Performance comparison of multi-beam massive MIMO by the switch configuration

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Abstract – **Massive MIMO enables the improvement on the transmission rate without increasing the burden on the signal processing by employing a large number of antennas at a base station (BS). However, it is reported that CSI estimation itself has a large overhead when considering massive MIMO. The authors have proposed analog-digital hybrid massive MIMO configuration which eliminates CSI estimation itself by applying analog multi-beam and their selection and blind algorithm. Moreover, the effectiveness of the proposed system is shown when ideal beam selection is applied by a matrix switch. On the other hand, it is not realistic to use the matrix switch when considering massive MIMO. In this paper, we propose multi-beam massive MIMO configuration using many-to-one switch. Via a computer simulation, the performance of each configurations is verified.**

Index Terms — **Massive MIMO, CSI estimation, multi-beam, CMA**

Fig. 1 Hardware configuration with matrix switch.

1. Introduction

Recently, the concept of massive MIMO has been proposed [1], because massive MIMO realizes simple signalprocessing in Multi-user MIMO (MU-MIMO) transmission. However, when the Channel State Information (CSI) feedback is employed from the user terminals (UTs) to an access point (AP), this procedure gives a very large overhead compared with the communication data [2].

To solve this problem, an implicit beamforming method which eliminates the CSI feedback was proposed [2]. However, even if implicit beamforming is applied for the massive MIMO system, the CSI estimation itself is still large overhead when considering the short packet communications such as Wireless LAN systems [3].

The authors have proposed analog-digital hybrid massive MIMO configuration which eliminates CSI estimation itself by applying analog multi-beam and their selection and blind algorithm using constant modulus algorithm (CMA) [4]. Moreover, the effectiveness of the proposed system is shown when ideal beam selection is applied by a matrix switch. On the other hand, it is not realistic to use the matrix switch when considering massive MIMO. In this paper, multi-beam massive MIMO configuration using many-to-one switch is proposed. Via a computer simulation, the performance of each configuration is compared.
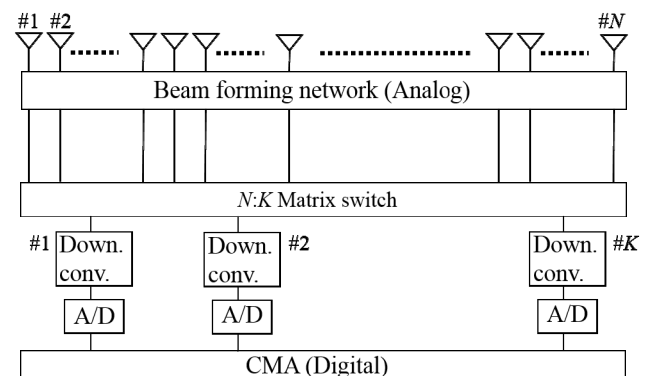
2. Proposed method

In the proposed method, the CSI estimation is not required. Therefore, asynchronous MU-MIMO transmission is realized without negotiation between the BS and users and overhead which gives low transmission efficiency does not ideally exist [4].

Fig. 1 shows the configuration with matrix switch by the proposed method in [4]. In the proposed method, N orthogonal multiple beams are prepared at analog part and K beams are selected for target users. However, it is difficult to use matrix switch in massive MIMO because the number of beams is very large and switch is very complex. In order to solve this problem, instead of matrix switch, we propose to use multiple switches with M versus 1 as shown in Fig.2. When M beams are input to a switch, the number of switches is N/M. In this configuration, if adjacent beams are input to same switch, users might not be sufficiently separated and the performance might be degraded.

To solve this issue, beam numbers are selected for each switch so that adjacent beams are not input to same switch as shown in Fig.3. We call this configuration *modified M*:1 switch configuration. In this configuration, adjacent beams can be selected without matrix switch, hence it is expected that the transmission performance by Fig. 3 is improved compared to that by Fig. 2.
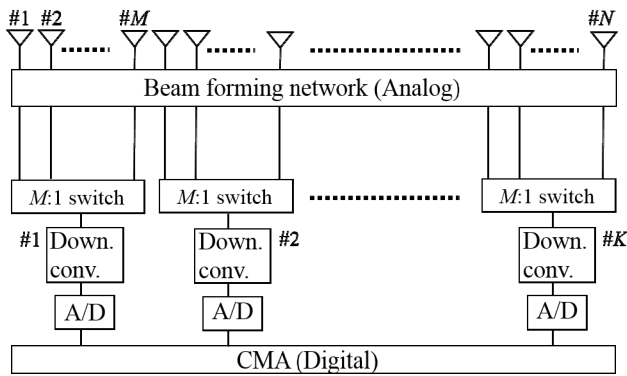
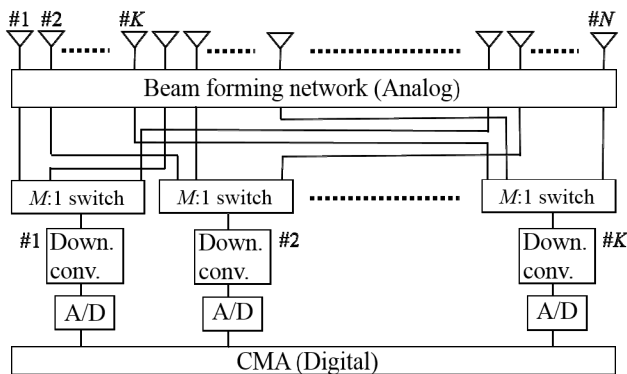Fig. 2 Hardware configuration with *M*:1 switch.

