A potential algorithm for enhancement performance of multiple user detection in code division multiple access scheme

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Abstract: The modern day technology requires high data rate to enhance transmission speed. Multi carrier CDMA system is a promising technique which enhances the transmission speed over single carrier technique. However, there is a major challenge in MC-CDMA system due to multi access interference (MAI) , channel inter symbol interference (ISI) due to multipath nature of channels in presence of additive white Gaussian noise(AWGN). Spreading codes play an important role in multiple access capacity of DS-CDMA system. Literature shown multiple of techniques proposed to compensate for multi access interference. Genetic algorithm is technique used in many areas for complex optimization problem. We proposed a novel method of reducing MAI for multi carrier CDMA systems and implement the system to improve the performance and reduced complexity of the system using multi objective optimization scheme based on genetic algorithm. This Thesis investigates the performance of GA based CDMA communication system. Another purpose is to estimate the signal from multiple users and thereby improving the BER rate. Simulations of the resulting system indicate an improved overall performance.

Index Terms **– CDMA-MUD, Genetic Algorithm (GA), Bit error rate, multiple access interface (MAI), convectional detector**

I. INTRODUCTION

Code division multiple access is based around a form of transmission known as Direct Sequence Spread Spectrum. Spread spectrum and CDMA are technologies mainly used in operational radar, navigation and telecommunication systems and playing a dominant role in the philosophy of the forthcoming generations of systems and networks. The CDMA history can be directly linked back to the 1940s when this form of transmission was first investigated. The use of the spreading codes which are independent for each user along with synchronous reception allow multiple users to access the same channel simultaneously. Code Division Multiple Access (CDMA) is a multiple access technique where different users share the same physical medium that is the same frequency band at the same time. The main ingredient of CDMA is the spread spectrum technique which uses high rate signature pulses to enhance the signal bandwidth far beyond what is necessary for a given data rate. In a CDMA system, the different users can be identified and hopefully, separated at the receiver by means of their characteristic individual signature pulses that is by their individual codes [1].

Direct sequence-code division multiple access (DS-CDMA) technique is used in cellular systems where users in the cell are separated from each other with their unique spreading codes. In recent times DS-CDMA has been used extensively. These systems suffers from multiple access interference (MAI) due to other users transmitting in the cell, channel inter symbol interference (ISI) due to multipath nature of channels in presence of additive white Gaussian noise (AWGN). Spreading codes play an important role in multiple access capacity of DS-CDMA system.PN sequence, M-sequences, gold sequences etc., has been traditionally used as spreading codes in DS-CDMA. These sequences are generated by shift registers and periodic in nature. So these sequences are less in number and also limit the security. This thesis presents an investigation on use of new type of DS CDMA receiver called Genetic Algorithm based DS-CDMA receiver. Genetic Algorithm is robust optimization

technique and does not fall into local minima hence this gives better weight optimization of any system. This Thesis investigates the performance of GA based DS-CDMA communication using gold code sequences. Extensive simulation studies demonstrate the performance of the different algorithm used in DS-CDMA receivers like Fuzzy Logic, Neural Network and the performance have been compared with receiver based on GA algorithm [3].

The utilization of DS-CDMA could viably upgrade general BW proficiency compared with traditional multiple access methods like FDMA and TDMA [1]. Spectrum is to a great degree costly. It must be bought from different administrative permitting specialists at sell off and some of the time those sell off have included billions of money. It speaks to an extensive venture by an administration transporter. In this manner, the data transmission effectiveness of a communication innovation will be an essential worry for any network administrator. The correct determination of appropriate different access techniques to give multi-client services is of extreme significance.

