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REANALYSIS OF BER FOR WAVELET BASED MC-CDMA COMMUNICATION

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ABSTRACT

As demand for higher data rates is continuously rising, there is always a need to develop more efficient wireless communication systems. The work described in this paper is my effort in this direction. We developed and evaluated a wavelet packet based multicarrier CDMA wireless communication system. In this system design a set of wavelet packets are used as the modulation waveforms in a multicarrier CDMA system. The need for cyclic prefix is eliminated in the system design due to the good orthogonality and time-frequency localization properties of the wavelet packets. Wavelet Packets have good properties such as orthogonality and multirate flexibility, and have resulted in a number of works for its applications to code division multiple access communications.

INTRODUCTION

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 despreaded using the corresponding spreading code [2]. Compared with OFDM or MC-CDMA, the need of guard intervals in OFDM or MC-CDMA is eliminated by using WP time diversity combining. Compared with Filtered multitone modulation (FMT) [3] in wireless application the spectra of each sub carrier in our WP approach are overlapped, resulting in more efficient use of the spectrum. In other words, the orthogonality of the transmitted waveforms is achieved not by either cyclic prefix or nonoverlapping subchannels, but rather by making use of the unique simultaneous time and frequency localization properties of the WP which are not achievable by the conventional DFT based OFDM, MC-CDMA, or FMT. This is similar in sprit to the pulse-shaped to the pulse-shaped OFDM. But our use of a complete set of wavelet waveforms, instead of only one wavelet waveform enables us to exploit explicitly the introduced time-diversity in a RAKE receiver design. This is different from the sub-space based blind method and different from the optimum frequency combining [6]. Compared with MC-DS-CDMA, on the other hand, our approach is practical for truly wideband applications since only on we RAKE receiver is needed (although one wavelet transform is needed per RAKE finger). In addition, time-diversity combining is in the sub chip level (many samples per chip). The entire frequency band is divided into a large number of narrow frequency bins, making chip duration much longer than that of MC-DS-CDMA. Therefore, our approach can be regarded as a hybrid between MC-CDMA and MC-DS-CDMA, but with wavelet packet waveforms replacing the sinusoidal waveforms. The computational complexity is $L_W L_R$ times that of MC-CDMA systems for a full wavelet packet binary tree implementation where, L_W is the length of wavelet filters (typically four to eight) L_R is the number of combined RAKE fingers which is still

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much less than MC-DS-CDMA in wideband applications.

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 [4]:

- 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);

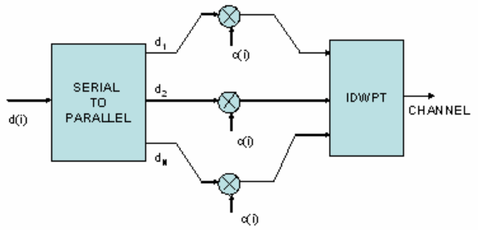
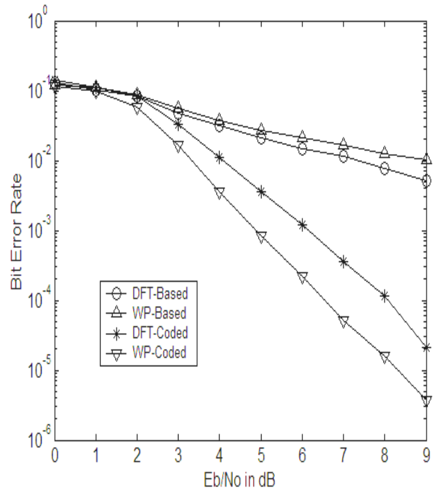


Fig1 Transmitter of WP-MC-CDMA System

One group spreads the user symbols in the frequency domain and the other spreads user symbols in the time domain [5]. Wavelet Packets have the property of both time and frequency localization [1]. Therefore, it is possible to make utilization of this property in two different ways. In this chapter a wavelet a wavelet Packet based multicarrier CDMA (WP-MC-CDMA) System and time domain detection algorithm is describe. To achieve time- domain diversity, the signaling of our proposed system would be similar to that of MC-DS CDMA .this is because such as approach is more sensitive to the relative time delay and thus multipath signals can be discriminated and then combined. There is a need of one RAKE combiner for each sub-carrier in an ordinary MC-DS-CDMA System, the complexity of the receiver depends highly on the number of sub carriers and limits the number of frequency bins.

