INTERFERENCE ALIGNMENT SCHEME FOR A MIMO USERS USING MULTIUSER PRECODING

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ABSTRACT

This paper proposes an interference alignment scheme for a multiple input multiple output (MIMO) users using multiuser precoding. Firstly we explain the multiple access channel (MAC) - broadcast channel (BC) duality removes the ICI using interference alignment while maximizes the total capacity of the corresponding cell, but the interference alignment is not perform explicitly to all users and the number of transmit antennas required is generally higher than the multi-user precoding. So, we propose a new approach using multi-user precoding to perform maximization capacity of users in each cell and maximize the data rate. The experimental results shows that the performance of sum rate with different SNR values.

KEYWORDS *—MIMO, cellular network, interference alignment (IA), beam forming.Interfering broadcast channels(IFBC)*

I. INTRODUCTION

The fundamental concept of interference alignment is to align the interference signals in a particular subspace at each receiver so that an interference- free orthogonal subspace can be solely allocated for data transmission. Dirty paper coding is a technique that can pre-subtract interference at the transmitter. This requires the transmitted signals to be a result of successive encoding of information intended for the different users[1,2,3,4] In pioneering work by Caire and Shamai[5], a set of achievable rates (the achievable region) for the MIMO BC was obtained by applying the “dirty paper” result[6] at the transmitter (or alternatively, coding for non causally known interference). It was also shown in[5], that the sum rate MIMO BC capacity equals the maximum sum rate of this achievable region for the two-user BC with an arbitrary number of transmit antennas (t>=1) and one receive antenna at each receiver (r1=r2=1). However, computing this region is extremely complex and the approach used in[5], to prove the optimality of dirty paper coding for sum rate does not appear to work for the more general class of channels (i.e., an arbitrary number of users and receive antennas) which we consider.

Multi-cell and multi-user downlink transmission schemes have been actively discussed for future generation cellular networks. In[7] ,the idea is to maximize the network capacity by efficiently mitigating interference. The aligning interferences onto multi-dimensional subspace (in-stead of one dimension) for simultaneous alignments at multiple non-intended base stations (BS). In the multi-cell MIMO Gaussian interfering broadcast channels (MIMO-IFBC), each BS supports multiple users within its cell. Therefore there exist two kinds of interference namely inter-user interference (IUI) and inter-cell interference (ICI). To mitigate both IUI and ICI, authors in[8] proposed a zero-forcing (ZF) scheme for the IFBC with the aim of maximizing the sum rate performance in a multiple-input single-output (MISO) scenario. In[9], the ZF scheme for the MIMO-IFBC was extended to the case of multiple receiver antennas. Authors provided a precise expression of the spatial multiplexing gain for two mutually interfering MIMO broadcast channels using linear transceiver. Authors in [10] developed an interference alignment technique for a downlink cellular system which requires feedback only within each cell. The scheme provided substantial gain especially when the interference from a dominant interferer is significantly stronger than the remaining interference. Furthermore, for a two-cell MIMO-IFBC, the authors in [11] proposed a novel interference alignment technique for jointly designing the transmitter and receiver beam forming vectors using a closed-form expression without a need for iterative computation. It was shown both analytically and numerically that the proposed scheme achieves the optimal DoF.

In this paper is organized as follows. MAC-BC duality in section II. Explain the Multi-user precoding in section III. The simulation results are presented in Section IV. Concluding remarks are made in Section V.

II. MULTIPLE ACCESS CHANNEL (MAC) - BROADCAST CHANNEL (BC) DUALITY

The transmitted symbol of user k is an Nr-dimensional vector uk which is multiplied by a Nt M × Nr precoding matrix Wk and sent to the base station's antenna array. Thus, since all base station antennas are coordinated, the complex antenna output vector x is composed of signals for all K users. Therefore, x can be written as follows

$$\mathbf{x} = \sum_{k=1}^{K} \mathbf{W}_k \mathbf{u}_k$$

The received signal yk for user k can be represented as

$$\mathbf{y}_k = \mathbf{H}_k \mathbf{W}_k \mathbf{u}_k + \sum_{j \neq k} \mathbf{H}_k \mathbf{W}_j \mathbf{u}_j + \mathbf{z}_k$$

where zk denoted the additive white Gaussian noise (AWGN) vector for user k. Hk is the channel matrix of kth user. Wk is the M × Nr precoding matrix. Assuming that Hk is a full rank matrix rank = (K − 1)Nr, we perform singular value decomposition (SVD)

$$\widetilde{\mathbf{H}}_k = \mathbf{U}_k \mathbf{\Lambda}_k \left[\mathbf{\Upsilon}_k \mathbf{V}_k\right]^T$$

