Performance Analysis of Modulation Techniques in GA assisted CDMA Wireless Communication System with AWGN Rayleigh Fading Channel

Jigna Desai, Dr.K.G.Maradia, Prof.N.B.Gohil

Abstract— The transmission from the base station to mobile or downlink transmission using 16-ary Quadrature Amplitude modulation (QAM), 64-ary QAM and Quadrature phase shift keying(QPSK) modulation schemes are considered in Code Division Multiple Access(CDMA) system. We have done the implementation and analysis of these modulation techniques when the system is subjected to Genetic algorithm (GA) for multiuser detection and Additive White Gaussian Noise (AWGN) with fading and Rayleigh fading d in the channel. The research has been performed by using simulation in MATLAB 7.7 and evaluation of Bit Error Rate (BER) against Signal-to-Noise Ratio (SNR) for CDMA system model. From analysis of three modulation techniques, the system could use more appropriate modulation technique to suit the channel quality, thus we can deliver the optimum and efficient data rate to mobile terminal.

Keywords— Bit Error Rate, Code Division Multiple Access, Genetic Algorithm, Additive White Gaussian Noise, Quadrature phase shift keying, Quadrature Amplitude modulation, Signal to Noise ratio ,Rayleigh fading

1. INTRODUCTION

Code Division multiple Access (CDMA) is being used by Universal Mobile Telecommunication System (UMTS) as platform of the 3rd generation cellular communication system. CDMA uses noise like broadband frequency spectrum where it has high resistance to multipath fading where as this was not present in conventional narrowband signal of 2nd generation communication system. High data rate signal transmission can be transmitted over the air by using CDMA system, thus enabling of multimedia rich applications such as video streams and high resolution pictures to end users. In this paper we have used genetic algorithm for multi –user detection in synchronous multipath channels. The paper is organized as follows. In the section- 2 we present the system model for multipath multi-user detection environment. Section-3 describes the multistage detector used in context of genetic algorithm and GA based detection procedure. Section-4 presents the different modulation techniques. In section-5 evaluation of three modulation techniques QPSK, 16-QAM, and 64-QAM is explained using simulation results and concluded.

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2 SYSTEM MODEL

We assume BPSK modulation and use direct sequence spread spectrum signalling, where each additive mobile unit possesses a unique signature sequence to modulate the data bits. The base station receives a summation of all the active user after they travel through different paths in the channel. The multipath is caused due to reflections of the transmitted signal that arrive at the receiver along with the possibility of the line of sight component being received also. These channel paths induce different delays, attenuations and phase shifts to the signals and the mobility of user causes fading in the channel. Also the signals from different users interfere with each other in addition to the additive white Gaussian noise present in channel. Multi-user detection refers to the detection of the received bit for all users jointly by cancelling the interference between the different users. The model for the received signal at the output of the multipath channel that we have described in the next section.

2.1 S-CDMA system model

We consider a bit synchronous CDMA system , where K users simultaneously transmit data packets of equal length to a single receiver. Here we will use the binary phase shift keying (BPSK) modulation technique. The transmitted signal of Kth user can be expressed in an equivalent low pass representation as

$$S_k(t) = \sqrt{\xi_k}\sum_{m=0}^{M-1} b_k^{(m)}\, a_k(t - mT_b) \qquad (1)$$

Where ξ_k is the kth user's energy bit, $b_k^{(m)}$ denotes the mth data bit of the kth user , $a_k(t)$ is the kth user's signature sequence, T_b is the data bit duration and M is the data bit transmitted in packet.
The kth user's signature sequence $a_k(t)$ may be written as ,

$$a_k(t) = \sum_{h=0}^{Nc-1} a_k^{(h)}\Gamma\, T_c(t - hT_c), 0 \le t < T_b \quad (2)$$

Where T_c is the chip duration , $a_k^{(h)}$ denotes the hth chip, Nc is the spreading factor , which refers to the number of chips per data bit duration T_b such that $N_c = {}^{T_b}/_{T_c}$ and Γ $T_c(t)$ is the chip pulse shape. The received signal for all k users at the receiver, which is denoted by $r(t)$ can be written as

$$r(t) = \sum_{k=1}^{K} S_k(t) + n(t) \qquad (3)$$

Where $n(t)$ is the zero mean complex additive white Gaussian Noise (AWGN) with independent real and imaginary components, each having a double sided spectral of $\sigma^2 = {}^{No}/_{2}$ W/Hz. At the receiver the output of a bank of filters matched to the corresponding set of the user's code is sampled at the end of bit interval. The output of the lth user's matched filter, denoted as Z_l can be written as

$$Z_l = \int_0^{Tb} r(t) a_l(t) dt \qquad (4)$$

Where $a_l(t)$ is lth user signal signature.

