Performance evaluation for multi-user environment by NOMA and beam-forming with user scheduling

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***Abstract* - Multiuser multiple-input multiple-output (MU-MIMO) has been much attracted much attention for improving the spectral efficiency within a limited frequency band. However, it is not possible to communicate with the users that exceed the number of base station (BS) antennas in the MU-MIMO transmission. We have proposed a method by using non orthogonal multiple access (NOMA) and Zero Forcing (ZF) at the BS and Minimum Mean Square Error (MMSE) at user terminals (UTs). Furthermore, user selection algorithm for the proposed system by utilizing channel capacity equation of ZF algorithm has been proposed. By the proposed system, it was shown that the proposed method realizes the transmission with four users with only two antennas at the BS. In this paper, the effectiveness of proposed method is evaluated when considering a large number of multiple users in order to show validity of proposed system in more realistic environment.**

***Index Terms* — multiuser MIMO, successive interference cancellation, zero forcing, minimum mean square error, user selection.**

1. Introduction

Generally, linear pre-coding schemes by Zero Forcing (ZF) and Block Diagonalization (BD) [1] etc. are applied in the MU-MIMO downlink from a point of view on the calculation complexity at a base station (BS). However, the transmission rate by the MUMIMO downlink is greatly decreased when the total number of antennas at the UTs exceeds the number of antennas at the BS.

In order to solve this issue, non orthogonal multiple access (NOMA) transmission has been proposed. NOMA realizes multiple access with relatively realistic computation load even if the total number of antennas at the UTs exceeds the number of antennas at the BS [2]. NOMA transmission realizes the communication with two users by only single antenna at the BS. However, it is difficult for the BS with single antenna to communicate over three users, because the methods for transmission power control and user selection are very complex.

We have proposed a NOMA transmission combined with transmit beamforming (BF) [3]. In the proposed method, it is shown that the BS with only two antennas enables simultaneous four user transmission. Because bit error rate (BER) performance by ZF is degraded when high spatial correlation is assumed, user scheduling selection algorithm by utilizing channel capacity equation of ZF algorithm has been proposed in order to reduce the outer-group interference[4]. However, only basic performance was evaluated when considering the proposed method in these studies [3][4].

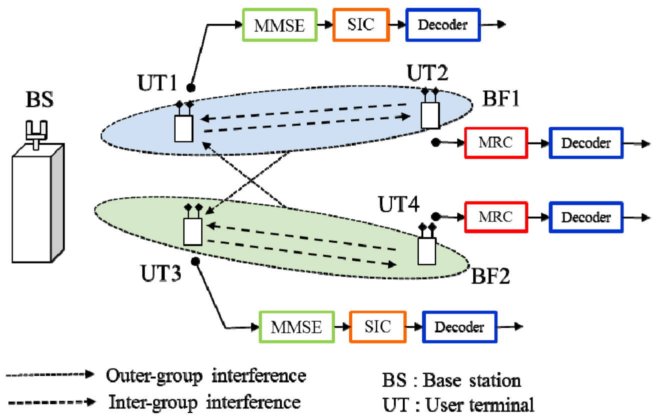

Fig. 1. Operational principle of the proposed method.

In this paper, we evaluate the effectiveness of proposed method when considering a large number of multiple users in order to show validity of proposed system [3][4] in more realistic environment. The effectiveness of NOMA plus transmit beam-forming with user selection algorithm is verified compared to conventional ZF algorithm when a large number of near and far users for the BS are randomly located inside the cell.

2. NOMA and beam-forming with user scheduling

Fig.1 is a configuration of NOMA with beam-forming [3]. Multiple UTs are located near and far for the BS and user groups are obtained for a certain scheduling such as signal to noise power ratio (SNR) criteria [2]. First, the ZF is applied for the UTs which are located at far place for the BS. Next, the interference from the other group is cancelled by Minimum Mean Square Error (MMSE) at the UTs which are located near the BS. Finally, the Successive Interference Cancellation (SIC) is employed to discriminate the signals inside the group.

In order to mitigate performance degradation by the interference to UT1 and UT3 in Fig.1, a user selection method using a channel capacity expression by ZF was proposed [3]. Fig.2 shows concept and scheme of scheduling for the proposed method. As shown in Fig.2, there are two stages for four user selection. First, as shown in Fig. 2(a), the far user (UT2 and UT4 in Fig.1) is selected by equation with transmission rate by ZF. Far users which consider both SNR after ZF and spatial correlation between two users are selected.