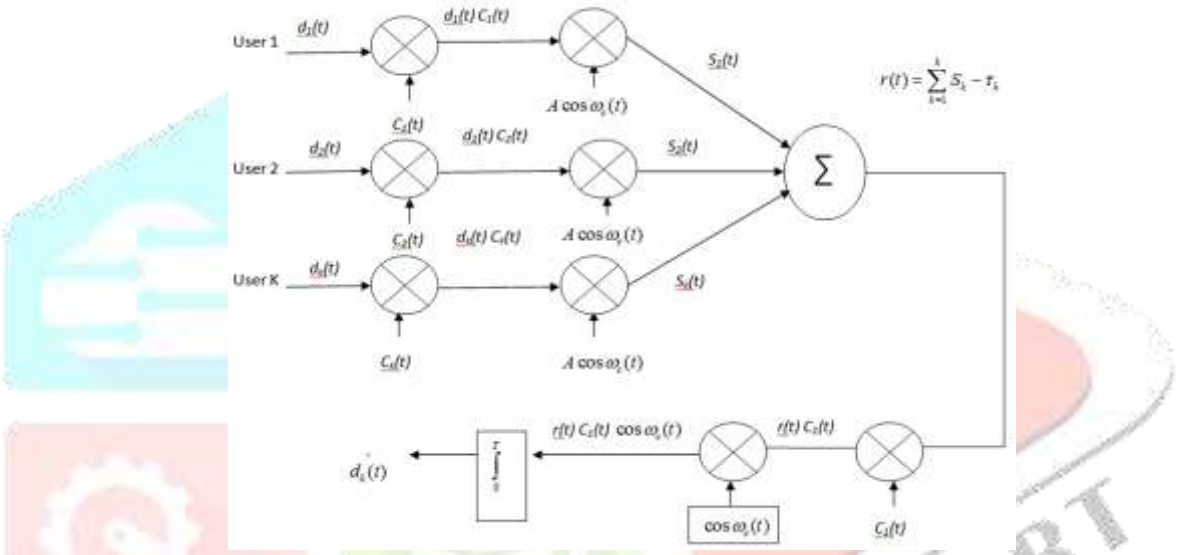

Figure 1. Block diagram of a simple asynchronous DS CDMA system

The transmitted signal is represented by:

$$S_k(t) = Ad_k(t)C_k(t)\cos(\omega_c t) \qquad (1.1)$$

Where, w_c is the carrier frequency measured in terms of rad sec^{-1} and carrier signal amplitude is represented by A. At the DS-CDMA receiver, the combination of the whole K user signal is received by receiver, made up of the transmitted signal from user 1 and (K-1) interfering signals. Disregarding the noise, the received signal is given by:

$$r(t) = \sum_{k=1}^{K} S_k(t - T_k) \qquad (1.2)$$

Where, T is called the propagation delay occurred from the sender to the receiver of the k^{th} user [9].

II. SURVEY ON MUD

In 1986, Verdu in [1] proposed the optimum multiuser detector (OMUD) which consists of a bank of matched filter followed by a maximum likelihood sequence estimator (MLSE).The MLSE detector generates a maximum likelihood sequence, ˆ b, associated with the trans-mitted sequence, as presented in Fig. 1. The vector b is estimated in order to maximize the sequence transmission probability given that r (t) is received; where r (t) is extended for all messages, considering all the transmitted messages with the same transmission probability. The OMUD has a computational complexity that grows exponentially with the number of users. Thus, since CDMA systems could potentially have a large number of users, the OMUD is impractical to implement. Therefore, many studies have been performed on sub-optimum detectors with less complexity and high performance, which is expected to be close to that of the OMUD.and edge extraction algorithm. Low level features like color and texture [5] are also possible to extract from given frame.

Some heuristic methods such as genetic algorithms (GA) have been applied to the problem of ML detector. The first GA-based multiuser detector (GA-MUD) was proposed by Juntti et al. [2] where the analysis was based on a synchronous CDMA system communicating over an AWGN channel. Consequently in [3], some new variants of GA were proposed for solving the problem. Tabu search algorithm [2], particle swarm optimization (PSO) [4],
wavelet transform [5], ant colony optimization [6], and adaptive algorithms such as LMS and RLS [7] are other novel methods that are applied to the problem of constructing Multiuser detectors.

All of the above methods are suggested for practical implementation of MUD but in these methods, the complexity of mathematical calculations and the minimum BER must be compromised accurately, and as is usual in heuristic search algorithms, they may get trapped
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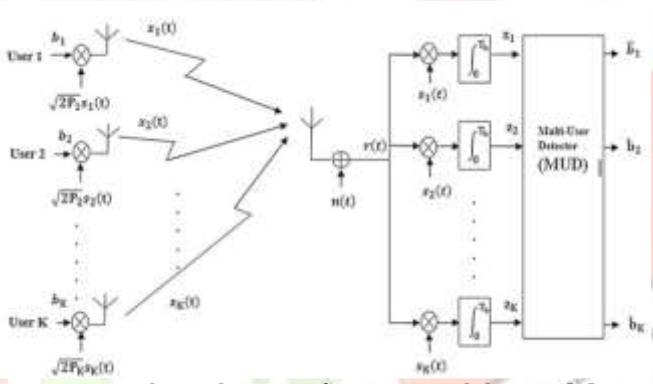

Figure 2. basic diagram of conventional detector[1]

III. OVERVIEW OF PROPOSED GENETIC ALGORITHMS ON CDMA SYSTEM

In previous section we have seen different literatures which proposed Multi user detection algorithms. Here are some of the important features of genetic algorithm applied for multiuser detection in CDMA for enhancement of performance.
Genetic algorithm contains a four stage life cycle that is described below.

