Antenna Pattern Effect on Block Beamforming Algorithms in Multi-User MIMO Communications

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1. Introduction

We focus on the MU-MIMO (Multi-User MIMO) and show the antenna pattern effect of BD (Block Diagonalization) [1] and BMSN (Block Maximum SNR) [2] methods.

2. System Model of Multi-User MIMO

The number of transmitting antennas, the number of users, and the number of receiving antennas for each user are N_T, N_U, and N_R, respectively, in the downlink of the MU-MIMO system. The channel matrix for all users is denoted by $\boldsymbol{H}$, and the transmission (pre-cording) weight matrix is $\boldsymbol{W}$ which is determined by using BD or BMSN [1],[2].

3. Antenna Pattern

Transmitter is a linear array and all transmitting antennas have the following same power pattern $p(\theta)$.

$$p(\theta) = D_n \cos^n \theta \quad (n = 0,1,2,\cdots) \qquad (1)$$

where θ is the transmitting angle from the array broadside direction. D_n is the antenna directivity given by $2(n+1)$ based on the radiating power of unity. On the other hand, all receiving antennas are assumed to be isotropic.

4. Performance Analysis by Simulation

Under the conditions in Table 1, we analyzed the average capacities of BD and BMSN methods (including BF and GE schemes [2]) in a Rice fading environment. Transmitting and receiving antennas are both a uniform linear array (ULA) with the element spacing of half wavelength. In addition, the angles of departure and the angles of arrival of multipath waves, i.e., one LOS (Line-Of-Sight) wave and 20 NLOS (Non-LOS) waves, are given randomly for each transmission trial and each user. Fig. 1 (a) shows the analysis results for the Rice factor K = -20dB, and Fig. 1 (b) shows the results for K = 20dB. In the figures, the dashed lines represent the isotropic case (n = 0) and the solid lines represent the best performance for varying n in each method.

From Fig. 1, we can see the following two points.

(i) The optimal value of n depends on the ratio of the number of transmitting antennas to the total number of receiving antennas. Moreover, the larger the degree of freedom on the transmitter, the larger the optimal value of n.

(ii) When there is a strong LOS wave, the optimal value of n does not change significantly, and the optimal n is small, i.e., n =1 or 2.

In (i), when the transmitter has enough degrees of freedom in the array, it is easy to direct the nulls to other users. Therefore, they can benefit from increasing the maximum radiation intensity by enhancing the directivity. Regarding (ii), the reason is that the LOS wave can also be a strong interference wave to other users, so the directivity increase and high-power radiation in a specific direction may become harmful. As a result, we have found the effectiveness of the transmitting antenna pattern with some directivity.

5. Conclusion

It is shown that antenna patterns can improve average capacitance in the downlink of the MU-MIMO system.

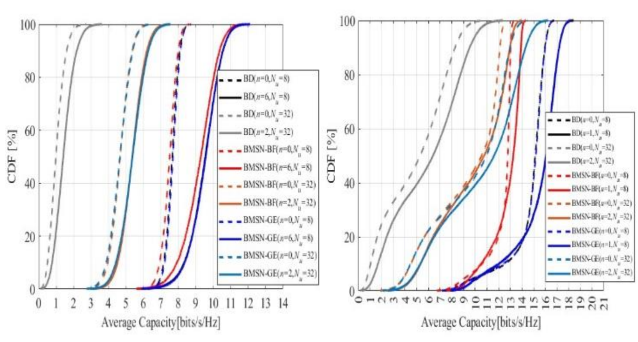
References

[1] Kentaro Nishimori, Basic Theory and Performance on Multi-user MIMO (in Japanese) , Corona publishing, 2014.

[2] N. Kikuma et al. IEICE Trans. Commun., vol.E102-B, No.2, pp.224-232, Feb. 2019.

Table 1 Simulation conditions.

(N_T, N_R)	(64, 2)	Input SNR	10dB
N_U	8 or 32	Rice factor K[dB]	-20 or 20
Transmission methods	Eigenmode transmission	Number of trials	1000



(a) K=-20dB (b) K=20dB

Fig.1 Average capacity characteristics.

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