Next, near users (UT1 and UT3 in Fig.1) are selected by

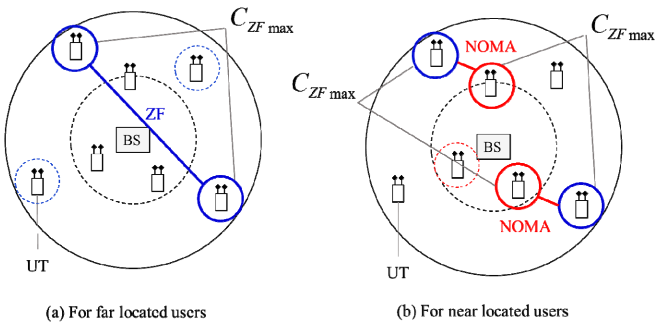

Fig. 2. Concept and scheme of scheduling for the proposed method.

the transmission rate by ZF between UT1 (UT3) and UT4 (UT2). Note that ZF is not actually employed for UT1 (UT3) and UT4 (UT2) and this process is used for a measure for the spatial correlation between UT1 (UT3) and UT4 (UT2). Hence, the spatial correlation between UT1 (UT3) and UT4 (UT2) is reduced by this method and performance degradation by outer-group interference is mitigated. As a result, MMSE performance improvement at UT1 (UT3) can be expected.

3. Performance evaluation with multi-user environment

In order to clarify the effectiveness of the proposed method with user selection, we employ the computer simulation. We consider that a large number of users where a realistic scenario is assumed. The simulation conditions are shown hereafter. The co-efficient of path loss is 3.5. We assume i.i.d. Rayleigh fading channel. The condition on the propagation channel is changed 1,000 times and we calculate the BER after sending 10,000 bits in each propagation channel. The numbers of BS and UT are two, respectively. QPSK and BPSK are used for UT1 (UT3) and UT2 (UT4) as the modulation scheme. The power ratio between UT1 (UT3) and UT2 is 4. The average SNR of far and near user is 10dB and 30dB. In this evaluation, simultaneous transmission is employed for only four users but all the multiple users are selected in turn by time division multiple access. The numbers of far and near users are the same.

Fig.3 shows total bit rate versus number of far users. Theoretical value of BF with NOMA and only ZF transmission are plotted in Fig.3. As can be seen in Fig.3, the total bit rate is improved in proportional to the number of users. It is observed that the total bit rates for CDF= 10 and 90% by the proposed method are about 2.2 and 2.5 times compared with those by theoretical value (ZF with BPSK), respectively.

Fig.4 shows probability where target achievable bit rate is obtained when different priorities by proposed user selection are considered. The number of far users is 4, 12, 20 and 50 in Fig.4 (a), (b), (c) and (d), respectively. “Highest” in Fig.4 means first selected four users. “Lowest” in Fig.4 is the last selected four users. Total achievable bit rate for “Highest” is improved when the number of users is increased. The probability with maximum bit rate (6 bits/symbol) is 88% and 95% for 20 and 50 users when “Highest” is assumed. On the other hand, total achievable bit rate for “Lowest” is decreased when the number of users is increased.

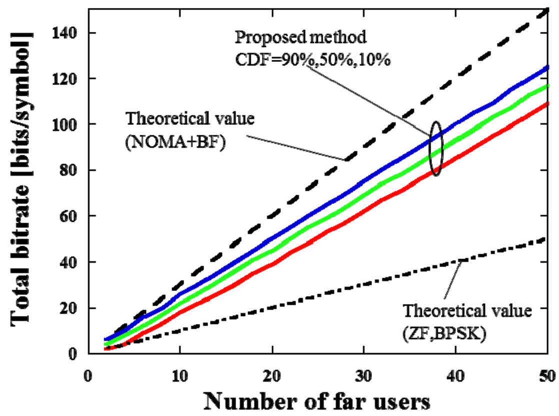

Fig. 3. Total bit rate versus Number of far users.

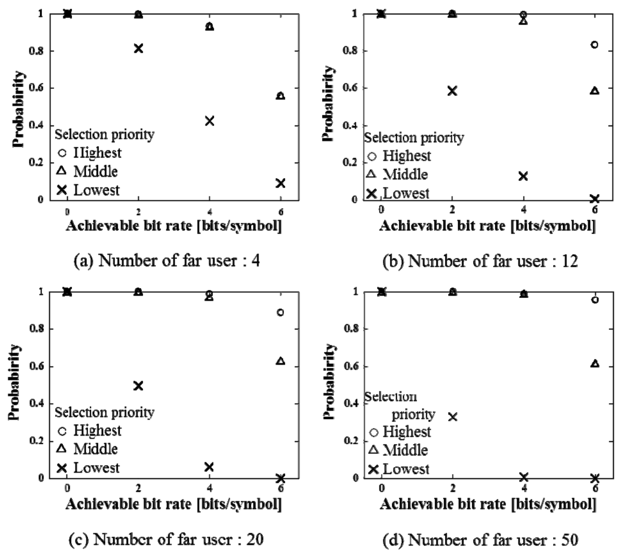

Fig. 4. Probability versus achievable bit rate.

4. Conclusion

The effectiveness of proposed method with user selection algorithm is verified compared to conventional ZF algorithm when a large number of near and far users for the BS are randomly located inside the cell. It is observed that the total bit rate for by the proposed method is over twice compared with that by theoretical value with only ZF algorithm.

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