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Research paper

Improvement of bit error rate performance of MC-CDMA system by using adaptive digital modulation schemes

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Abstract

In Wireless Communication, the transmission channel suffers due to multipath propagation and channel dispersion due to Inter Symbol Interference (ISI), thereby degrades the system performance greatly. Future communication requires high data rate and effective utilization of bandwidth. Hence, there is a need to improve the Bit Error Rate (BER). The proposed work is Adaptive Modulation (AM), combined with Multi Carrier Code Division Multiple Access (MC-CDMA) based transmission system. It is a promising way to increase the data rate and it uses bandwidth in a efficient manner. The Adaptive Modulation based MC-CDMA systems applied to a wide-area environment, can achieve high data rate up to 100Mbps. In this paper M-ary PSK, M-ary QAM and M-ary CPM modulation techniques are used. The Adaptive modulation based MC-CDMA systems perform well for around 10 number of users. As a whole, the adaptive MC-CDMA system is found to give the optimum BER performance of given digital modulation schemes for fourth generation environment.

Keywords: *Multi Carrier Code Division Multiple Access (MC-CDMA); Additive White Gaussian Noise (AWGN; Inter Symbol Interference (ISI); Bit Error Rate (BER)*

1. Introduction

Nowadays the networking consumer system is large and growing in a fast manner. In home and work places the people need transparent internetworking communication. So this internetworking should be on demand, with whatever they want, regardless of time or location. Multi Carrier CDMA is a multiple access technique used for future wireless communication in fourth generation. This technique is a combination of two multiple access techniques. The first one is OFDM (Orthogonal Frequency Division Multiplexing) and the second technique is CDMA (Code Division Multiplexing) [1-2].This can achieve very large data rate up to 100Mbps. MC-CDMA is a multi carrier modulation technique which helps to increase the data rate and efficiently utilize the bandwidth. Second technique is CDMA (Code Division Multiplexing). This can achieve very large data rate up to 100Mbps. MC-CDMA is a multi carrier modulation technique which helps to increase the data rate and efficiently utilize the bandwidth. However the input high rate data stream is divided into multiple number of low rate sub data streams and each sub stream is modulated by the same subcarriers. Here each data stream share the same sub carriers. So we can effectively use the available bandwidth with the help of MC-CDMA technique. These are the advantages of multi carrier modulation over the wireless communication channel. However one of the disadvantages is that the Signal to Noise ratio is time variant in the wireless medium due to multipath fading conditions. So the transmission channel conditions vary continuously during transmission, simultaneously the channel meets poor link stability. MC-CDMA provides great robustness against multipath fading.

In addition the combination of Adaptive modulation based MC-CDMA to maintain the link stability. This technique also reduces the complexity by using Fast Fourier Transform (FFT) and Inverse FFT [3-4].

2. Related work

2.1. Adaptive modulation

Adaptive modulation is a dynamically change the appropriate modulation scheme according to the channel conditions provided by the channel estimator. The channel estimator received the current channel related information from the channel. This information is fed to modulation selector. The modulation selector deicide the suitable digital modulation scheme depending on the channel condition and provide this information to modulator and demodulator. For this adaptive modulation sub band transmission method is used to decrease the complexity of the system. Each sub carriers are grouped together and present in the same sub band. The modulation technique is selected based on the estimated quality of the channel in the receiver balanced by the current MC-CDMA symbol [5,6]. The adaptation procedure for the adaptive modulation is shown in Figure 1.

2.2. Principle of MC-CDMA technique

In MC-CDMA the high rate input data stream is split into number of low rate sub streams that are transmitted in parallel over a narrow band channels. Each data stream is multiplied by a Walsh Hadamard Orthogonal spreading codes. The Orthogonal property avoids the interference between multiple information signals that are transmitted in parallel in a single communication channel [7].

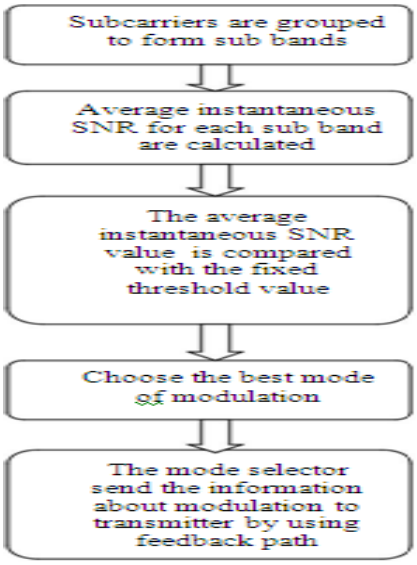

Fig. 1: Flow Chart for Adaptation Scheme.