A. Initialization

Initially several individual solutions are at random generated to create an initial population covering the entire range of possible solutions .

B. Selection

During every consecutive epoch, a proportion of the Present population is selected to breed a new generation. Individual solutions are selected through a fitness-based method like wheel choice, wherever fitter solutions area unit generally more possible to be selected.

C. Reproduction

The next step is to generate a second generation Population of solutions from those selected through genetic Operators: crossover (also known as recombination), and Mutation. For every new answer to be created, a combine of "parent" solutions is selected for breeding from the pool selected previously. New set of parents area unit selected every time and therefore the process continues till a replacement population of solutions of acceptable size is generated.

D. Termination

This generational process is continual till a termination condition has been reached. Here the fixed variety of generations reached is taken as the criteria for the Termination of the program.

IV. ALGORITHM FOR GENETIC ALGORITHM

Genetic algorithms are inspired by Darwin's theory of evolution. Solution to a problem solved by genetic algorithms uses an evolutionary process.

Algorithm begins with a set of solutions (represented by chromosomes) called population. Solutions from one population are taken and used to form a new population. This is motivated by a hope, that the new population will be better than the old one. Solutions which are then selected to form new solutions (offspring) are selected according to their fitness. The more suitable they are the more chances they have to reproduce. This is repeated until some condition like improvement of the best solution) is satisfied.

1)[Start] Generate random population of n chromosomes (suitable solutions for the problem) the population is defined to be the collection of all the chromosomes. A generation is the population after a specific quantity of iterations of the genetic loop. A chromosome is made out of genes, every one of which reflects a parameter to be enhanced. Therefore, each individual chromosome demonstrates a possible solution to the enhancement problem. The dimension of the GA refers to the dimension of the search space which is same as the number of genes in every chromosome.

2)[Fitness] Evaluate the fitness f(x) of every chromosome x in the population. The fitness function characterized a way for the GA to analyse the performance of every chromosome in the population. As the fitness function is the only relation between the GA and the application itself, the function has to be chosen with utter care. The fitness function must reflect the application appropriately with respect to the way the parameters are to be minimized.

3)[New population] Create a new population by repeating following steps until the new population is complete.

3a. [Selection] The selection operator chooses chromosomes from the present generation to be parents for the next generation (the better fitness more chance to be selected).Parents are selected in pairs. Once one chromosome is chosen, the probabilities are renormalized without the chosen chromosome, so that the parent is chosen from the remaining chromosomes. Thus each pair is made up of two different chromosomes. It is possible for a chromosome to be in excess than one pair.

