDMA stands for Code Division Multiple Access. 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.Code Division Multiple Access (CDMA) is a spread spectrum technique that uses neither frequencychannels nortime slots. All users in a CDMA system use the same frequency band and transmit simultaneously. Association (TIA) as an Interim Standard (IS-95).

In a Code Division Multiple Access (CDMA) system, many users use simultaneously the entire frequency band to transmit their data and users' data is separated on the basis of their unique spreading code.

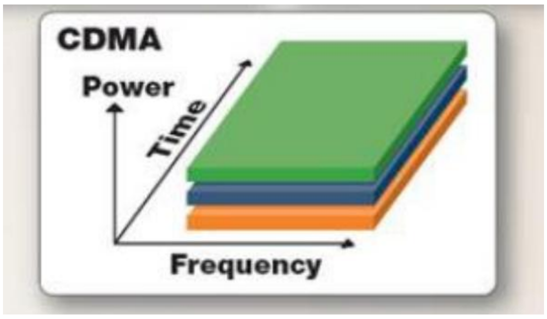


Fig. 1: Code Division Multiple Access (CDMA)

It is logical that the user spreading code be mutually orthogonal so as to avoid interference among different users. The DS-CDMA system is well known for eliminating the effects of Multiple Access Interference (MAI) which limits the capacity and degrades the BER performance of the system. This thesis deals with the bit Error Rate (BER) performance of a DS-CDMA system over AWGN and on different modulation techniques, which is affected by the different number of users. In DS-CDMA systems, overcoming near/far effects and fading is imperative for satisfactory performance. One way to combat the near/far effect is to use stringent power control, as is done in most of the commercial systems. Another approach is Multi-User Detection (MUD). In addition to mitigating the near/far effect, MUD has the more fundamental potential of raising capacity by cancelling MAI. This paper also shows performance evaluation of DS-CDMA with Successive Interference Cancellation (SIC) receiver, which is a sub-optimal method of Multiuser detector (MUD).

II. DS-CDMA

Direct sequences code division multiple access (DS-CDMA) is a popular wireless technology. In DS-CDMA communications, all of the user's signals overlap in time and Frequency and cause mutual interference .The conventional DS -CDMA detector follows a single user detection strategy in which each user is detected separately without regard for the users. Better strategy is multi-user detection, where information about multiple users is used to improve detection off each individual user. This article describe numbers of important user DS-CDMA detectors.DS-CDMA is a type of spread-spectrum communication system in which multiple signal channels. Occupy the same frequency band, being distinguished by the use of different Spreading codes.

III. BRIEF REVIEW OF LITERATURE SURVEY

Since thesis work cannot be complete without the literature review because literature review helps us to find out the problem statement for further research and thus also able to know progress or new invention in the relevant field. In wireless communication the main requirement is signal reception with minimum noise or interference or we can say with higher SNR value. This requirement is the key source for new research or invention of new techniques because there are various types of noise and interference and many factors in the environment which affects the performance of CDMA wireless systems. Some of techniques are used by various research scholars in different mode or different methods to improve the band width efficiency, performance, capacity and SNR of the CDMA wireless system for different types of channels and noise environment.

IV. PROPOSED SYSTEM

A.Multiuser Detection (MUD)

Multiuser detection is a technology that spawned in the early 80's. It has now developed into an important, full-fledged field in multi-access communications. Multiuser Detection (MUD) is the intelligent estimation/demodulation of transmitted bits in the presence of Multiple Access Interference (MAI). Because all users are considered as signals for each other, therefore, instead of users interfering with each other, they are all being used for their mutual benefit by joint detection. The multiuser channel is just the superposition of many single user channels. Single user and multiuser spread spectrum systems have similar transmitter and receiver structures. Reduced interference leads to capacity increase of the system. It also solves the near/far problem. A cellular system has a number of mobiles which communicate with one base station (BS). The BS has to detect all the signals whereas each mobile is concerned with its own signal. This implies that the BS must know all the chip sequence. In multiuser detection, one of the main drawbacks is that of complexity. There is always a trade-off between complexity and performance of the system. Due to above mentioned two points, the main use of the multiuser detection system is for the BS, or in the reverse link (mobile to BS). The Base Station records information only on the mobiles in its own cell. This limits improvements to be expected in a MUD system.