The serial input data stream are converted into parallel data stream using Serial to Parallel Converter and modulated on different sub-carriers. Each symbol is allocated to one subcarrier according to the modulation scheme. The modulation technique depends on the data rate requirement. The IFFT translate the frequency domain data into time domain samples and preserve the orthogonality between different subcarriers. These time domain samples are then applied to Guard Interval block [8-9].

3. Proposed work

3.1. Adaptive modulation based multicarrier CDMA

Multiple User Multi Carrier - CDMA is a multiple access scheme which is a combination of both CDMA and OFDM techniques. In CDMA, user's unique spreading the signal over a large spectrum. The advantages of MC-CDMA are it allows multiple accesses, and reduces Multipath fading because of spreading the signal over a large spectrum. Also it achieves frequency diversity by transmitting each symbol over several subcarriers and hence it is immune to interference and signal distortion. Fig 2 shows the schematic diagram of Multi Carrier-CDMA transmitter system. The input binary data is spread by using Walsh Hadamard code, then these data are fed to Serial to Parallel converter to change high rate serial stream to low rate parallel streams. Each parallel data are modulated using appropriate modulation technique like M-ary PSK, M-ary CPM (Continuous Phase Modulation) , QAM (Quadrature Amplitude Modulation) depending on data rate requirement. In fig 2, the spreader spreads the input binary data in time domain by the spreading sequence of user j. The spreading data are applied to the S/P converter followed by IFFT and, P/S converter. After parallel to serial conversion the time domain samples are fed to the low pass filter which removes the noise in the signal. The filtered output is then modulated and transmitted to the receiver. The receiver performs the reverse operation of transmitter. Each user symbol is recovered by using demodulator, FFT and dispreading. The required message is obtained finally.

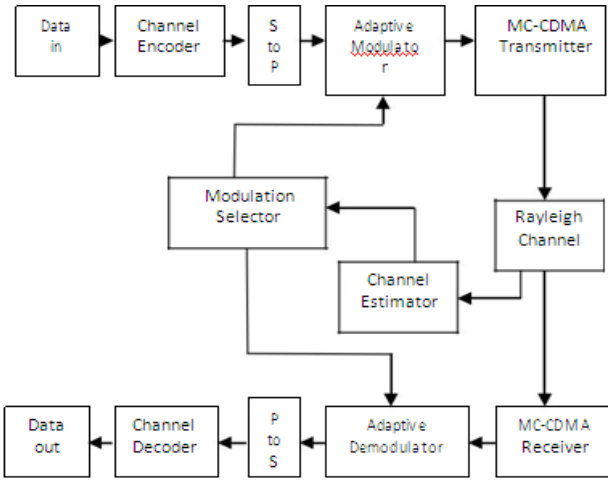

Fig. 2: A Schematic Diagram of Adaptive Modulation Based MC-CDMA System Flow.

The advantages of MC-CDMA are it allows multiple accesses, and reduces Multipath fading because of spreading the signal over a large spectrum. Also it achieves frequency diversity by transmitting each symbol over several subcarriers and hence it is immune to interference and signal distortion [10].

3.2. Rayleigh model

Mobile radio channel impairments cause the signal to distort or fade significantly at the receiver as compared to AWGN channels. Rayleigh model is suitable for radio signals on propagation environment [11].

3.3. Walsh hadamard code

Walsh Hadamard code is used to detect and correct the error during transmission of messages on a very noisy environment and time varying channels. Each Walsh functions represents independent sequence value of binary signal x= element of $[0,1]^k$, k denotes the length of the code and code word is Had(x) [12]. This Walsh function is represented by two vectors x,y=element of $\{0,1\}^k$ as follows:

$$[X, y] = \sum_{i=1}^{k} xi\ yj \bmod 2 \quad (1)$$

4. Software simulation

The simulation was conducted by using MATLAB to find out the output performance of the MC-CDMA system. show the simulation result show the performance of MC-CDMA system for Rayleigh channel using Walsh code with Adaptive modulation, the number of users considered up to 14.

Figure:3 shows the BER performance of the adaptive modulation based MC-CDMA system with varying number of CDMA users in the Rayleigh fast fading channel with Walsh coded data with M-ary QAM and M-ary PSK and M-ary CPM. The switching levels for the modulation schemes are set to achieve a BER better performance.

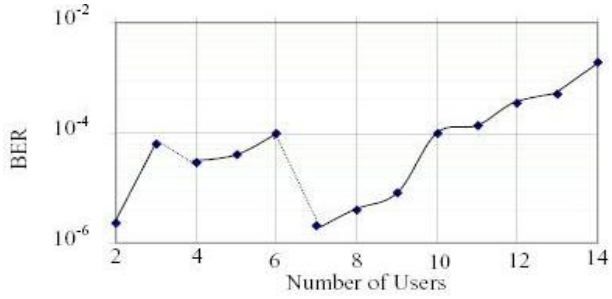

Fig. 3: Adaptive Modulation of MC-CDMA System, Total Number of Users = 14.

