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Comparative Analysis of MC-CDMA System with Wavelet Packet Based MC-CDMA System Using Different Modulation Techniques

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Abstract: *Recently conventional Multi-Carrier Code Division Multiple Access (MC-CDMA) techniques attract more attention of researcher's due to its high frequency spectrum efficiency and high data rate transmission. MC-CDMA is a Multiple access scheme used in Orthogonal Frequency Division Multiplexing (OFDM) based telecommunication systems, allowing the system to support multiple users at the same time. Specialized wavelet packet waveform set is used as the modulation waveform in a multicarrier CDMA system. The wavelet packet waveform is the waveform generated from a full binary wavelet packet tree. This paper presents a design of conventional MC CDMA and wavelet packets based MC CDMA and their comparison on the basis of performance matrices. The performance parameter used in this comparison is Bit Error Rate (BER). The spectral analysis is done by wavelet.*
Keywords: *OFDM, MC-CDMA, WPMC-CDMA, AWGN Channel, Bit Error Rate.*

I. Introduction

Multi carrier CDMA technique has become popular in wireless communications, mainly due to its high spectral frequency, frequency selective fading and flexibility to support integrated applications [1]. MC-CDMA is the combination and improvement of CDMA technique and OFDM parallel transmit technique [2]. In [3], authors presented the concept of combined equalization for uplink MC-CDMA and perform a theoretical analysis which shows that better single-user bounds than the classical matched-filter bounds are achieved with the proposed concept. In [4], authors proposed a novel fractionally spread multicarrier CDMA arrangement i.e. the FS MC-CDMA scheme, which employs both T-domain spreading and F-domain spreading. Specifically the employment of concatenated T-domain spreading for improving the achievable performance, when communicating over wireless channels exhibiting both frequency-selective and time-selective fading is presented. In [5], authors proposed a multicarrier direct sequence code division multiple access, the so called pre-multi-coded MC-DS-CDMA system. In this scheme, the basic MC-DS-CDMA system is augmented with a pre-coder and a multi-code encoder at the transmitter. A frequency based multiple access architecture, frequency division multi carrier CDMA (FD-MC-CDMA) is proposed in [6]. The proposed architecture combines the best elements of FDMA and MC-CDMA to simultaneously exploit frequency diversity and minimize multiple access interface (MAI). In [7], authors proposed a technique for interference suppression in multicarrier code-division access systems which exploit the structural differences in signals that arrive at the receiver with Doppler shifts or carrier offsets. In [8], authors presented a new method of using MC-CDMA as transmission scheme, instead of Orthogonal Frequency Division Multiplexing in WiMAX based on the IEEE 802.16 standards.

In this paper, a specialized wavelet packet waveform set, i.e., the waveform generated from a full binary wavelet packet tree, is used as the modulation waveform in a multicarrier CDMA system. A novel receiver is designed that utilizes the time domain localization property of the wavelet packets. In this design multipath signals within one chip period are combined in the time domain to achieve time–domain diversity in a manner similar to the conventional RAKE receiver design. Each RAKE finger uses a wavelet packet transform to demodulate the corresponding path of the multicarrier signal in the time–domain rather than the frequency domain. The demodulated signal is then de-spread using the corresponding spreading code [9]. Compared with WP Based MC-CDMA and conventional MC-CDMA, the need of guard intervals in WP MC CDMA or MC-CDMA is eliminated by using WP time diversity modulation (FMT) in wireless application [10]. The spectra of each sub carrier in WP approach are overlapped, resulting in more efficient use of the spectrum. In other words, the orthogonally of the transmitted waveforms is achieved not by either cyclic prefix or non-overlapping sub channels, but rather by making use of the unique simultaneous time and frequency localization properties of the WP which are not achievable by the conventional MC-CDMA and WP MC-CDMA. This is similar in spirit to the pulse-shaped conventional MC CDMA. The complete set of wavelet waveforms are used instead of only one wavelet. Waveform helps to exploit explicitly the introduced time-diversity in a RAKE receiver design.

This paper presents performance analysis of wavelet packet based MC CDMA in comparison with the conventional MC-CDMA using Additive White Gaussian Noise (AWGN) Channel in term of bit error rate (BER). This paper is organized as follows: Section II describes the system modeling. Section III describes the Bit Error Rate and finally the simulation results and their discussions are presented in section IV. Finally the section V includes the concluding remark.

II. System Modeling

The CDMA system consists of transmitter as well as receiver. The details of MC-CDMA receiver/transmitter and WP MC-CDMA receiver/transmitter are given in the sections following.