3 GENETIC ALGORITHM

The simplest form of genetic algorithm involves three types of operators : selection, cross over, mutation

3.1 Selection

This operator selects chromosome in the population for reproduction. The fitter the chromosome, the more times it is likely to be selected to reproduce. Selection is based on fitness function.

3.2 Crossover

This operator randomly chooses a locus and exchanges the subsequence before and after that locus between chromosomes to create two offspring. For, example, the strings 10000100 and 11111111 could be crossed over after the third locus in each to produce the two offspring 100-11111 and 111-00100.The crossover operator

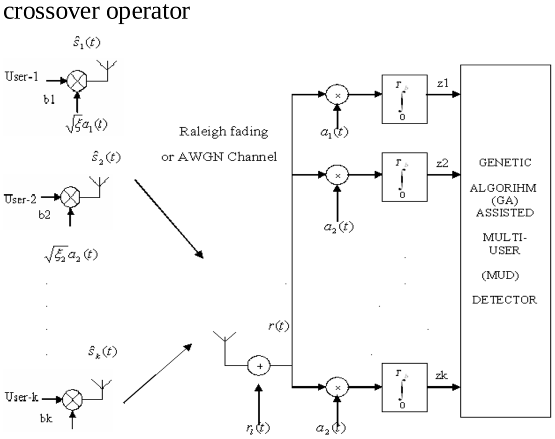

Figure 1 GA based CDMA system model

Roughly mimics biological recombination between two single chromosome organisms.

3.3 Mutation

This operator randomly flips some of the bits in a chromosome. For example, the string 00000100 might be mutated in its third position to yield 00100100 that can occur at each bit position in a string with some probability, usually very small (e.g., 0.01). There are two basic parameters of GA, crossover probability and mutation probability. Crossover probability represents the frequency of the crossover. If there is a crossover, offspring is made from parts of parent's chromosome. If crossover probability is 100%, than all the offspring is made by crossover. If it is 0%, whole new generation is made from exact copies of chromosomes from old population. Mutation probability describes how often parts of chromosome is mutated. If there is no mutation, offspring is taken after crossover without any change. If mutation is performed, part of chromosome is changed. Mutation prevents falling GA into local extreme, but it should not occur very often, because than GA will in fact change to random search.

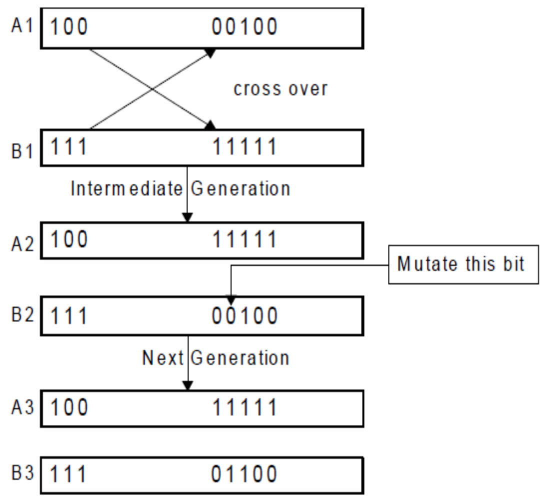

Figure 2 Crossovers and Mutation

3.4 Flow of GA

The GA assisted search can be terminated, if there are no further improvements in the maximum fitness value after several consecutive generations. In this case time required for GA to reach a decision is uncertain. If the structure of the search space is time-invariant, then it is possible to set a threshold, such that the GA assisted search is terminated, once the fitness value of an individual is found to exceed this threshold. Unfortunately neither of these termination criteria can be applied to GA assisted CDMA multi-user detection, since typically a fixed implementation complexity is also required and also the search space is time variant due to noise and fading imposed by the transmission channel. Hence in this application we have terminated the GA assisted search at the 8th generation and the individual associated with the highest fitness assisted search at the 8th generation and the individual associated with the highest fitness value at this point will be detected solution. By specifying the exact number of generation, the computational complexity of GA can be decreased.