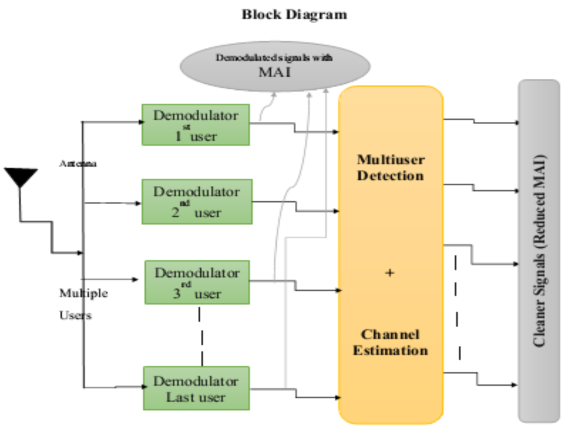


Fig.2 Base Station Receiver

B.MUD Concepts and Techniques:

The signal received at the BS is the superposition of signals from all users, multipath components for each user's signal, and Additive White Gaussian Noise (AWGN).There are Nu users in the system and the data signals from these users are designated as d1(t),d2(t),...,dNu(t). The data symbols within the data signals are spread by multiplying with Respective spreading sequences K1(t), K2(t),... ,KNu(t). The channel introduces delays τ1,τ2,...,τNu to signals from different users, and A1(t),A2(t),...,ANu(t) are the fading coefficients for the single resolvable path of each user. Spreading sequences K1(t), K2(t),... ,KNu(t) is given by

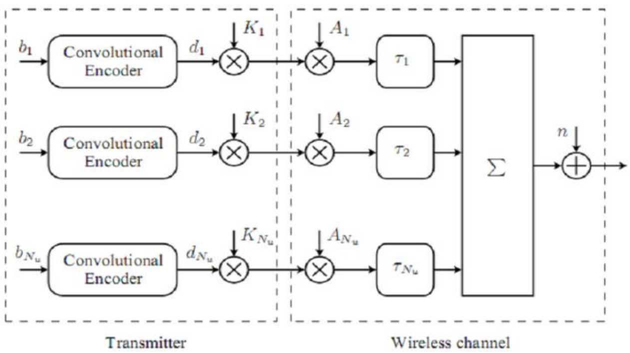


Fig.3: Communication via satellite uplink

$$\bar{K}_i(t) = \sum_{m=1}^{N} C_{im}\, p(t-(m-1)T_e)$$

Where,
C_{im} is the m^{th} chip of the spreading sequence K_i (t).
N is the length of spreading sequence.
p(t) is the chip pulse shape that is assumed to be rectangular
Received signal at baseband is given by

$$y(t) = \sum_{k=1}^{K} u_t\,(t) + z(t)$$

Where K number of users z(t) is the complex AWGN Sampled output of the matched filter for the kth user:

$$y_k = \int_0^T y(t)s_k(t)dt$$

$$= C_k X_k + \sum_{j\neq k}^{K} X_j C_j \int_0^T S_k(t)S_j(t)dt + \int_0^T S_k(t)Z(t)dt$$

1^{st} term - desired information
2^{nd} term - MAI
3^{rd} term - noise
Let's assume two-user case (K=2), and

$$r = \int_0^T S_1(t)\, S_2\,(t)dt$$

Outputs of the matched filters are:

$y_1 = C_1X_1 + rC_2X_2 + Z_1$; $y_2 = C_2X_2 + rC_1X_1 + Z_2$

Detected symbol for user k:

$$X_k = \mathrm{sgn}(y_k)$$

If user 1 is much stronger than user 2 (the near/far problem), the MAI term rc_1x_1 present in the signal of user 2 is very large.

