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Iterative Interference Cancellation for Multi-Carrier Modulation in MIMO-DWT Downlink Transmission

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[7]

☆ 84 [8]

Abstract

The Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) scheme represents the dominant radio interface for broadband multicarrier communication systems. However, with insufficient Cyclic Prefixes (CP), Inter-Symbol Interference (ISI) and Inter-Carrier Interference (ICI) occur due to the time-varying multipath channel. This means that the performance of the system will be degraded. In this paper, we investigate the interference problem for a MIMO Discrete Wavelet Transform (MIMO-DWT) system under the effect of the downlink LTE channel. A Low-Density Parity-Check (LDPC) decoder is used to estimate the decoded signal. The proposed iterative algorithm uses the estimated decoded signal to compute the components required for ICI/ISI interference reduction. In this paper, Iterative Interference Cancellation (IIC) is employed to mitigate the effects of interference that contaminates the received signal due to multiple antenna transmission and a multipath channel. An equalizer with minimum mean square error is considered. We compare the performance of our proposed algorithm with the traditional MIMO-OFDM scheme in terms of bit error probability under insufficient CP. Simulation results verify that significant improvements are achieved by using IIC and MIMO-IIC for both systems.

Introduction

Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) scheme is used to increase coupling capacity and spectrum efficiency in a radio multicarrier communication system. That is to say, it improves the overall system performance by providing huge throughput and coverage probability of all users simultaneously. However, to address the issue of block fading multipath channel under insufficient cyclic prefix (CP) and guard interval, effective receiver design is important.

To increase the spectral and power efficiency, the Discrete Wavelet Transform (DWT) with a Multi-Carrier Modulation scheme (MCM) has been designed and represented in different scenarios (Zhang & Cheng, 2004 [9]; Galli & Logvinov, 2008 [10]; Harbi & Burr, 2014 [11]; Chafii, Harbi & Burr, 2016 [12]; Chafii *et al*, 2018 [13]). In Chafii, Harbi & Burr (2016 [12]), the effect of varying the number of selected levels of the decomposition and reconstruction algorithms has been introduced. The main advantages of DWT-MCM over OFDM is the best time-frequency localization of its waveforms due to the choice of the mother wavelet and scaling functions (Oltean & Isar, 2009 [14]).

DWT-MCM also proved to be more robust with respect to the temporal variation (or changeability) of the wireless channel (Oltean, 2007 [15]). Better use of the channel in various interference environments was gained by using modulation techniques based on multirate wavelets, due to their dimensionality in time and frequency (Lindsey & Dill,1995 [16]). Multichannel filter banks and wavelet transforms in encryption and channel modulation have been investigated and studied using various schemes, such as CDMA signature spread, fractal modulation and superimposed multi-tone modulation (Wornell, 1996 [17]). The inherent versatility of wavelet transforms, with a number of interesting additional advantages, makes it a good candidate for multi-carrier schemes (Jamin & Mähönen, 2005 [18]). The method of wavelet packets has been widely adopted in mobile networks as a multi-carrier multiple access technique and in cognitive radio applications (Mathew, Premkumar & Lau, 2010a [19]). The ingrained orthogonality of multi-wavelets made it suitable for the single and multi-carrier schemes and for reducing the Multiple Access Interference (MAI) in a multi-user CR network (Mathew, Premkumar & Lau, 2010b [20]). Recently, an iterative algorithm for interference reduction is shown in different systems, such as SISI-FBMC, SISO-OFDM, and MIMO-OFDM transceivers under insufficient guard interval and different channel conditions (Harbi & Burr, 2016a [21], 2016b [22], 2018 [23]; Mahama *et al.*, 2019 [24]a, 2019b [25], 2020 [26]; Harbi, 2017 [27]).

In this paper, we propose an iterative algorithm scheme which reduces the interference among users for MIMO-DWT/OFDM systems to eliminate ISI/ICI interference due to fast fading multipath channel. The desired components can be calculated from the estimated decoded signals. At a given received antenna, the proposed scheme uses these components to decrease the ICI/ISI from multiple antenna transmission.

The remainder of this paper is organized as follows. In the next section, we describe the DWT-based MCM formulation and summarize the reconstruction and decomposition algorithms. Following that, we define the system model of the proposed algorithm for interference management, and introduce the main assumptions required for our analysis. Then, we discuss our simulation results. Finally, we summarize our contributions as a conclusion to the paper.

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