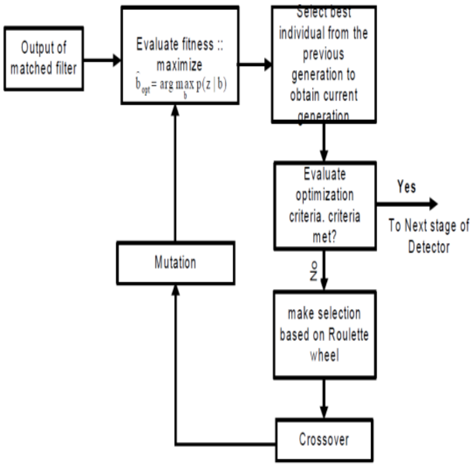

Figure 3 .GA flow chart

4 MODULATION TECHNIQUES

There is different modulation techniques have been used for modulation in GA assisted CDMA wireless communication system. In our work we have used QPSK, 16 QAM and 64 QAM

4.1QPSK modulation

QPSK is one example of M-ary PSK modulation techniques (M=4) where it transmits 2 bits per symbol. The phase of the carrier takes on one of four equally spaced values, such as 0, π/2, π and 3π/2, where each value of phase corresponds to a unique pair of message bits .The basic signal for QPSK can be expressed as

$$S_{QPSK}(t)=\left\{\sqrt{E_s}\cos\left[(i-1)\frac{\pi}{2}\right]\phi_1(t)-\sqrt{E_s}\sin\left[(i-1)\frac{\pi}{2}\right]\phi_2(t)\right\} \quad i=1,2,3,4 \tag{5}$$

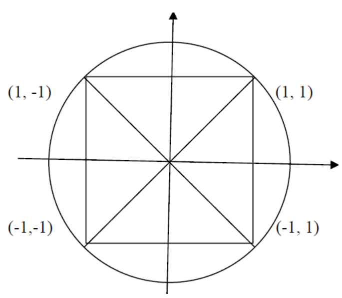

Figure 4. Constellation diagram of QPSK

4.2 M-ary QAM

QAM is a modulation technique where its amplitude is allowed to vary with phase.QAM signalling is viewed as combination of Amplitude shift keying and Phase shift keying. Also it can be viewed as ASK in two dimension. The general form of M-ary QAM can be defined as

$$S_i(t)=\sqrt{\frac{2E_{min}}{T_s}}a_i\cos(2\pi f_c t)+\sqrt{\frac{2E_{min}}{T_s}}b_i\sin(2\pi f_c t) \quad 0\le t\le T \quad i=1,2,.......,M \tag{6}$$

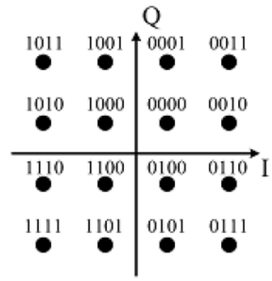

Figure 5. Constellation Diagram of 16-QAM

5 SIMULATION RESULT AND CONCLUSION

Following figures shows the BER versus SNR performance of the GA based CDMA wireless communication system for three modulation techniques using Walsh code for fixed four users. Here we have used uniform crossover and mutation probability is 0.01 . This simulation is performed on platform Matlab 7.7 with PC configuration of 2.53 GHz CPU,2GB RAM and 320 GB hard drive.

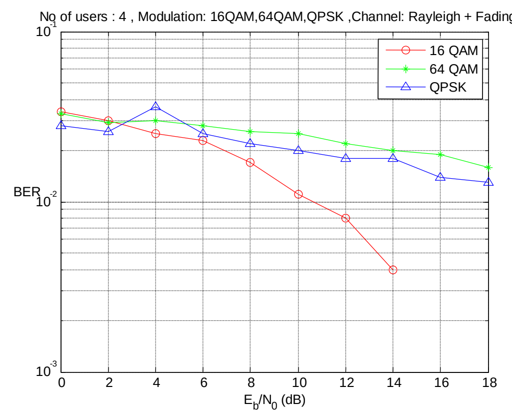

Figure 6. BER/SNR plot for QPSK,16 QAM,64 QAM modulation technique with Rayleigh fading channel(f_d=100Hz).

