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Performance analysis of wavelet packet multirate multicarrier multicode CDMA for wireless multimedia communications

Maryam M. Akho-Zahieh, Nasser Abdellatif*

Department of Electrical and Computer Engineering Applied Science Private University, Amman 11931, Jordan

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ABSTRACT

Different kinds of Multirate (MR) communication systems, such as multicode (MCD) scheme and variable spreading length (VSL) schemes, have been considered for accommodating information sources with different data rates in Multicarrier code-division multiple access (MC-CDMA). In this paper, we propose the use of MCD scheme for MR services in MC/MCD-CDMA system that employs wavelet packets (WPs) as subcarriers. The bit error rate (BER) performance for the system was investigated by means of analytical methods and numerical results in a slow fading frequency selective Nakagami channel. The performance analysis includes the effects of diversity techniques, channel intensity profile, diversity order and fading parameter. Also, the effects of different service rates and number of users in each service rate were investigated. The performance of the system was compared to that of MC/MCD-CDMA based on sinusoidal carrier. Results reveal that BER performance is proportional to the service rate and our proposed system outperform the other system.

1. Introduction

Next generation wireless communication systems are expected to deal with multimedia communication services including voice, data and video that transmit various kinds of data with bit rates being from low rate to much higher rate. Different kinds of multi-rate communication systems are considered for accommodating information sources with different data rates. Multicarrier code-division multiple-access (MC-CDMA) has been viewed as a powerful candidate due to its capabilities of achieving high capacity over frequency selective fading channel [1–3]. To obtain multiple services in a single system, designing a multirate communication system is a right choice. Multirate (MR) services can be provided in CDMA system by two schemes. One is multicode (MCD) scheme and another is multiprocessing gain (MPG) scheme, which is also called variable spreading length (VSL) scheme [4,5]. In the MCD scheme, the number of multicodes for each user varies according to the data rate while the processing gain of all users is fixed. In VSL or MPG scheme, the processing gain varies from user to user, but chip rate and number of multicodes are fixed. Performance of these two schemes in MCD-CDMA has been studied and compared in [6–11]. In [12] the use of MCD scheme for multirate services to obtain a technique called multirate MC/MCD-CDMA system has been proposed.

All above systems are based on sinusoidal carriers, hence these systems have high sidelobes energy with potential high energy leakage that can interfere with adjacent carriers causing inter-carrier interference (ICI) problem and accordingly degrading the system performance. Also, sinusoidal carriers lack localization in frequency and time domains; because of that, time diversity within one chip duration is difficult to achieve and time guard is needed between different carrier. Wavelet packets (WP) are not plagued by many of the above problems because they have much lower sidelobes and negligible sidelobe energy leakage. This property is effective in suppressing ICI and multiple access interference (MAI). Also WPs are naturally orthogonal and well localized in both frequency and time domains; hence it is not necessary to have frequency/time guard between different user signals. The basic idea of using wavelet packets in multicarrier multicode-CDMA systems has been proposed and analyzed in [13–15], this system is denoted as WP-MC/MCD-CDMA.

The aim of this paper is to use the MR services in the WP-MC/MCD-CDMA system to obtain a technique called WP-MR/ MC/MC-CDMA system. The performance of system has been explored and the impact of rates, number of users and number of multicodes for different multirate services on the performance of the system was investigated.

* Corresponding author. Tel.: +962 79383800; fax: +962 65609940.
E-mail addresses: maryamm@asu.edu.jo, maryam.akhozahia@gmail.com (M.M. Akho-Zahieh), nasser_abdellatif@asu.edu.jo, nasser.abdellatif@gmail.com (N. Abdellatif).

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$$d_{kj_{\Re}}(t) = \sum_{i=-\infty}^{\infty} d^{i}_{kj_{\Re}} \prod\nolimits_{T/H} (t - iT/H)$$

