Cooperative Beamforming in MIMO-OFDMA Cognitive Radio Systems

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Abstract—**In this paper, a new algorithm is proposed for cooperative beamforming in the multiple input multiple output (MIMO) orthogonal frequency division multiple access (OFDMA) cognitive radio (CR) systems. The objective is to maximize the signal to interference plus noise ratio (SINR) of the selected secondary users subject to guarantee the primary user's quality of service over all subchannels. In each subchannel, in addition to the primary user (PU), one secondary user (SU), whose quality of service is the best, is selected to be serviced. The transmitter and receiver beamforming vectors are estimated by a two-step iterative algorithm. The performance of the algorithm is evaluated by computer simulations under different scenarios.**

Index Terms— **Cognitive radio, MIMO-OFDMA, cooperative beamforming**

I. INTRODUCTION

The cognitive radio (CR) system goal is to improve efficiency of spectrum usage by sharing bandwidth between licensed and unlicensed users. Multiple input multiple output (MIMO) orthogonal frequency division multiple access (OFDMA) technique is an appropriate candidate for the CR system to achieve this goal [1]. Different resource allocation schemes have been proposed for the MIMO-OFDMA CR systems recently [2]-[5]. Two adaptive post IFFT/FFT beamforming algorithms have been proposed in [2] based on minimum mean square error (MMSE) criterion. Resource allocation in the OFDMA CR systems has been addressed in [3] by maximizing the sum of the multiple SUs' weighted rate under the multiple PUs' interference temperature constraints. In [4], resource allocation for non-real-time services in OFDM-based CR systems has been investigated. A sum SUs' weighted rate maximizing over all subchannels and time slots has been proposed in [4] subject to total allowable transmit power and SUs' proportional rate guarantee. A Cooperative beamforming algorithm with power allocation has been proposed in [5] for downlink of the MIMO CR systems based on maximizing total SINR of SUs' subject to 1) maximum allowable transmit power, 2) a minimum threshold for PU's SINR in order to guarantee the required PU's QoS and 3) having the same SINR for all SUs.

In this paper, we propose a new algorithm for MIMO-OFDMA CR systems based on [5]. In the proposed algorithm, in addition to one PU, only one selected SU that has the best QoS can be serviced in each subchannel. In the criterion of the proposed beamforming algorithm, the SINRs of the selected SUs are maximized subject to a minimum threshold for the SINRs of all PUs in order to guarantee the required PUs' QoS. A two-step iterative algorithm is derived to estimate the transmitter and receiver beamforming vectors of the PUs and the selected SUs based on the proposed criterion.

In the following, a MIMO-OFDMA CR system is modeled based on P PUs and K SUs in Section II. The proposed algorithm is developed in Section III. Computer simulation results are presented in Section IV and Section V concludes the paper.

II. SYSTEM MODEL

A MIMO-OFDMA CR system with P primary transmitter-receiver links and K secondary transmitter-receiver links is shown in Fig. 1 where ith PU transmitter, ith PU receiver, jth SU transmitter and jth SU receiver are equipped by antenna arrays with N_{p_i} , M_{p_i} , N_{s_j} and M_{s_j} elements, respectively. The structure of each transmitter and receiver are shown in Fig. 2 and Fig. 3, respectively. As seen in Fig. 2 and Fig. 3, beamforming vectors are applied before IFFT blocks in transmitter and after FFT blocks in receiver. The transmitted

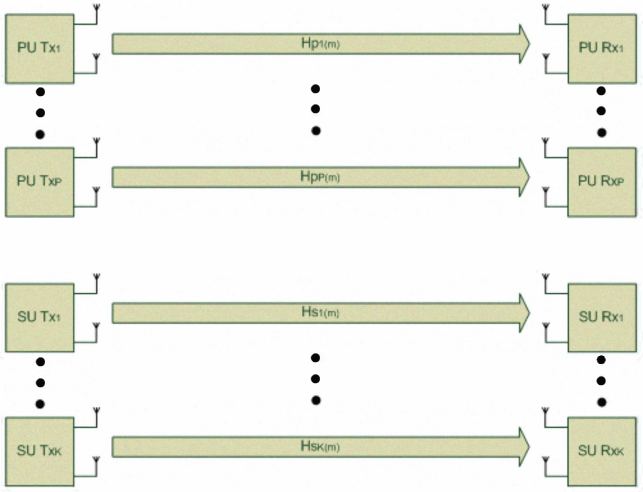

Fig. 1 The model of cognitive radio system.

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