

Transmit Antenna Subset Selection for Downlink MIMO Systems in Multicell Networks

*Jee Woong Kang, **Hui Won Je, and **Kwang Bok Lee

*Samsung Electronics Co. Ltd., **School of Electrical Engineering and INMC, Seoul National University.

*jw75.kang@samsung.com

Abstract

This paper discusses transmit antenna subset selection schemes for downlink closed-loop multiple-input multiple-output (MIMO) systems in multicell environments. A simplified-cooperative scheme is proposed to increase the sum of the mutual information of the links in all cells. The proposed simplified-cooperative scheme is realistic in that it only utilizes a limited amount of information from adjacent links, while the conventional cooperative scheme requires a large amount of information such as channel state information and MIMO transmit configurations of adjacent links. In spite of the use of a limited amount of information, the proposed scheme provides almost 90 percent of the average mutual information provided by the cooperative scheme. Furthermore, the proposed scheme shows significant enhancements over the competitive scheme which does not consider the effects of antenna subset selection on the performance of adjacent links.

I. INTRODUCTION

Information theoretic results have shown that the capacity of wireless communication systems can be greatly enhanced by deploying multiple antennas at both the transmitter and receiver [1]-[3]. Early research on multiple-input multiple-output (MIMO) systems was focused on a one-to-one link environment where only a single transmitter-receiver pair exists. In this scenario, the optimal transmit scheme maximizing capacity is known as water-filling power allocation along with channel decoupling by singular value decomposition (SVD) [4]. The full channel state information (CSI) of the MIMO channel, however, should be fed back to the transmitter, which causes MIMO systems to have a large overhead and to be vulnerable to time variation of channel states. Various semi-optimal schemes requiring less feedback have been investigated, and transmit antenna subset selection is one of these [5], [6]. In this scheme, transmit power is equally distributed to the selected antennas. As a result, only the index of the selected subset is fed back to the transmitter, greatly reducing the feedback burden.

Recently there has been increasing interest in multicell systems which are composed of multiple transmitter-receiver links [7]-[9]. Since each link interferes mutually, the MIMO transmit configuration of one link affects the mutual information of the other links as well as that of its own. In this context, the optimal transmit scheme for open-loop MIMO multicell systems was discussed by Blum [8], and a transmit scheme for closed-loop MIMO multicell systems were investigated in another paper by Ye and Blum [9]. Based on [9], in the cooperative scheme in this paper, it is assumed that MIMO transmit configuration of each transmitter is determined to maximize the sum of the mutual information of all links in the multicell system. On the other hand, in the competitive scheme, each MS in every cell is assumed to compete with each other to increase the mutual information of its own link. In [9], the mutual information of the cooperative scheme is shown to be larger than that of the competitive scheme.

The cooperative scheme in [9] presents an upper limit of the mutual information for MIMO multicell systems. However, this is difficult to apply in a realistic environment. The first reason for this difficulty is that each transmitter is required to know the full

CSI of the desired link for the channel decoupling by SVD. Secondly, each transmitter is required to know a large amount of information of adjacent links such as the CSI and MIMO transmit configurations. Each transmitter calculates the instantaneous mutual information of adjacent links as a function of its own MIMO transmit configuration.

In this paper, a simplified-cooperative scheme using a transmit antenna subset selection is proposed for the closed-loop downlink MIMO systems in multicell environments. In the proposed scheme, the mutual information of adjacent links is considered as well as that of the desired link. Contrary to the cooperative scheme, the amount of the required information is much reduced, since the *average* mutual information of adjacent links calculated from stochastic channel model is utilized instead of the instantaneous mutual information. As a result, the proposed scheme is easy to implement in realistic environments where available information is limited.

The rest of the paper is organized as follows: system models are presented in Section II; the simplified-cooperative scheme with limited feedback information is proposed in Section III; numerical results are presented in Section IV; and finally, conclusions are given in Section V.

The following notations are employed in this paper. The superscript H and T denote the transpose and transpose conjugate, respectively. $\det\{\mathbf{A}\}$ represents the determinant of matrix \mathbf{A} , and \mathbf{I}_M means the M by M identity matrix. $\max\{a,b\}$ and $\min\{a,b\}$ respectively denote the larger and smaller value between a and b .

II. SYSTEM MODELS

A downlink MIMO multicell system comprised of M cells is considered. It is assumed that a single MS is selected by user schedulers at the given time and frequency in each cell. The MS and base station (BS) are assumed to be equipped with N_r receive antennas and N_t transmit antennas, respectively. Then, the received signal vector \mathbf{y}_i at the i -th MS (the MS in the i -th cell) is modeled as

$$\mathbf{y}_i = \sqrt{P_i} \mathbf{H}_{i,i} \mathbf{x}_i + \sum_{j \neq i} \sqrt{P_j} \mathbf{H}_{i,j} \mathbf{x}_j + \mathbf{n}_i, \quad (1)$$

where P_i is the transmit power at the i -th BS (the BS in the i -th cell), and $\mathbf{H}_{i,j}$ is the channel impulse response matrix of the link from the j -th BS to the i -th MS. \mathbf{x}_i is the transmit signal vector at

This work was supported by National Research Laboratory (NRL) program, Korea.