A Study of User Selection Method for Access Control Scheme on Multi-Beam Massive MIMO System

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***Abstract*—Multi-user multiple input multiple output (MU-MIMO) and massive MIMO transmission techniques can perform high-speed and simultaneous transmissions in wireless communications. However, transmission technologies need channel state information (CSI) feedback for channel estimation. CSI feedback decreases transmission efficiency owing to the overhead of access control for frame exchange. In related work, multi-beam massive MIMO transmission with CSI feedback elimination was proposed to resolve this issue.**

In this paper, we proposed an access control scheme for multi-beam massive MIMO transmission called the overhead less access control scheme and studied a user selection method for fairness for terminals. We confirmed that the proposed access control with user selection scheme obtains a transmission efficiency of 90% or more.

I. INTRODUCTION

The number of user terminal stations (STAs) using wireless communication systems such as wireless local area networks (WLANs) has increased, thereby causing congestion and depletion of radio bands. In order to solve this problem, multi-user multiple input multiple output (MU-MIMO) transmission was standardized within the IEEE 802.11ac standard [1]. MU-MIMO transmission enables high-speed communications and simultaneous communication with many STAs using signal processing of the physical (PHY) layer technology. In addition, massive MIMO transmission [2] utilizing more antennas than MU-MIMO for next-generation wireless communications such as 5G has been actively studied in recent years. However, transmission efficiency is decreasing owing to large overhead, such as channel state information (CSI) feedback for channel estimation in the medium access control (MAC) layer. In related work, multi-beam massive MIMO transmission for eliminating CSI feedback [3] has been proposed to address these issues.

In this paper, we propose an access control scheme for multi-beam massive MIMO transmission called the overhead less access control scheme (OLACS). OLACS can reduce overhead such as CSI feedback and block acknowledgment (BA) algorithm, and obtains high transmission efficiency. Furthermore, we propose a user selection method for fairness communication on OLACS. We evaluated the performance of these schemes by computer simulation. The results confirmed that the proposed scheme has a high transmission efficiency of 90% or more.

The remainder of this paper is organized as follows. Section II discusses conventional technologies and the issues they face with regard to the access control protocol overhead of the MU-MIMO system. Section III describes the proposed schemes in detail. Section IV evaluates the performance of the proposed schemes with simulation experiments. Finally, Section V concludes this paper.

II. ISSUE WITH THE CONVENTIONAL SCHEME

In this section, we introduce issues with the conventional access control protocol of the MU-MIMO system on the IEEE 802.11ac standard. The MU-MIMO system can communicate simultaneously downlink transmissions to many STAs at same time and in the same frequency band. However, a CSI feedback algorithm for channel estimation is necessary to achieve the MU-MIMO system. The CSI feedback performs channel estimation by exchanging packets with the access point (AP) and each STA. The null data packet announcement frame transmitted to each STA from the AP for the first time at CSI feedback has an overhead because the frame length increases depending on the number of STAs. Then, the overhead of the beamforming report (BR) frame transmitted from each STA to the AP increases as the number of antennas increase. In addition, since the AP that received the BR frame transmits the BR poll frame to the next STA, the overhead time will defer when the number of STAs increase. Furthermore, the BA algorithm becomes a large overhead owing to the need to exchange the BA frame and BA request frame in the AP and each STA. Thus, the access control protocol of the MU-MIMO system has a considerably large overhead and transmission efficiency sharply decreases in the MAC layer.

III. OVERVIEW OF THE PROPOSED SCHEME

In this section, we provide an overview of the proposed scheme. The proposed scheme consists of multi-beam massive MIMO transmission using PHY layer technology, the OLACS of MAC layer technology, and a user selection method for fairness communication. We propose two technologies in the MAC layer for multi-beam massive MIMO transmission of related work in the PHY layer.

