Non-Coherent Interference Cancellation for MIMO MC-CDMA System

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Abstract

The paper presents a new Non-Coherent interference cancellation scheme to the MIMO MC-CDMA (Multi-Carrier Code Division Multiple Access) systems in order to alleviate the interference due to multipath fading, noise, and multi-user in the dense wireless systems. Unlike other traditional coherent interference cancellation methods that depend on strict synchronization and channel state information (CSI) to work, the proposed method can be used without the phase alignment, so it is less susceptible to realistic channel impairments. By means of the simulation results, we show that the offered approach can drastically decrease the bit error rate (BER) in MIMO MC-CDMA systems, especially in very dynamic fading conditions. This method can improve the performance of the wireless communication systems that are practiced nowadays like 5G and 6G, where interference management is essential.

Keywords: MC-CDMA, BER, MMSE, CSI

1. Introduction

The recent emergence of wireless communication technologies, e.g., 5G and beyond, has contributed to a rise in the interest in effective approaches to managing interference, in particular, when the user count in an environment is large, and the channel environment is complicated. One of the promising technologies that offer high spectral efficiency and resistance to multipath fading is the MC-CDMA (Multi-Carrier Code Division Multiple Access) [1-2]. Therefore, with more users, inter-user interference (IUI) and multi-path interference emerge as the major problems in getting optimum performance of the system [3-5]. Interference is mitigated for MIMO CDMA system in [6]. The proposed system the interference is mitigated with iterative based non coherent equalizer.

Conventional forms of interference cancellation like the coherent interference cancellation uses accurate channel state information (CSI) and synchronization of the phases between the receiver and the transmitter. Such methods are however not very practical in practice where synchronization errors, frequency offsets, and fast fading conditions can impair performance [7]. The wireless communication system performance largely depends on the attributes of the medium. If the medium does not have strong signals, then the error becomes higher at the receiver [8-11]. Non-coherent interference cancellation (NCIC) in comparison does not rely on phase synchronization and uses statistical features of the received signal, and therefore, is more robust in practice in deployment.

The adaptive NCIC algorithm described in this paper is aimed to improve the signal-to-interference-plus-noise ratio (SINR) of MC-CDMA systems that do not need precise information on the channel phase. We demonstrate that the suggested approach vastly minimizes interference and enhances the reliability of systems in particular in fading channels.

2. System Model

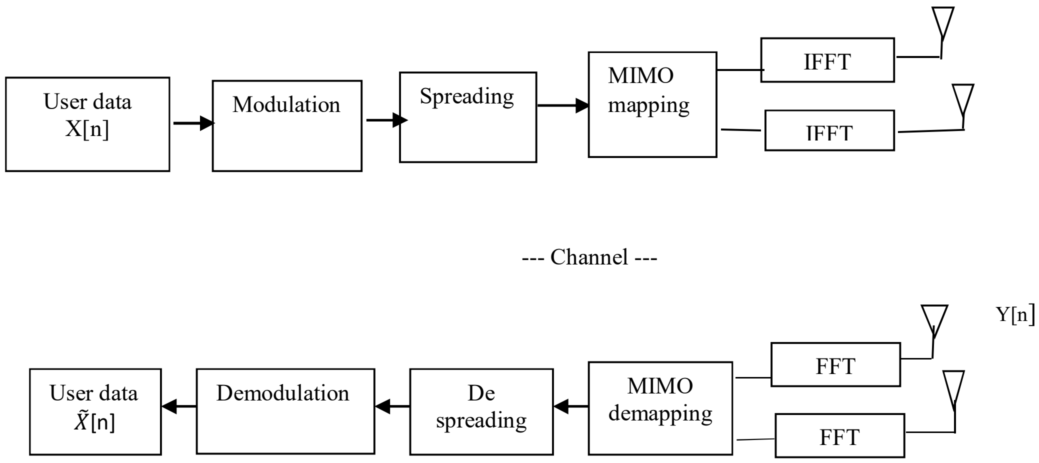

Fig. 1. Block diagram of MIMO MC-CDMA system

The proposed block diagram of MIMO MC CDMA system is represented by the figure 1. MC-CDMA is a hybrid of the OFDM (Orthogonal Frequency Division Multiplexing) and CDMA (Code Division Multiple Access) systems, the signal of each user is spread across various subcarriers using a different spreading code. The following are the major parts of the system model:

Transmitter: The data stream to be sent is coded and modulated and the signal is subsequently spread across several subcarriers with the spreading code followed by the modulated symbols being sent over antennas using an OFDM frame.

