Downlink Multiuser MIMO-OFDM Transmission using Simple Receive Antenna Selection

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***Abstract* - This paper proposes a downlink MU-MIMO-OFDM transmission using simple receive antenna selection. In the proposal, base station transmits to users with selected receive antenna per subcarrier to obtain diversity gain. The proposal also decreases computational complexity by narrowing down the number of antenna combination in accordance with correlation value between receive antennas at each user. From experimental evaluations, it is indicated that the proposal offers high channel capacity with greatly reduced antenna combination.**

***Index Terms* — Downlink MU-MIMO; OFDM; antenna selection.**

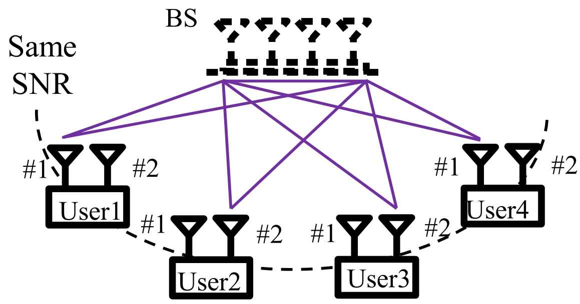

Fig.1. System model.

1. Introduction

For the advancement of the downlink multiuser multiple input multiple output (DL-MU-MIMO) transmission, DL-MU-MIMO with coordinated transmitter-receiver algorithm, receive antenna selection, and so on have been researched in [1][2]. These techniques obtain a diversity gain by exploiting multiple antennas at each user. This paper focuses on the receive antenna selection which realizes high channel capacity and low computational complexity at user side. However, DL-MU-MIMO transmission with receive antenna selection requires computational complexity at base station (BS) side to select an antenna combination with maximum channel capacity from all of antenna combinations.

For the reduction of the computational complexity, DL-MU-MIMO transmission with a simple receive antenna selection is proposed in this paper. In the proposal, BS simultaneously transmits to multiple users with the selected receive antenna per subcarrier to obtain diversity gain. Moreover, the proposal decreases the computational complexity by narrowing down the number of antenna combinations in accordance with antenna correlation value between receive antennas at each user. Concretely, when the antenna correlation value at a certain user is higher than threshold, an antenna with maximum norm is just selected. As patterns of antenna combination are decreased by using the proposed antenna selection, it is expected to also decrease the computational complexity. In order to clarify the effectiveness of the proposal, we have measured channel responses in an indoor environment and evaluated it by analyzing measurement results. Experimental results show that the proposal offers high channel capacity with greatly reduced antenna combination.

2. Proposed Transmission

We consider a DL-MU-MIMO orthogonal frequency division multiplexing (OFDM) system where BS transmits to N_U users as shown in Fig.1. BS and user have N_{BS} and two antennas, respectively. $\mathbf{H}_n(k)=[\mathbf{h}_{1,n}(k)^T\ \ \mathbf{h}_{2,n}(k)^T]^T\in\mathbb{C}^{2\times N_{BS}}$ denotes channel response of the k^{th} (k = 1…K) subcarrier between BS and user-n. $\mathbf{h}_{1,n}(k)$, $\mathbf{h}_{2,n}(k)$ are channel response between BS and the first and second antennas of user-n, respectively. As this paper assumes DL-MU-MIMO-OFDM transmission with receive antenna allocation per subcarrier, channel response after receive antenna selection defines $\hat{\mathbf{h}}_n(k)$. The received signals of the k^{th} subcarrier at user-n, $y_n(k)$ is expressed by the transmitted signal $x_n(k)$ as

$$y_n(k)=\hat{\mathbf{h}}_n(k)\mathbf{w}_n(k)x_n(k)+\sum_{l=1,l\neq n}^{N}\hat{\mathbf{h}}_l(k)\mathbf{w}_l(k)x_l(k)+n_n(k) \quad (1)$$

where $\mathbf{w}_n(k)\in\mathbb{C}^{N_{BS}\times 1}$ is pre-coding weight of the k^{th} subcarrier for user-n and $n_n(k)$ is the additive white Gaussian noise vectors of the k^{th} subcarrier with variance of σ^2. It is assumed that equal power is allocated to each user because each user has the same communication quality. For the practical use, pre-coding weight is calculated based on the zero-forcing [3], which is a low complexity weight calculation method.

This paper proposes a simple receive antenna selection for DL-MU-MIMO-OFDM transmission. In the proposal, AP firstly calculates antenna correlation values between receive antennas each user. When the calculated correlation value is higher than threshold, ρ_{th}, an antenna with maximum norm becomes a candidate for antenna selection. On the other hand, when the correlation value is less than threshold, both antennas become a candidate for antenna selection. Finally, AP calculates channel capacities of antenna combinations including antenna candidates and selects an antenna

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combination with maximum channel capacity. By using the proposal, patterns of antenna combination are decreased, so it is expected to also decrease computational complexity.

3. Experimental Evaluation

We have measured MIMO-OFDM channel responses between BS and each user in an indoor environment as shown in Fig.2. The center frequency, bandwidth are 5.18 GHz and 20 MHz, respectively. BS and users have four and two of dipole antennas with element space if 0.5 wavelengths. The heights of AP and STA are about 1 m, respectively. After experimental measurement, measured channel responses are normalized to average of signal to noise ratio (SNR) of 20dB because of the basic evaluation about spatial correlation.

