Transmit filter design for OFDM MU-MIMO downlink

○Nobuyuki Sato, Fumiyuki Adachi, Hiroaki Muraoka

RIEC, Tohoku University

I. Introduction

Recently, with a rapid growth of wireless data traffic, development of broadband and high capacity mobile communications networks is necessary. To achieve broadband communications everywhere, distributed antenna network (DAN), in which a large number of antennas are spatially deployed over a service area, is attracting a much attention. We have been studying multi-user multiple-input multiple-output (MU-MIMO) using ZF based joint transmit and receive filtering [1] (here called joint Tx/Rx ZF filtering) and joint Tx/Rx MMSE filtering [2] to achieve high capacity communications.

II. Joint Tx/Rx Filtering

We consider OFDM downlink transmission with MU-MIMO allowing accommodating U user equipments (UEs) using N_t transmit distributed antennas (DAs) and N_r receive antennas. Channel matrix between DA's-UE's is decomposed by singular value decomposition (SVD) [3]. SVD of an $N_r \times N_t$ channel matrix $\mathbf{H}_u(k)$ for the k (=1,2,…,N_c) subcarrier can be described as

$$\mathbf{H}_u(k) = \mathbf{U}_u(k)\left(\mathbf{\Lambda}_u(k)\right)^{1/2}\mathbf{V}^H_{signal,u}(k), \quad (1)$$

where $\mathbf{U}_u(k)$ is an $N_r \times N_r$ unitary matrix, $\mathbf{\Lambda}_u(k)$ is an $N_r \times N_r$ diagonal matrix containing the N_r eigenvalues, and $\mathbf{V}_{signal,u}(k)$ is an $N_t \times N_r$ matrix corresponding to the signal subspace. Rx filter $\mathbf{W}_u(k)$ is given as $\mathbf{W}_u(k)=(\mathbf{U}_u(k))^H$ for both joint Tx/Rx filtering. Tx filter $\mathbf{G}_u(k)$ of joint Tx/Rx ZF filtering and MMSE filtering for the uth UE are given as

$$\mathbf{G}_u(k) = \begin{cases} \beta\left\{\mathbf{V}_{signal,u}(k)(\mathbf{V}_{signal,u}(k))^H\right\}^{-1}\mathbf{V}_{signal,u}(k) & \text{for ZF} \\ \beta\left\{(\mathbf{H}_u(k))^H\mathbf{U}_u(k)(\mathbf{U}_u(k))^H\mathbf{H}_u(k)+\gamma^{-1}\mathbf{I}_{N_r}\right\}^{-1} & \\ \times(\mathbf{H}_u(k))^H\mathbf{U}_u(k) & \text{for MMSE} \end{cases}, \quad (2)$$

where β is the power normalization coefficient and γ is the average received SNR or the average received signal-to-interference plus noise ratio (SINR). If the co-channel interference (CCI) from adjacent macro-cells cannot be neglected, the SINR must be used for obtaining the Tx filter.

III. Throughput Performance Evaluation

We assume 7 macro-cells (the center macro-cell is the cell of interest and is surrounded by 6 macro-cells). 7 DAs are deployed in each macro-cell. We assume a frequency-selective block Nakagami-Rice or Rayleigh fading depending on DA-UE's distance. No fading correlation between DAs, pass loss having path loss exponent α=3.5, and log-normal shadowing having standard deviation σ=7 (dB) are assumed. U=2 UE's are randomly located in each macro-cell.

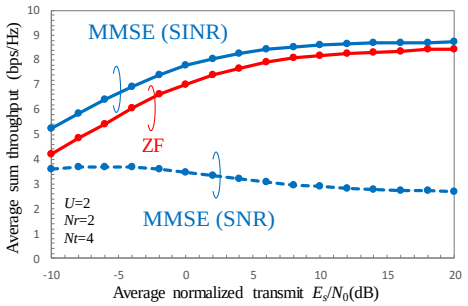

Fig.1 Comparison between joint Tx/Rx MMSE and ZF Tx filtering.

Fig.1 plots the average sum throughput as a function of the average normalized transmit E_s/N_0 when N_t=4 and N_r=2. The total transmit signal-to-noise power ratio from N_t=4 distributed antennas is given by the average normalized transmit E_s/N_0 (dB) plus path loss (dB) for a distance of the macro-cell radius. In DAN, since the distance between DA and UE is short, the receive SNR is sufficiently high everywhere in a macro-cell, the noise enhancement by ZF is not significant and can provide a good sum throughput. However, it is seen from Fig.1 that joint Tx/Rx MMSE filtering taking into account CCI provides slightly higher sum throughput than joint Tx/Rx ZF filtering. It should be pointed out that if CCI is not taken into account, joint Tx/Rx MMSE filtering is quite inferior to joint Tx/Rx ZF filtering.

IV. Conclusion

In this paper, we discussed about transmit filter design for joint Tx/Rx filtering for OFDM MU-MIMO downlink. In DAN, CCI from adjacent macro-cells cannot be neglected. It was confirmed that and joint Tx/Rx MMSE filtering taking into account SINR provides higher sum throughput than joint Tx/Rx ZF filtering.

Refferences

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