Packet Transmission Scheduling for Enhancing Power Saving and TCP Throughput Performance in Wireless LAN with Multicast/Unicast Flows

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***Abstract*—In recent wireless LANs, multicast transmission is increasing in addition to unicast that is transferred mainly based on TCP. On the other hand, because mobile and wearable computers have been diffused widely, power saving of wireless stations becomes more important. In this paper, in general environments where multicast and unicast flows coexist, we propose a new transmission method of both multicast and unicast packets, that assigns sufficient transmission opportunities for unicast TCP flows, while achieving power saving performance for wireless stations receiving multicast flows.**

I. Introduction

In recent wireless LANs, multicast transmission is increasing in addition to unicast that is transferred mainly based on TCP. On the other hand, because mobile and wearable computers have been diffused, widely, power saving of wireless stations (STAs) becomes more important also for multicast transmission.

To reduce energy consumption for wireless LAN multicast, the operating period of the transceiver at each STA needs to be decreased by setting the transmission rate to higher values within the limitation of not increasing fading packet loss probability. N. Choi et al. extend Auto-Rate Fallback (ARF) [1], which is one of representative rate adaptation methods for unicast, to multicast [2]. However, in this method, transmission rates are adapted to provide transmission with low fading packet loss probability to all the STAs in a multicast group. Hence, even if a few STAs where only low transmission rates are available exist, packets need to be transmitted to all the STAs at a low rate. As a result, the power consumption is increased by the extension of the operating period of their transceivers. To solve this, A. Mehdizadeh et al. [3] and Directed Multicast Service in IEEE 802.11aa convert multicast packets to unicast ones and transmit them individually to all the receiver STAs. Although this approach can use higher transmission rates for some STAs, network traffic increases drastically as the number of receiver STAs increases.

Thus, we have proposed a power saving method [4] that enables to use higher transmission rates for some STAs even if STAs that can use only low transmission rates exist. However, the previously proposed method assumes environments where only multicast flows exist. In wireless LAN, generally, unicast flows transferred by TCP coexist with multicast flows.

Therefore, in this paper, we propose a new transmission method of both multicast and unicast flows, that assigns sufficient transmission opportunities for unicast flows transferred by TCP, while achieving power saving performance for STAs receiving multicast flows like the previously proposed method.

II. Multi-rate parallel multicast transmission for power saving

We have proposed multi-rate parallel multicast transmission for power saving of some STAs that can use higher transmission rates [4]. In this method, multicast packets are transmitted multiple times at high and low rates by burst. The receiver STAs are classified into two groups, high-rate and low-rate groups depending on their available transmission rates that are determined by their channel conditions. STAs in high-rate and low-rate groups can receive packets at the high and low rates that are used to transmit multicast packets. Here, STAs in high-rate group can save power consumption by sleeping while multicast packets are transmitted at the low rate.

The specific packet transmission procedure is described in Fig. 1. First, in "high-rate transmission period", multicast packets (D(1), $\cdots$,D(L) in Fig. 1) are transmitted at a high rate from the access point (AP). Then, after "period of collecting reception status", the same packets are sent at a low rate in "low rate transmission period". The low transmission rate is set to the minimum rate among available rates of all the STAs to provide reliable multicast transmission. The high transmission rate is dynamically decided to achieve total power saving performance as highly as possible, based on the packet reception statuses that are notified from some of the STAs through exchanging AR and ACK frames in period of collecting reception status, as shown in Fig. 1.

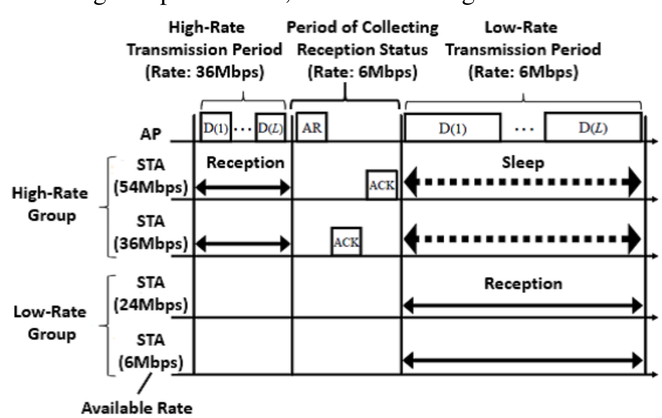

Fig. 1. Multi-rate parallel multicast transmission for power saving.

III. Proposed Method

The proposed method assumes downlink transmission from an AP to its associated STAs in environments where both multicast and unicast packets are transferred. Here, unicast packets are transferred by TCP.

The proposed method assigns sufficient transmission opportunities to unicast packets, and simultaneously, achieves enough power saving performance of STAs receiving multicast packets. Multicast packets are transmitted basically with the previously proposed method [4] but the mechanisms of selecting the packet to be transmitted and reserving the channel, described later, are added.