1.1 MC-CDMA Transmitter

An OFDM carrier signal is the sum of number of orthogonal sub-carriers, with baseband data on each sub-carrier being independently modulated commonly using some type of quadrature amplitude modulation (QAM) or phase-shift keying (PSK). This composite baseband signal is typically used to modulate a main RF carrier. S (n) is a serial stream of binary digits. By inverse multiplexing, these are first de multiplexed into N parallel streams, and each one mapped to a (possibly complex) symbol stream using some modulation constellation (QAM, PSK, etc.). An inverse FFT is computed on each set of symbols, giving a set of complex time-domain samples. These samples are then quadrature-mixed to pass band in the standard way [11]. The transmitter of MC-CDMA is shown in Fig. 1.

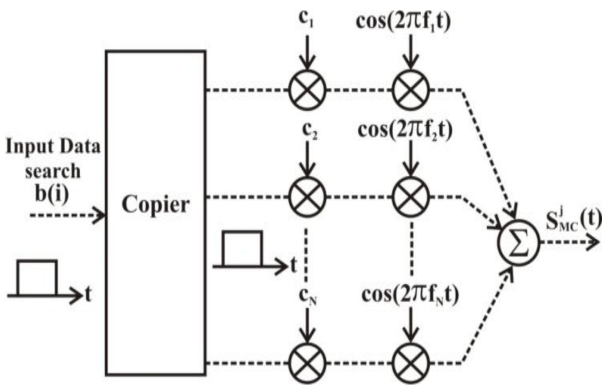

Fig. 1. Transmitter of MC-CDMA

1.2 MC-CDMA Receiver

The receiver picks up the signal r(t), which is then quadrature-mixed down to baseband using cosine and sine waves at the carrier frequency. This also creates signals centered on 2fc, so low-pass filters are used to reject these. The baseband signals are sampled and digitized using analog-to-digital converters (ADCs), and a forward FFT is used to convert back to the frequency domain. This returns N parallel streams, each of which is converted to a binary stream using an appropriate symbol detector. These streams are then re-combined into a serial stream, s (n) which is an estimate of the original binary stream at the transmitter [12]. The receiver of MC-CDMA is shown in Fig. 2.

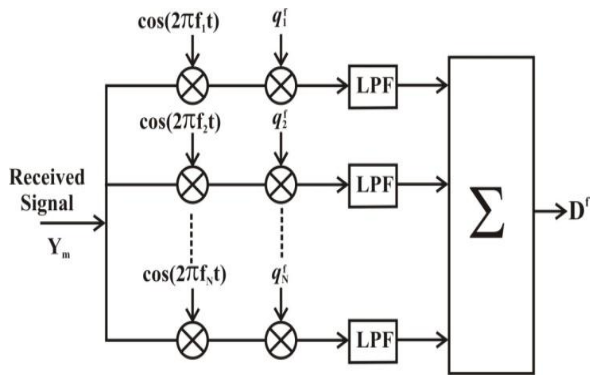

Fig. 2. Receiver of MC-CDMA

1.3 Transmitter of WP MC-CDMA

Although a number of different schemes are proposed in the literature, the multicarrier CDMA schemes can be categorized mainly into two groups.

- First one spreads the original data stream using a given spreading code, and then modulates a different sub carrier with each chip (the spreading operation in the frequency domain).
- Second spreads the serial-to-parallel (S/P) converted data streams using a given spreading code, and then modulates a different sub carrier with each of the data stream (the spreading operation in the time domain).

One group spreads the user symbols in the frequency domain and the other spread user symbols in the time domain. Wavelet Packets have the property of both time and frequency localization. The transmitter of WP-MC-CDMA is shown in Fig. 3.

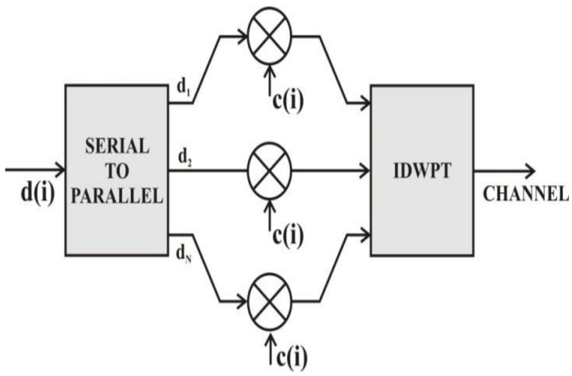

Fig. 3. Transmitter of WP-MC-CDMA

1.4 Receiver of WP MC-CDMA

A series of delayed version of the received signals are detected by single path detectors. In Each single path detector, a DWPT (Digital Wavelet Packet Transform) block is used for demodulation of the signal for the corresponding resolved path. The multi-user interference can be effectively eliminated if the desired user spreading code is known, which is assumed true in the following. The DWPT demodulated signal is forwarded to the dispreading part to obtain a detected decision variable for the resolved path [13]. The receiver of WP-MC-CDMA is shown in Fig. 4.