Channel: The signal sent is subjected to the phenomenon of multipath fading and the received signal has interference caused by the delaying versions of the sent signal. The system works based on the Additive White Gaussian Noise (AWGN) and Rayleigh. It is assumed that the channel is frequency selective and can have Doppler shifts as a result of mobility.

Receiver: The receiver receives the signal that has been received and this signal is influenced by both the multi-path fading and interference by other users. Whereas the non-coherent receiver lacks the need of phase synchronization between the transmitter and receiver, it is more resilient to fading and frequency offsets.

The proposed system implemented using spatial combining technique, which is one of the widely used method for multiple antenna case. And also implemented using zero forcing (ZF) and minimum mean square error (MMSE) technique to design the receiving system. MMSE is one of the sub optimum method which resolves the multipath effect fading problem [13].

3. Proposed Method: Non-Coherent Interference Cancellation

The noncoherent interference cancellation approach is introduced in this section, and in this case, there is no requirement of having exact phase synchronization. The method proposed exploits statistical properties of the received signal, e.g. the correlation pattern of the transmitted symbols, the interference signals.

3.1 Algorithm

Initialization: Detect the interference of the neighbor users according to the received signal statistics.
Interference Cancellation: Cancelled the estimated value of the received signal interference.
Signal Detection: is recovery of the transmitted symbols: The standard detection algorithms (MMSE/ZF) are employed.
Iteration: Repeat, and the signal detection error estimates are refined, and the signal detection is improved.

Though explicit phase synchronization is not required, the proposed method is more adaptable to the real-life scenario, that is Doppler shifts and frequency offsets.

4. Simulation Results

In this section, we present simulation results comparing the performance of the proposed non-coherent interference cancellation method with ZF and MMSE based receiving systems. Below table 1 shows the simulation parameters.

Table 1: Simulation Parameters

Table parameters	
Antenna size	2X2
Modulation	QPSK
Noise environment	AWGN
Channel Model	Rayleigh fading

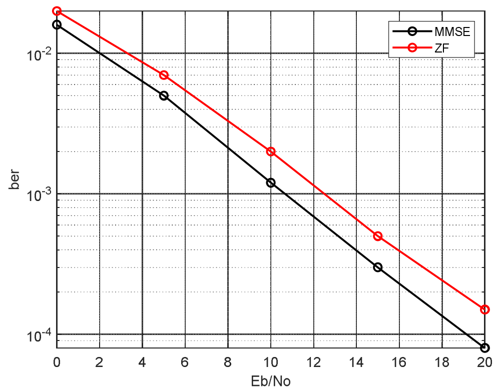

Fig. 2 BER Vs SNR for BPSK modulation

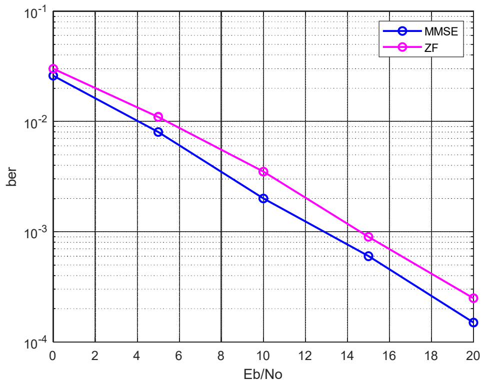

Fig. 3 BER Vs SNR for QPSK modulation

Figures 2, represents the BER vs SNR performance of ZF and MMSE based received systems over BPSK modulation. From the graph it is observed that MMSE is preforming better than ZF. Figure 3, plotted between BER and SNR of proposed system over QPSK modulation. And from the graph it is clear that MMSE is better than ZF.

4. Conclusion

This paper has introduced a non-coherent interference cancellation (NCIC) method of MIMO MC-CDMA systems. This proposed method provides a considerable improvement in performance over a more traditional system since it reduces interference but does not need a careful phase synchronization. Simulation indicates that NCIC application successfully mitigates the levels of bit error rates (BER) in different fading environments and thus can be used as a viable remedy to the present-day wireless communication networks. The future work may introduce the approach of using machine learning methods to maximize interference cancellation and estimation.

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