A. Multi-Beam Massive MIMO Transmission

The multi-beam massive MIMO transmission [3] can transmit and receive packets from the AP and STAs without CSI feedback. The feature of massive MIMO technology is the narrow beamforming. Therefore, CSI feedback is eliminated by preparing a plurality of narrow fixed multi-beam directivities. Since beams are separated for each STA, it is possible to receive packets from each STA at the same time. Furthermore, only the desired signals can be obtained by

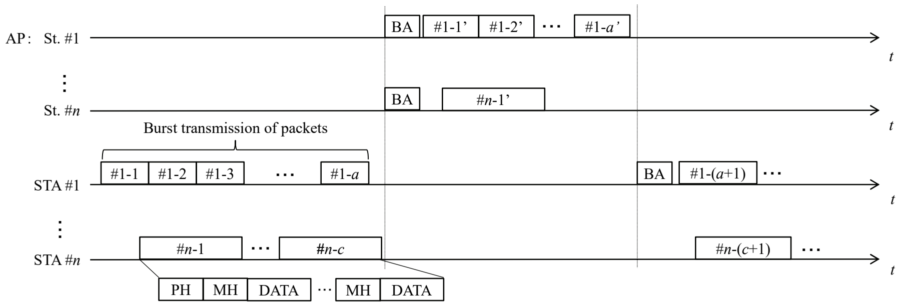

Fig. 1 Example of access control sequence on proposed scheme

removing the interference signal by constant state algorithm (CMA).

B. Overhead-less Access Control Scheme

We propose an access control scheme for multi-beam massive MIMO transmission [4]. An example of the access control sequence of OLACS is shown in Fig. 1. Since the multi-beam massive MIMO transmission cannot transmit and receive simultaneously, it operates with time-division multiple access. The packets are burst transmitted at the generated timing. Then, the AP transmits BA frame to each STA; if the AP has packets for each STA, then the AP transmits the packets to each STA. Thus, this access control scheme can reduce the large overhead, and the proposed scheme has high transmission efficiency.

C. User Selection Method for Fairness

The multi-beam massive MIMO transmission and OLACS cannot communicate if there are multiple STAs in the same beam. Therefore, we studied a user selection method for fairness communication. Examples of STA arrangement and packet arrangement in streams (St.) are shown Fig. 2. If STAs are deployed as shown in Fig. 2(a), STAs achieve communication fairness and efficiency by arranging packets as shown in Fig. 2(b). This method can decrease interference by reducing the number of streams and having a high transmission rate.

IV. Performance Evaluations

In this section, we evaluate the proposed scheme by computer simulation [5], [6]. The results of the transmission efficiency are shown in the Fig. 3. The conventional scheme used MU-MIMO transmission. The evaluation parameters are as follows: frequency is 5.2 GHz, bandwidth is 20 MHz, packet size is 1,500 bytes, number of streams at AP is 8, number of stream at STA is 2, and the base system is the IEEE 802.11ac standard. The horizontal axis is the offered traffic and the vertical axis is the maximum transmission efficiency. In the conventional scheme, the transmission efficiency is 70% or less owing to overhead such as CSI feedback. On the other hand, the proposed scheme achieves high transmission efficiency since large overhead is eliminated even if the number of STAs increases. The results show that the proposed scheme achieves a high transmission efficiency of 90% or more.

V. Conclusion

In this paper, we proposed and evaluated a user selection method for OLACS. The proposed scheme obtained high transmission efficiency of 90% or more using a multi-beam massive MIMO transmission system. These results confirm the reliability and efficiency of the proposed schemes.

Acknowledgments

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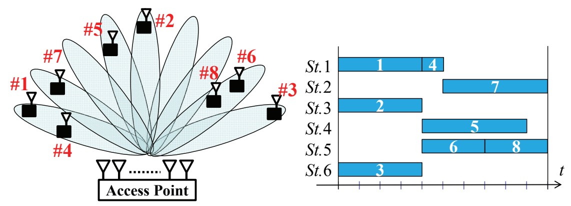

(a) Example of STA arrangement (b) Example of packet arrangement

Fig. 2 User selection method of the proposed scheme

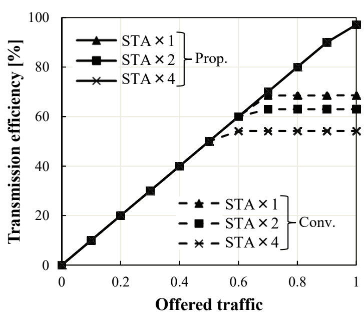

Fig. 3 Offered traffic vs. transmission efficiency