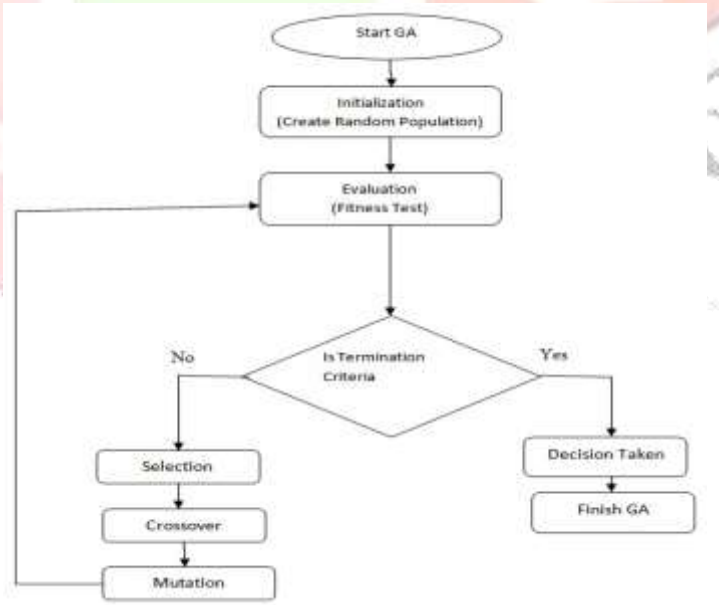

Figure-3 Flow diagram of GA

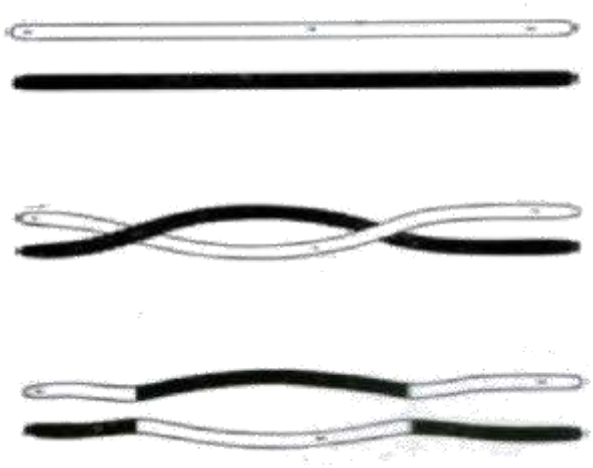

Figure-4 Crossover

3b. [Crossover] Crossover is the GA's primary local search routine. The crossover/reproduction operator computes two offspring for each parent pair given from the selection operator. These o spring, after mutation, make up the new generation. A probability of crossover is predetermined before the algorithm is started which governs whether each parent pair is crossed-over or reproduced. Reproduction results in the o spring pair being exactly equal to the parent pair. The crossover operation converts the parent pair to binary notation and swaps bits after a randomly selected crossover point to form the offspring pair.

3c. [Mutation] with a mutation probability mutate new o spring at each locus (position in chromosome).

4) [Replace] Use new generated population for a further run of algorithm

5) [Test] If the end condition is satisfied, stop, and return the best solution in current population

6) [Loop] Go to Evaluation step

V. SIMULATION RESULTS AND DISCUSSION

Simulation shown in figure (A)for 50 users and 10 bit as PN-codeword. The resulting signal is introduce with AWGN noise and received at receiver side. But in simulation shows for 20 symbols.

Simulation shown in figure (B) transmitted BPSK signal and Received BPSK symbols. Simulation shown in figure (C) having the higher BER and small value of SNR. As we increase the SNR value to higher level we are not getting much improvement in BER level. All these results are detected at receive by using traditional detector

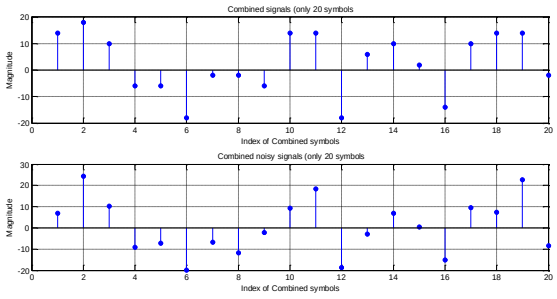

Figure (A)

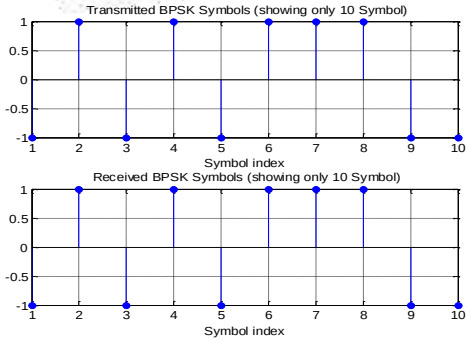

Figure (B)

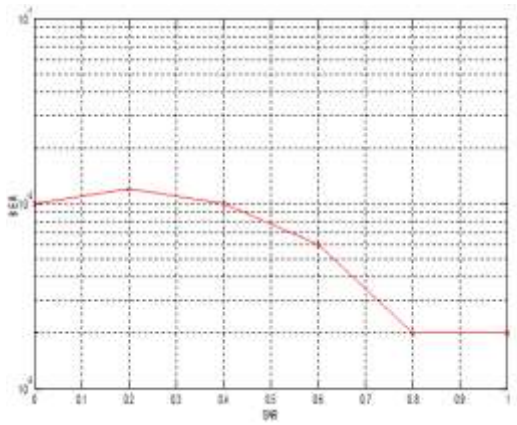

Figure (C)

User data bits are incorporated with BSPK modulation and then BPSK trans-mitted signal spread with PN sequence code and then signal transmitted through AWGN channel. Simulation shown in figure (D) shows the comparison of BER level of CDMA Multi user detection implemented using conventional method and using Genetic Algorithm when increasing the value of SNR. By observing the comparison graph we found optimization in BER at higher value of SNR in GA assisted CDMA MUD then traditional method of CDMA MUD.