The system first assigns the highest order modulation format and as the number of users increases, the system changes the modulation scheme appropriately according to the estimated channel conditions (CNR on pilot symbol). If estimated CNR is within the stored switching level range for the modulation scheme under operation it maintains the same modulation format. In figure 3, the BER is 10^{-4} for 10 users and the number of user is increased to 14 then the BER is 10^{-3}.So the bit error rate is better for up to 10 users. The Number of Users Vs BER values are shown in Table: 1.

Table 1: Number of Users vs BER

Channel	Number of Users	Bit Error	Modulation Schemes
Rayleigh Channel	2	$10^{-5.8}$	M-ary PSK M-ary CPM, QAM
	4	10^{-4}	
	6	10^{-4}	
	8	$10^{-5.6}$	
	10	$10^{-4.0}$	
	12	$10^{-3.5}$	
	14	$10^{-3.0}$	

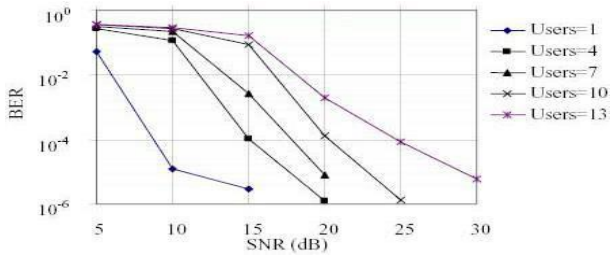

Fig. 4: BER Vs SNR of Adaptive Modulation of MCDMA System, No. of Users =1, 4, 10&13.

Figure.4 shows the Signal to Noise Ratio Vs BER performance of Adaptive Mc-CDMA system. It shows that the BER for the number of users 1,4,7,10,13 respectively. If the 1 and 4 then the BER is better for 15 dB SNR. However the users 7,10,13 provide poor BER for 15 dB SNR, when the SNR is increased to 25dB the system provides good BER i.e. 10^{-6} and 10^{-4}.We know that the BER improves up to 10 users and beyond 10 users we need to increase the SNR value.

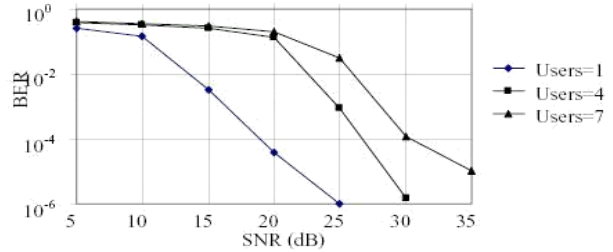

Fig. 5: BER Vs SNR of Adaptive Modulation of MC-CDMA System, No. of Users =One, Four &Seven.

Figure: 5 shows the BER Vs SNR performance of users 1, 4 and 7 for up to 35dB SNR. We note that the SNR is increased to 35dB the system can achieve optimum performance the BER is10-5 and $10^{-6.}$

Table 2: Data Rate of Adaptive Modulation based MC-CDMA System

Signal to Noise Ratio in dB	Number of Users	Type of Modulation	Symbol Rate	Data Rate per User
15	1-3	8PSK	640k symbols /s	1.92 Mbits/s
	4-6	4- ary CPM		1.28 Mbits/s
	7-14	2QAM		640kbits/s

Table: [2] shows the switching between one modulations to another for increasing the number of users. The number of user is 1 to 3 then the high rate modulation 8PSK is preferred and the data rate is 1.92 Mbps. Next the modulation is switch to CPM for 4 to 6 users and the data rate is 1.28Mbps.The low rate modulation QAM is switch to [7] to 14 users and it can achieve the data rate 640 kbps as shown in the table 2.

The simulation parameters are shown in table: 3.It shows that the sub carrier spacing is around 25 kHz and the channel bandwidth is 20 MHz.

Table 3: Simulation Specifications

Channel Bandwidth	20 MHz
Subcarrier Spacing	25kHz
Number of bits for data user	1024
Modulation	M-ary PSK,M-ary CPM and QAM
Spreading Code	Walsh Code
Code length	32 chips
Channel	Rayleigh
Simulation	BER Vs Number of Users SNR Vs BER
Software	MATLAB

5. Conclusion

The simulation results shows that the Adaptive modulation based MC-CDMA system using Walsh code gives better performance. Walsh Hadamard code is suitable for spreading and scrambling sequences in Multiple User Multi Carrier-CDMA systems. The result of Rayleigh channel on MC-CDMA system shows optimum BER of 10^{-5} and 10^{-6} when the SNR is 35 dB.

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