The block diagram of MAC-BC duality as shown in figure 1

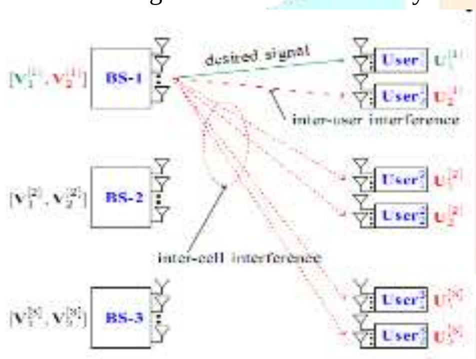

Figure 1. MAC-BC duality shows shown for the case of three cells and two users in each cell.

The MAC-BC duality removes the ICI using interference alignment while maximizes the total capacity of the corresponding cell, but the interference alignment is not perform explicitly to all users and the number of transmit antennas required is generally higher than the multi-user precoding. This is the drawback of MAC-BC duality.

III. MULTI-USER PRECODING (MUP)

Multi-user precoding is a method of precoding the data such that the effect of the interference can be canceled subject to some interference that is known to the transmitter. The MUP removes the ICI and inter user interference (IUI) while maximizes the total capacity of the corresponding cell. It requires less number of antennas compare to MAC-BC duality.
The symmetric modulo operation of precoding is defined as

$$\text{mod}_A(x) = x - 2A\lfloor (x + A + jA)/2A \rfloor$$

Where A is 16-QAM constellation i.e. A=4 and x is the data symbols.
Consider K independent users in the multi-user MIMO system. We assume that the BS and each MS are equipped with NB and NM antennas, respectively. The channel gain between the u^{th} user MS and BS is represented by HDL. The received signal is expressed as

$$\mathbf{y}_u = \mathbf{H}_u^{DL} \sum_{k=1}^{K} \mathbf{W}_k \tilde{\mathbf{x}}_k + \mathbf{z}_u$$

$$= \mathbf{H}_u^{DL} \mathbf{W}_u \tilde{\mathbf{x}}_u + \sum_{k=1,\, k \neq u}^{K} \mathbf{H}_u^{DL} \mathbf{W}_k \tilde{\mathbf{x}}_k + \mathbf{z}_u$$

Where W is the codebook [W1 W2 W3…Wk]. The objective is to choose an appropriate codeword that improves the overall system performance such as channel capacity or error performance. H^{DL} is the channel gain and z_u is the AWGN noise.
In this work, single user precoding matrices W1 are obtained as

$$\mathbf{W}_1 = \frac{1}{\sqrt{4}}\begin{bmatrix} 1 & 1 & 1 \\ 1 & e^{j2\pi\cdot1\cdot2/4} & e^{j2\pi\cdot1\cdot3/4} \\ 1 & e^{j2\pi\cdot2\cdot2/4} & e^{j2\pi\cdot2\cdot3/4} \\ 1 & e^{j2\pi\cdot3\cdot2/4} & e^{j2\pi\cdot3\cdot3/4} \end{bmatrix}$$

For multi user of cells

$$\mathrm{W}_i = \mathrm{diag}\left(\left[e^{j2\pi\cdot1/4}\ e^{j2\pi\cdot8/4}\ e^{j2\pi\cdot61/4}\ e^{j2\pi\cdot45/4}\right]\right)^{i-1}\mathrm{W}_1,\quad i = 2, 3, \cdots, 64$$

IV. EXPERIMENTAL RESULTS

In this section we compare the performance of muti-user detection and MAC-BC duality in terms of the sum rate with different degree of freedom (DoF).