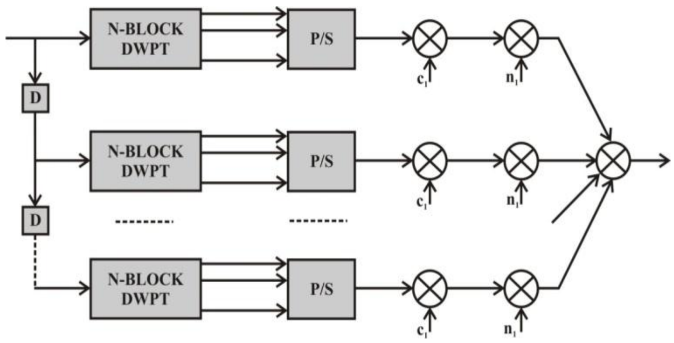

Fig. 4. Receiver of WP MC CDMA

III. Bit Error Rate

The bit error rate or bit error ratio (BER) is the number of bit errors divided by the total number of transferred bits during a studied time interval. The bit error rate of BPSK in AWGN can be calculated as BER= Error/ total number of bit [14].

IV. Simulation Results and Discussion

In this section, we have presented various BER vs. SNR Plots. Performance of the MC-CDMA and wavelet packet based MC-CDMA is shown in Fig. 5 and Fig. 6 respectively for AWN Channel. Simulation results in Fig. 5 and Fig. 6 show that the advantage of BPSK modulation technique for the conventional MC-CDMA and wavelet packet based MC-CDMA and wavelet packet based MC-CDMA system BPSK modulation is quite satisfactory as compared to other modulation techniques in AWGN channel. Performance of one user MC-CDMA for AWGN is carried out using BPSK (Binary phase shift key) and QPSK (Quadrature phase shift key) following modulation techniques.

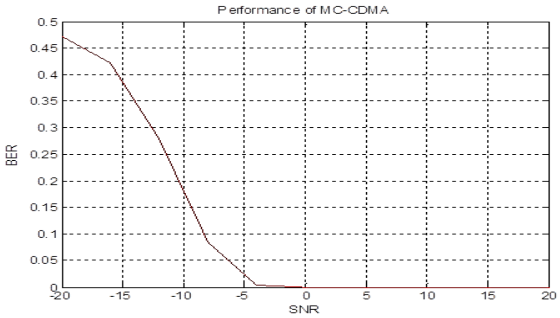

Fig. 5. Performance analysis of BER using BPSK Technique

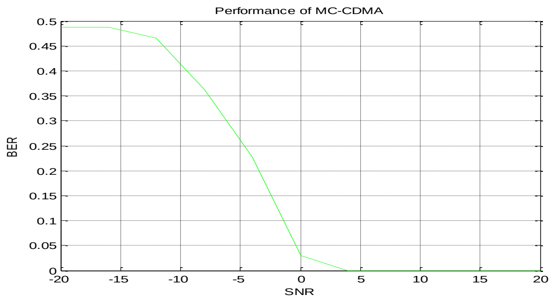

Fig. 6. Performance analysis of BER using QPSK Technique

Performance of WP MC-CDMA for two users in AWGN channel is shown in Fig. 7 and performance of MC-CDMA for two users in AWGN channel is shown in Fig. 8.

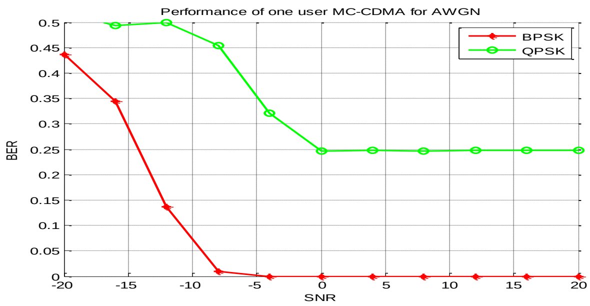

Fig. 7. WP MC CDMA System for 2 users

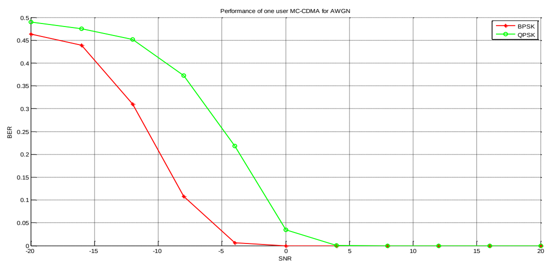

Fig. 8. MC CDMA System for 2 users

V. Conclusion

In this paper, comparative analysis of MC-CDMA system with wavelet packet based MC-CDMA system using different modulation techniques is presented. The analysis is carried out for one user as well as two users. The results presented show the performance of different modulation techniques. Wavelet packet based MC-CDMA system BPSK modulation is quite satisfactory as compared to other modulation techniques in AWGN channel.

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Biographies

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