C. Optimum Multiuser Detection

The optimum solution jointly maximizes the likelihood functions for K users by choosing the bits {b1, b2, …, bK} that minimizes the mean square error (MSE) between the estimated received signal and the actual composite received signal, which is the sum of the received signals for all K users plus noise. The complexity of the optimum detector is O (2K), which increases exponentially with the number of users. In addition to complexity, the optimum detector requires a priori knowledge of the amplitudes of all K users, which is typically not available to the receiver. Although, the optimum detector has been to dramatically increase the capacity of the system, its complexity deems it infeasible to implement in the real world. The work by Verdu gave hope that the capacity can ultimately increase using suboptimal multiuser detectors that balance between the two extreme cases of using the optimal detector or the matched filter detector.

Result-

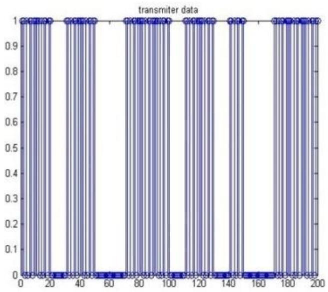


Fig.TX (When Error=0)i.e. SNR=100

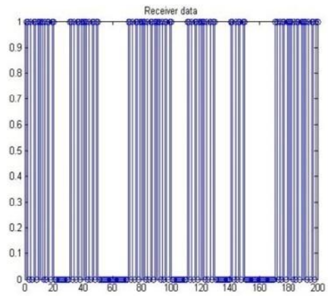


Fig.RX(When Error=0)i.e. SNR=100

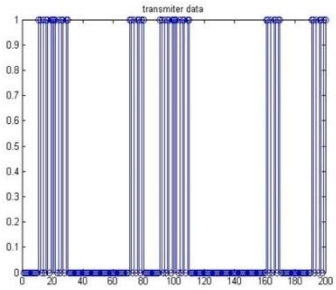


Fig.TX (When Error=9)i.e. SNR=10

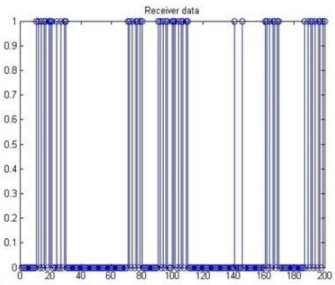


Fig. RX(When Error=9)i.e. SNR=10

When the transmitted signal (ts) and the received signal (rss) are compared (shown in Figs 1st) we get zero error because of higher SNR. So both the figures are same.

In Fig. 2nd because of less SNR, 9 errors are noted as displayed above.

D. Sub-Optimum Multi-user Detectors

Linear multiuser detectors attempt to attain as much of the capacity increase as the optimum detector while reducing the complexity of the system such that it can be implemented. They are simply linear filters that attempt to suppress MAI. In these detectors, a linear mapping (transformation) is applied to the soft outputs of the conventional detector to produce a better set of outputs to provide better performance. The two popular linear multiuser detectors are the decorrelating detector and the Minimum Mean Square Error (MMSE) detector.The decorrelating detector attempts to completely eliminate all MAI while the MMSE detector tries to minimize the square of the residual noise plus interference. Therefore, the decorrelating detector is a special case of the MMSE detector, where the noise is zero. The decorrelating detector has the same noise enhancement problem as the zero-forcing Equalizer.