Specifically, when the AP buffers both of multicast packets and unicast TCP packets to be transmitted, the transmission of the multicast packets is postponed until the current time reaches their acceptable delay (defined below). Here, by exploiting the available duration before the multicast transmission must be done due to the limitation of the acceptable delay, the TCP packets are transmitted. We assume that an acceptable delay is set to each multicast packet buffered at the AP. This acceptable delay means the maximum delay from the buffering at the AP to the arrival at the destination STA.

For the multicast transmission, RTS whose receiver is intentionally set to the transmitter AP is sent at the low rate before multicast packets are transmitted. This special RTS reserves the channel and avoids the collision with packet transmission from STAs that can use only the low rate while the multicast packets are transmitted at the high rate. The STAs cannot detect the transmission at the high rate, hence the channel reservation is required to avoid the collision. No CTS is returned because the receiver address of RTS is not one of the receiver STAs.

IV. Performance Evaluation

We evaluate the performance of the proposed method by computer simulation with QualNet 5.2. Several STAs are randomly placed within 300 m from an AP. Each STA receives a multicast flow whose packet size and transmission interval are 1,024 byte and 5 msec based on UDP from a server connected to the AP with a wired link. In addition, each STA receivers a file with infinite size as a unicast flow based on TCP NewReno from the server. The packet size is 1,460 byte. IEEE 802.11a is used as the physical layer protocol. In the proposed and the previously proposed methods, the low transmission rate is set to 6 Mbps. and the high transmission rate is adaptively set based on the control in the previously proposed method. The acceptable delay set to each multicast packet is 50 msec in the proposed method. For the unicast transmission, the transmission rate of each STA is set based on ARF. The available transmission rate of each STA is decided depending on the distance to the AP. The simulation time is set to 100 sec.

Figure 2 evaluates total energy consumption at the STAs. From this result, the previously proposed method reduces the energy consumption compared with DCF because STAs that can use the high transmission rates reduce the operating period of their transceivers and sleep after the reception. Moreover, the proposed method achieves better reduction of the energy consumption than the previously proposed method. This is because the number of packets that are transmitted by one burst multicast transmission procedure is increased, and this leads to further reduction of total operating period of the transceivers and increase of sleeping period.

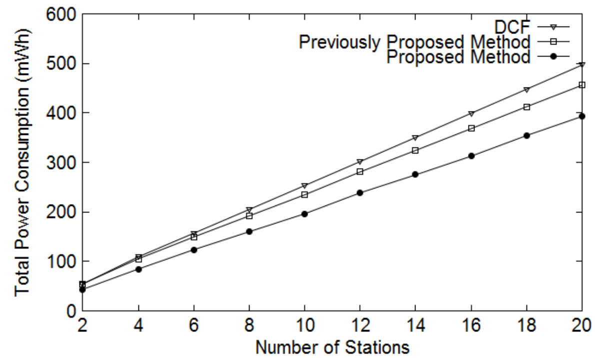

Fig. 2. Total energy consumption at the STAs.

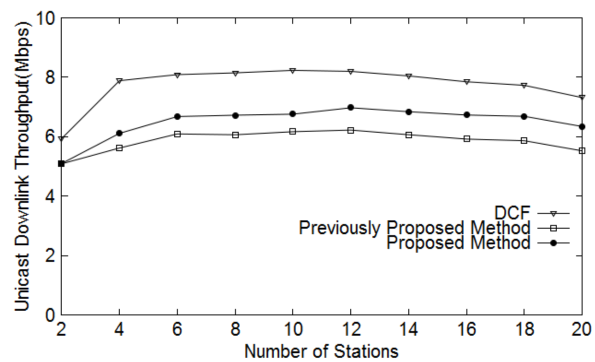

Fig. 3. Total TCP throughput to the STAs.

Figure 3 evaluates total TCP throughput to the STAs. From this result, compared with the previously proposed method, the proposed method increases the TCP throughput, although the throughput is smaller than DCF because of larger overhead to transmit multicast packets. The throughput increase in the proposed method is because it assigns transmission opportunities sufficiently to TCP packets.

V. Conclusion

In this paper, we proposed a new transmission method of both multicast and unicast packets for enhancing power saving and TCP throughput performance. Through performance evaluation, we confirmed that the proposed method reduced total energy consumption of wireless stations while achieving sufficient TCP throughput. Future works include an adaptation to dynamic change of the number of wireless stations and TCP flows.

References

[1] M. Lacage et al., "IEEE 802.11 rate adaptation: A practical approach," *Proc. ACM MSWiM 2004*, pp. 126–134, Oct. 2004.

[2] N. Choi et al., "Multicasting multimedia streams in IEEE 802.11 networks: a focus on reliability and rate adaptation," *Journal of Wireless Networks*, vol. 17, no. 1, pp. 119–131, Jan. 2011.

[3] A. Mehdizadeh et al., "Multicast-Unicast Data Delivery Method in Wireless IPv6 Networks," *Journal of Network and Systems Management*, vol. 22, no. 4, pp. 583 - 608, Feb. 2013.

[4] Y. Umeno, Y. Tanigawa, and H. Tode, "Dynamic Multi-Rate Parallel Transmission for Power Saving of Stations in Wireless LAN Multicast," *Proc. IEEE SECON 2014*, June 2014.