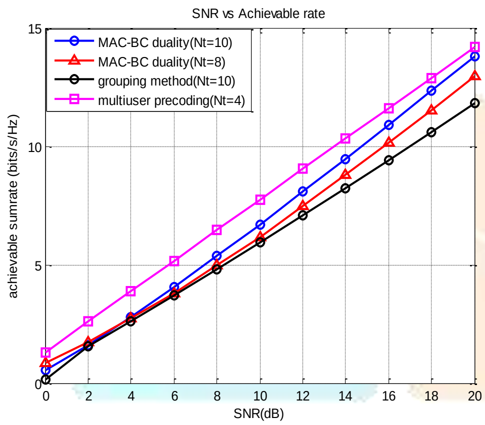

Fig. 2. The achievable rates for the proposed hybrid interference alignment scheme with different number of antennas setting (DoF = 12).

Fig. 2 depicts the sum rate versus SNR of the multi-user detection and compares it with the grouping method and MAC-BC duality. It outperforms the perfect interference alignment algorithm due to increase subspace dimension for mitigating intra-cell interference.

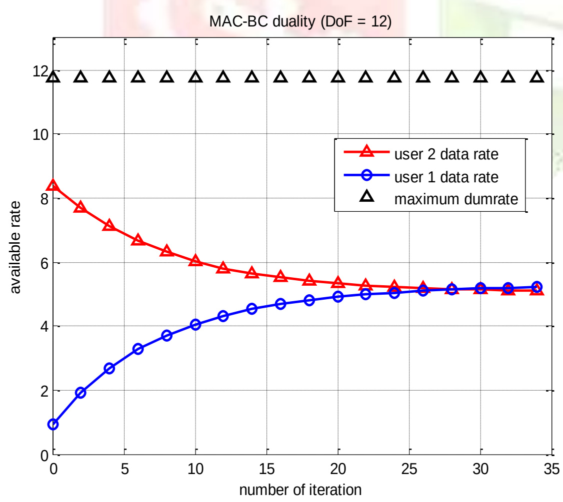

Fig. 3. Rate balancing of the proposed hybrid interference alignment algorithm using the MAC-BC duality (DoF = 12)

Fig. 3 depicts the convergence of the data rate for the two users of MAC-BC duality. The total rate is less than that of the scheme that does not use rate balancing constraint. However, the rate balancing constraint ensures fairness among users.

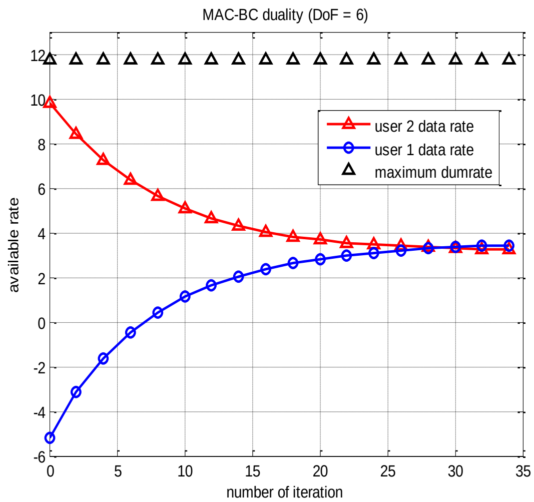

Fig. 4. Rate balancing of the proposed hybrid interference alignment algorithm using the MAC-BC duality (DoF = 6)

Fig. 4 depicts the convergence of the data rate for the two users of MAC-BC duality. The total rate is less than that of the scheme that does not use rate balancing constraint. However, the rate balancing constraint ensures fairness among users.

V. CONCLUSION

We proposed an interference alignment scheme for multi-user precoding and MAC-BC duality scheme. The multi-user precoding removes the ICI and inter user interference (IUI) while maximizes the total capacity of the corresponding cell. It requires less number of antennas compare to MAC-BC duality. The simulation results demonstrated the performance of the algorithms for various SNR values.

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BIOGRAPHY

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