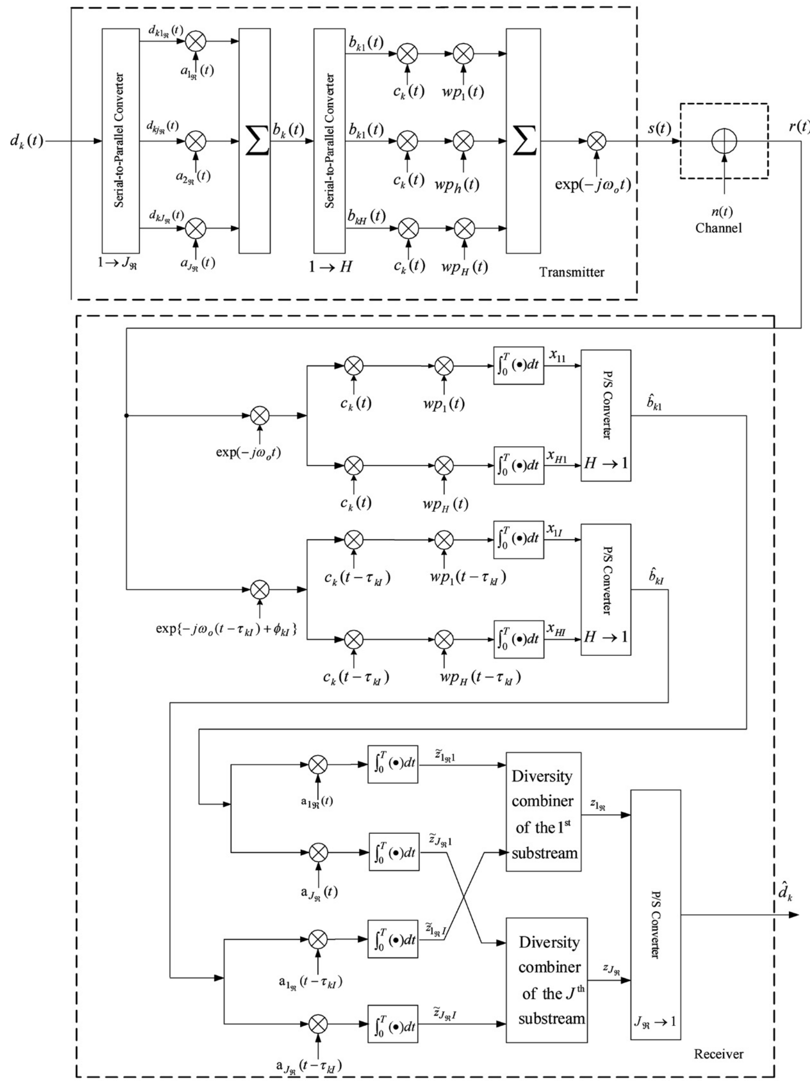

Fig. 1. Transceiver of WP-MR/MC/MCD-CDMA system.

Three methods of space diversity namely, selection diversity (SD), equal gain combining (EGC) and maximum ratio combining (MRC) were used to combat the effect of multipath fading and thus enhance the system's performance. The system's performance with different diversity techniques was investigated in terms of bit error rate (BER) in a slow fading frequency selective Nakagami channel. The performance analysis includes the effects of different service rates, number of users in each service rate, channel multipath intensity profile, diversity order and fading parameter

The performance of the proposed system is compared with the performance of sinusoidal (SIN) based MR/MC/MCD-CDMA denoted as SIN-MR/MC/MCD-CDM [12].

2. WP-MR/MC/MCD-CDMA system model

The transceiver of WP-MR/MC/MCD-CDMA system is shown in Fig. 1. Each of the transmitter and receiver consists of two parts multirate multicode part and processing gain wavelet packet part. The multirate users are classified into $\mathbb{N}$ groups according to data rate service. Each user is indexed by two variables: k indicates the user number and $\Re$ indicates the service group. There are in total $K = \sum_{\Re=1}^{\mathbb{N}} K_{\Re}$ users, where $K_{\Re}$ represents the number of users for the service group $\Re$. Each user has $\mathbb{N}$ multicode sets and can provide only one kind of rate service at a time. The bit stream, $d_k(t)$, for kth user of the service group $\Re$ has bit duration $T_{\Re} = T/J_{\Re}H$ and is given by

$$d_k(t) = \sum_{i=-\infty}^{\infty} d^{i}_{k} \prod_{T/(J_{\Re}H)} \left(t - i\frac{T}{J_{\Re}H}\right)$$

where $\Pi_x(\cdot)$ represents a rectangular pulse of duration x, $d^{i}_{k} \in \{\pm 1\}$ is the ith value of the bit stream, T is the bit duration, $J_{\Re}$ is the number of substreams for a service group $\Re$ in multicode part and H is the number of superstreams in the wavelet packets part. Note that