Fig.3 plots threshold value, ρ_{th}, of antenna correlation versus averages of channel capacity per subcarrier on DL-MU-MIMO-OFDM transmission and reduction rate of antenna combination by using the proposed antenna selection. First of all, channel capacity increases in response to increase of threshold value. This is because the number of antenna combination also increases. On the contrary, reduction rate of antenna combination decrease in response to increase of threshold value. However, the number of antenna combination is greatly decreases by using low value of threshold. For example, results of reduction rate indicates 77% (ρ_{th} = 0.7), 65% (ρ_{th} = 0.8), and 42% (ρ_{th} = 0.9) in this indoor environment. From these results, it is found that there is the relation of the trade-off of channel capacity and reduction rate. Therefore, to adjust threshold value is required by use case.

Fig.4 shows the cumulative distribution function (CDF) of channel capacities with antenna selections of proposal (ρ_{th} = 0.7), optimum, and random. Also the simulated channel capacities are shown in Fig.4. In the simulation results, it is assumed that channel response is a normalized flat fading channel as independent and identically distributed (i.i.d.) zero-mean complex Gaussian. From this figure, it is found that channel capacities of the experimental results are less than these of the simulation results. This is because this environment is line of sight (LOS) condition which the spatial correlation is higher than i.i.d. channel. However, channel capacities can be improved by using receive antenna selection in both experimental and simulation results. Moreover, even if the number of antenna combination decreases by using the proposed antenna selection, the degradation of channel capacity is so small.

4. Conclusion

This paper proposes DL-MU-MIMO-OFDM transmission with simple receive antenna selection per subcarrier and evaluates it in an indoor experimental environment. From the experimental results, it is clarified that the proposal offers to reduce the computational complexity of 77% while keeping highly channel capacity.

References

[1] M. Codreanu, A. Tolli, M. Juntii, and M. Latva-aho, "Joint design of Tx-Rx Beamforers in MIMO downlink channel", IEEE Transaction on Signal Processing, vol.55, no.9, pp.4639-4655, Sept. 2007.

[2] M. Sadek, A. Tarighat, and A.H. Sayed, "Active antenna selection in multiuser MIMO communications", IEEE Transaction on Signal Processing, vol.55, no.4, pp.1498-1510, April 2007.

[3] Q.H. Spencer, A.L. Swindlehurst, and M. Haardt, " Zero-forcing methods for downlink spatial multiplexing in multiuser MIMO channels", IEEE Transaction on Signal Processing, vol.52, no.2, pp.461-471, Feb. 2004.

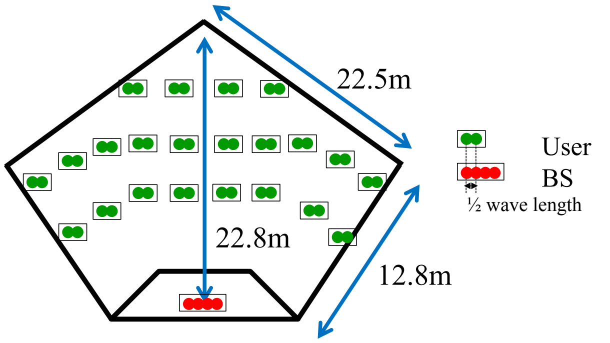

Fig.2. Experimental environment.

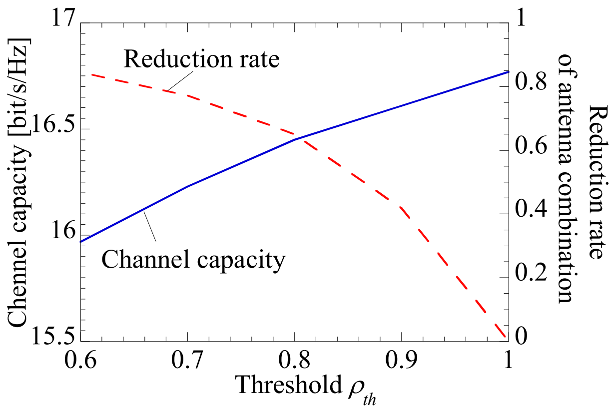

Fig.3. Threshold analysis.

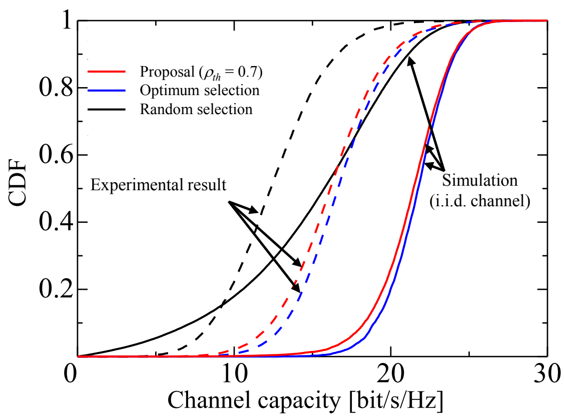

Fig.4. CDF of channel capacity (ρ_{th} = 0.7).