RECEIVER OF WP-MC-CDMA



The proposed multipath combining receiver is shown in Fig2

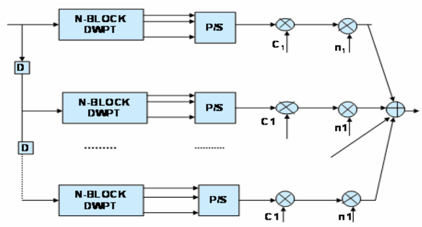


Fig.2 Multipath receiver of Wavelet Packet MC-CDMA System

Where a series of delayed version of the received signal 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 [2]. The result of these detectors is combined in the RAKE combiner to obtain a final decision vector.

ANALYSIS OF PDF

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The probability density function of z, conditioned on d^1, is

$$P(z/d^1) = \frac{1}{2\pi}\int_{-\infty}^{\infty} \emptyset(\omega)e^{-j\omega z}\, d\omega \quad \text{------ (i)}$$

Which can be evaluated by the residue theorem once the λ_i**s** are computed.
The probability density function of z is:

$$P(z) = \frac{1}{2\pi}\sum_{d^1} p(z/d^1) \quad \text{--------------(ii)}$$

The data symbols have 2^{63} different combinations. PDF for WP & Sinusoid waveform is analyzed. for five-path and ten-path NLOS channels when AWGN is not included in the calculated . In comparison the same density distribution functions of z when sinusoid waveforms are used instead of wavelet packets. It is the time localization property of wavelet packets that make it possible to eliminate the need of guard intervals.

"This means that the WP-based approach has a lower interference level and enables the elimination guard intervals between symbols."

SIMULATION RESULTS

In this section the overall simulation procedure is explained. All simulations were carried out using MATLAB7. The proposed time-domain RAKE receiver design is evaluated by means of simulation for synchronous transmission case. In this simulation, the number of sub carrier is set to 64. The channel is assumed multipath plus Gaussian noise, time-invariant within the simulation length. The bit error rate is calculated by running the simulation for 100000 symbols. The proposed WP-based multicarrier CDMA system has also been compared with the DFT-based system. Since the length of the channel is set to be ¼ of one symbol duration, in the DFT-based system the data rate is 80% of the original data rate due to the cyclic prefix. The performance comparison of the two systems in the case of 30 active users is shown in Fig.3. The channel is a five path NLOS channel. The DFT-based system uses the conventional frequency-domain maximal ratio combining. It can be seen that for the non-coding case the WP-based system achieves a slightly higher BER with 25%higher data rate than the DFT-based system. When coding is applied to both systems the WP-based system achieves a much better BER performance than the DFT-based system. This performance improvement is achieved with the price of a higher system complexity. In this case it can be seen that although it encounters higher interference level per interfering user since the NLOS channel makes it more difficult to achieve precise path match, the new WP-based system still outperforms the DFT-based system.

CONCLUSION

In conclusion, the proposed wavelet packet based multicarrier CDMA system and detection algorithm have the ability to distinguish and combine multipath signals within chip duration due to the time localization property of the wavelet packets. This ability eliminates the need for the guard interval between consecutive symbols. We presented here the system designs for wavelet packet based multicarrier CDMA communications. In this system design a set of wavelet packets are used as the modulation waveforms in a multicarrier CDMA system. The need for cyclic prefix is eliminated in the system design due to the good orthogonality and time-frequency localization properties of the wavelet packets.

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