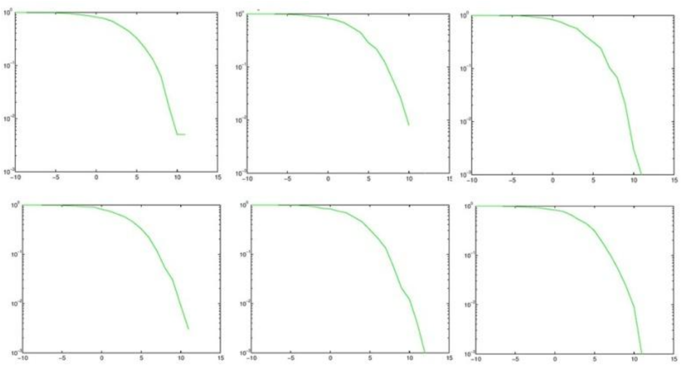


Fig. Plot of SNR (x-axis) vs. BER (y-axis) for 6 different users

Table: Input from six different DS-CDMA users and plotting the BER

SNR IN DB	USER 1	USER 2	USER 3	USER 4	USER 5	USER 6
1	0.9950	0.9930	0.9900	0.9930	0.9880	0.9920
2	0.9930	0.9870	0.9930	0.9950	.09920	0.9950
3	0.9860	0.9880	0.9860	0.9830	0.9850	0.9920
4	0.9880	0.9840	0.9830	0.9820	0.9740	0.9790
5	0.9780	0.9780	0.9730	0.9700	0.9710	0.9770
. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .	. . . . .
22	0.0080	0.0130	0.0030	0.0100	0.0100	0.0110
23	0.0010	0	0.0040	0.0010	0.0040	0.0010
24,1.0E-03	0	0	1.000	0	1.000	1.000
25	0	0	0	0	0	0
26	0	0	0	0	0	0

The above table shows that if we go on increasing the SNR in db then the BER will gradually decreases and finally at about 26th sample its value will almost become zero for all the six users.

E.Successive Interference Cancellation

In DS-CDMA communications there occurs mutual interference between the different users' overlapping signals as they occupy the same frequency band simultaneously. The detection of every single user can be improved by using the information about the other users and detecting the users jointly instead of one by one. There is a method which is called subtractive interference cancellation and means that one or several users after being detected are subtracted from the received signal. There exist two main types of this method: successive- and parallel interference cancellation.

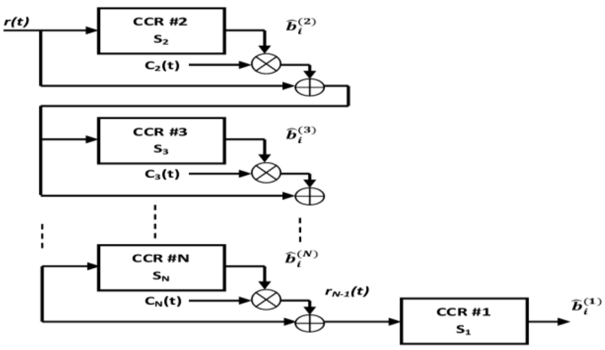


Fig.6: Successive Interference Cancellation

The first step is to detect the data sent by an undesired fixed user, to subtract from the received signal the estimated contribution of this user.

The data transmitted by the user is estimated using a CCR with a decision threshold S2.

Then the estimated signal is reconstructed by multiplication with the code of the undesired user, and subtracted from the received signal. Then we get a new signal.

$$r_1(t) = r(t) - \acute{b}_i^{(2)} C_2(t)$$

This process can be repeated either on the total undesired users (in this case, the SIC has N-1 stages), or a part of the undesired users.

At the end of the procedure, the signal rN-1 (t) is applied to the input of the conventional receiver of the desired user # 1

$$r_{N-1}(t) = r(t) - \acute{b}_i^{(2)} C_2(t) - \acute{b}_i^{(3)} C_3(t) - \cdots - \acute{b}_i^{(N)} C_N(t)$$
$$= b_i^{(1)} C_1(t) + \sum_{j=2}^{N} (b_i^{(j)} - \acute{b}_i^{(j)} C_j(t)$$

F. Parallel Interference Cancellation

The parallel interference cancellation receiver has the principle of the reproduction interference from undesired users, to remove it from the total received signal, for this the PIC requires several steps:
detection of data sent by each undesired user is done by the conventional correlation receiver (CCR) with a detection threshold "St", at the output of each receiver, we obtain the estimation$b_i^{(k)}$ of the data sent by the undesired user # k,
The second step is to reconstruct the signals transmitted by undesired users by multiplying the estimated $b_i^{(k)}$data by the corresponding code C_k(t)
We obtain in the third step, the interference term ri (t) which is actually the sum of the reconstructed signals, then it is subtracted from the received signal r (t):