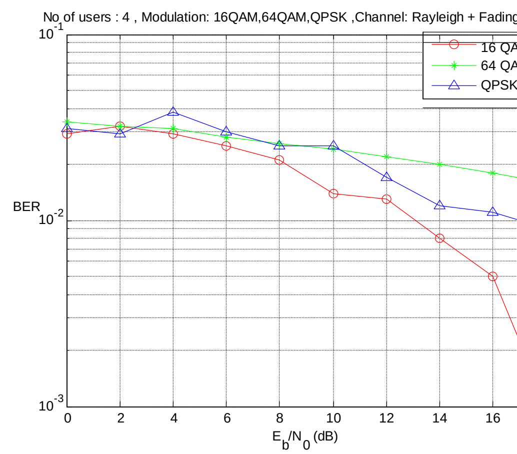

Figure 7. BER/SNR plot for QPSK,16 QAM,64 QAM modulation technique with Rayleigh fading channel(f_d =50Hz)

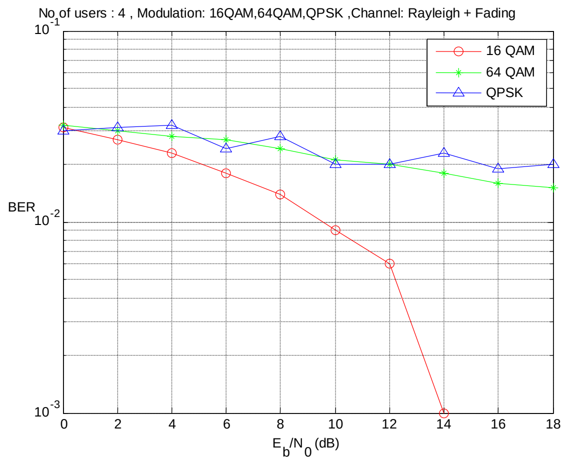

Figure 8.BER/SNR plot for QPSK,16 QAM, 64 QAM modulation techniques with Rayleigh fading channel.(f_d=20Hz)

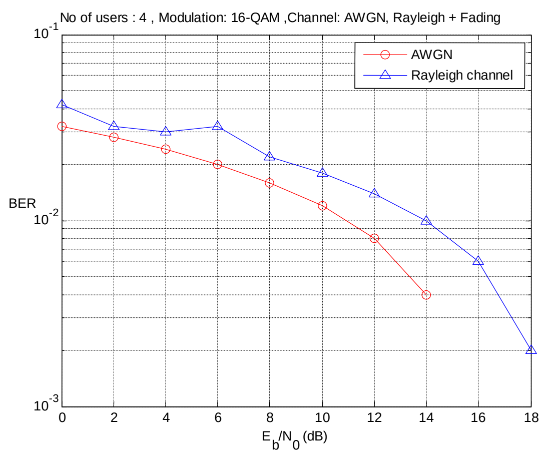

Figure 9. BER/SNR plot for 16 QAM modulation with AWGN Channel and Rayleigh fading Channel

From Figure 6,7 and 8 it is interpreted that as we change Doppler shift than 16 QAM would be better. So in Figure 9 we have used 16 QAM to compare AWGN channel and Rayleigh fading channel, where we notice that bit error rate versus SNR reduces for AWGN channel. While higher order modulation rates are able to offer much faster data rates and higher levels of spectral efficiency for the radio communications system, this comes at a price. The higher order modulation schemes are considerably less resilient to noise and interference. As a result of this, many radio communications systems now use dynamic adaptive modulation techniques. They sense the channel conditions and adapt the modulation scheme to obtain the highest data rate for the given conditions. As signal to noise ratio decrease errors will increase along with re-sends of the data, thereby slowing throughput. By reverting to a lower order modulation scheme the link can be made more reliable with fewer data errors and re-sends.64-QAM modulation scheme is used in broadcasting of digital TV transmission A bandwidth efficient modulation scheme delivers a higher data rate within a limited spectrum bandwidth. All the initial phases of 3G networks take advantage of this kind of modulation.

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