Fig. 3 *Modified* hardware configuration with *M*:1 switch.

Fig. 4 SINR versus difference of DoA when 2 users exist.
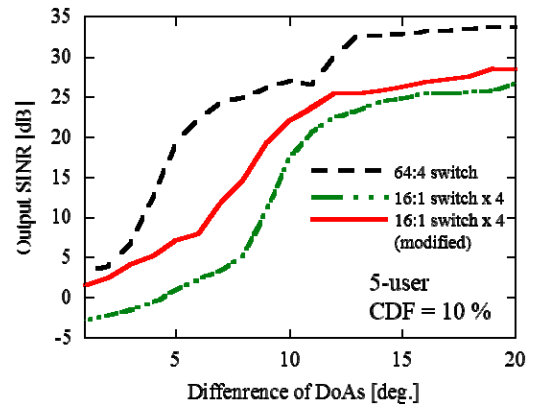
Fig. 5 SINR versus difference of DoAs when 5 users exist.

3. SINR characteristics of each configurations

To verify the basic performance of each configuration by proposed method, the computer simulation is carried out. When five users exist in multi-path environment, the signal to interference plus noise power ratio (SINR) is evaluated. In this simulation, single cluster model is assumed and angular spread at the BS assumed to be 10. The signal to noise power ratio (SNR) per antenna at the BS is 20 dB. The number of multi beams is 64 and the number of selected beams is 4. Least square method is adopted as an optimization algorithm regarding the CMA [5]. The propagation condition is changed and the number of trials is 10,000.

The SINR versus difference of DoAs ($\Delta\theta$) between two users and five users with CDF=10% is plotted in Fig. 4 and Fig 5. As can be seen in Fig. 4, the SINRs are greater than 25 dB and there is almost no difference in each SINR characteristics when only two users exist. On the other hand, when the number of users is five in Fig. 5, the SINR by the configuration with 16:1 switches in Fig. 3 is lower than that with 64:4 switch in Fig. 2. When $\Delta\theta$ is 8°, the SINR is 5.3 dB in the configuration with 16:1 switch in which adjacent beams are input to same switch. However, 15 dB SINR improvement is obtained by *modified* configuration in Fig. 3 compared to by the configuration in Fig. 2.
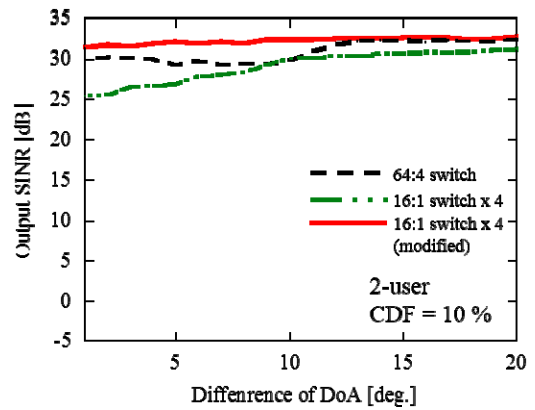
4. Conclusion

In this paper, we have proposed multi-beam massive MIMO configuration with multiple many-to-one switches. Via computer simulation, although the performance is decreased in the configuration with many-to-one switch from the configuration with matrix switch. To solve this problem, we proposed *modified* configuration which adjacent beams are not input to same switch. By using *modified* configuration, it is shown that SINR can be greatly improved when comparing *conventional* configuration with many-to-one switches.

References

[1] H. Papadopoulos et al.,"Massive MIMO Technologies and Challenges towards, 5G", IEICE Trans.Commun. Vol.E99-B, No.3, pp602-621, March 2015.
[2] T. Murakami, H. Fukuzono, Y. Takatori and M. Mizoguchi, ``Multiuser MIMO with implicit channel feedback in massive antenna systems", IEICE Communications Express, Vol.2, No.8 pp.336--342, Aug. 2013.
[3] Hiraguri and K. Nishimori, "Survey of transmission methods and efficiency using MIMO technologies for wireless LAN systems (Invited Survey Paper)," IEICE Trans. Commun. Vol.E98-B, No.7, pp.1250-1267, July 2015.
[4] K. Nishimori et al, "Multi-beam Massive MIMO Using Analog Beamforming and DBF Based Blind Algorithm", Proc. of ISAP2015, Nov. 2015.
[5] I. B. G. Agee, "The Least-Squares CMA: A New Technique for Rapid Correction of Constant Modulus Signals," Proc.IEEE ICASSP, pp.953–956, 1986.