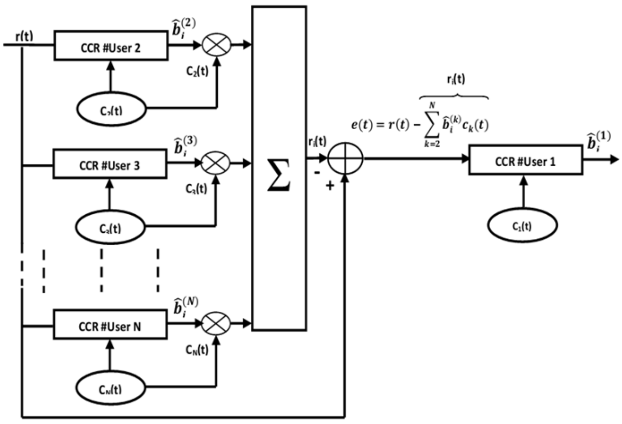


Fig.7: Parallel Interference cancellation

$$e(t) = r(t) - r_i(t) \quad and\ as, \quad r_i(t) = \sum_{k=2}^{N} \acute{b}_i^{(K)} C_k(t)$$
$$e(t) = r(t) - \sum_{k=2}^{N} \acute{b}_i^{(K)} C_k(t)$$

The last step is the detection of the desired user data # 1 from the signal "cleaned" from the interference e(t). This detection is done through a CCR with a decision threshold Sf.

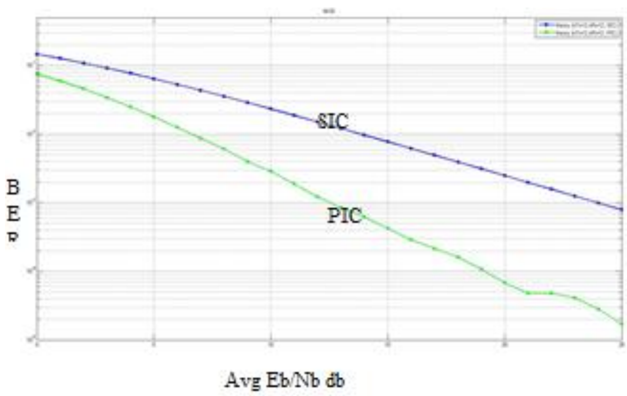


Fig.8:Output of SIC and PIC

The error performance of the PIC receiver has been obtained for DS CDMA system. For comparison the SIC and

PIC receivers have also been simulated and their error performance so obtained the improvement inerror performance of iterativePIC receiver and Figure SIC depicts the comparison of error performance of various interference cancellation receivers.

G.Compare with others present Techniques

The below table shows the comparison between the present MUD technique and others MUD technique. Thepercentile BER of present technique is better than be others techniques, but the complexity and time taken by the present technique is increase.

Sr.no		BER in %	Performance	Complexity	Time
Present Technique	OMUD	75	Good	Less	Less
	Sub-OMUD	83	Good	Less	Less
	SIC	59	Average	Medium	Large
	PIC	77	Very Good	Large	Very Less
Others Technique	Adp-MUD	48	Moderate	Less	Less
	Blind-MUD	65	Moderate	Less	Less
	MMSE	43	Moderate	Less	Average
	CIC	28	Low	Medium	High

Table. 2: Comparison with present technique and other technique

V. CONCLUSION

The main contribution of this master thesis/paper is development of algorithms for simulation of Multiuser Detection and channel interference cancellation, which offer an essential improvement in bit error rate performance and reduced Multiple Access Interference to increases capacity of system. And Improvement in performance relative to recently presented de-correlative detectors in impulsive noise.

Reduced near-far resistance.

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Abbreviations used in Table No. 2:

1) OMUD - Optimal Multiuser detection
2) Sub-OMUD- Optimal Multiuser detection
3) SIC - Successive Interference Cancellation
4) PIC- Parallel Interference Cancellation
5) Ad-MUD-adaptive Multiuser detection
6) Blind-MUD-Multiuser detection
7) MMSE- Minimum Mean Square error
8) CIC-Convectional Interference Cancellation

R. G.Koli
M.Tech. Scholar of Department of Engineering, in Walchand college of Engineering Sangli, India.

S.K.Parchandekar
Associate Professor Department of Electronics Engineering Walchand college of Engineering Sangli, India.

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