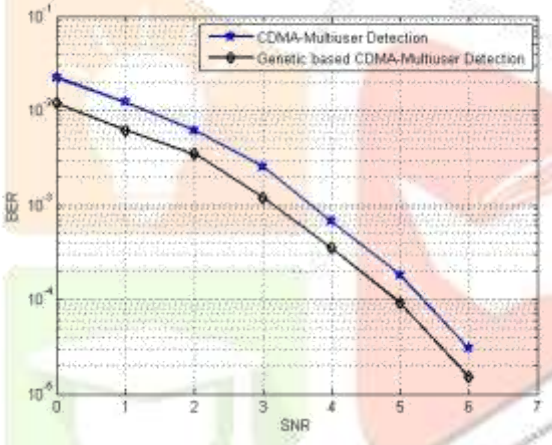

Figure (D). Comparison of BER vs SNR implemented using both methods

VI. SIMULATION RESULTS OF PROPOSED TECHNOLOGY

Simulation in figure (E) shows the comparison of BER level of CDMA Multi user detection implemented using conventional method and using Genetic Algorithm when increasing the value of SNR. In this case I have implemented the multiuser detection in CDMA by incorporating the Genetic Algorithm at the receiver side under AWGN with Rayleigh fading channel using QPSK modulation. By observing the comparison graph we found optimization in BER at higher value of SNR in GA assisted CDMA MUD then traditional method of CDMA MUD.

Result shows the graph of BER performance when increasing SNR for Traditional CDMA MUD and GA assisted MUD. Result shows optimization in BER. Even a small improvement matters a lot in actual CDMA system where multiple users transmit data at same time slot and same frequency band. Optimization in terms of BER results into performance enhancement of overall CDMA system.

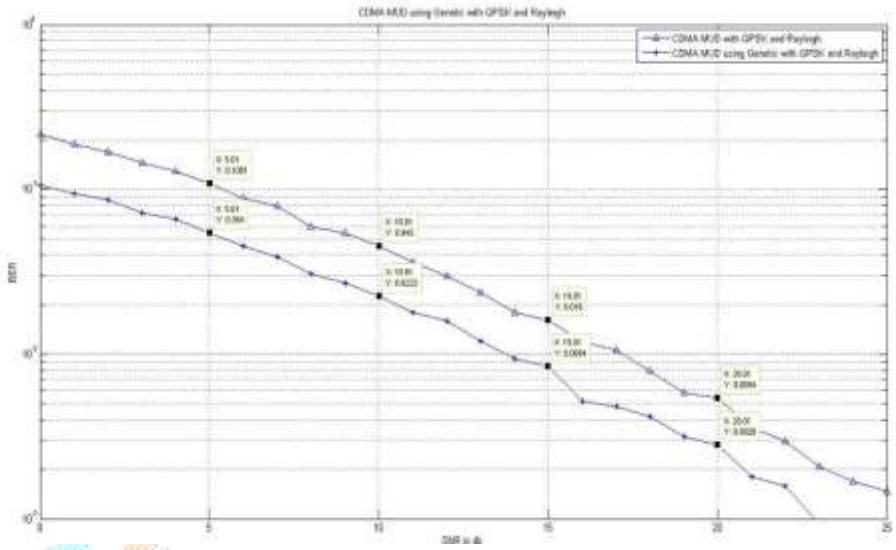

Figure (E). Comparison of BER versus SNR when MUD implemented using Both Method Using QPSK

VI. CONCLUSION

Multiuser detection in CDMA system is received attraction with modern day wire-less communication system. CDMA is conventionally detected by matched filter bank. However, there are limitations of matched filter bank that such receiver is unable to retrieve signal at the ideal level. The traditional MUD systems are facing multiple access interference and near-far problem.

This thesis is a compilation of two different approaches for multi-user detection in CDMA based wireless systems in presence of noise over AWGN channel and multi path fading environment. Further, it was also shown that in the conventional algorithms multi user detection used are slightly lacking in terms of BER at different values of SNR. This called for the need for better algorithms. The Genetic Algorithm(GA) was then introduced which takes the conventional algorithms one step further by incorporating the better fitness function in the multi user detection.

From the simulation results of BER V/S SNR for different level we have seen that the Performance of the Genetic Algorithm is considerably better than the traditional method used for CDMA multi user detection. Even a small improvement matters a lot in actual CDMA system where multiple users transmit data at same time slot and same frequency band. Optimization in terms of BER results into performance enhancement of overall CDMA system.

VII . REFERENCES

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