A Scheme Improving Performance of IEEE 802.11 Multicast Protocol

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***Abstract*—The IEEE 802.11 multicast protocol is proper to send data to multiple recipients. Nowadays, Wi-Fi equipped smart phones are in the access of almost every person which increases amount of data transmissions. In this paper, we discuss the flaws in existing IEEE 802.11 multicast protocol and propose an efficient way to improve its performance. The proposed system has an assisting station (AS) and the stations that want to join a multicast group have radio frequency monitoring (RFMON) modules which help themselves overhear the data. Thus, for multicasting, the access point (AP) transmits unicast data to AS by the fixed Internet protocol (IP) address while stations in multicast group can also receive the data. The proposed system improves efficiency and reliability, while reducing delay for multicast transmissions.**

Keywords-IEEE 802.11; Multicast; Wireless Network; RFMON mode.

I. INTRODUCTION

Unicast transmission is to send a message to a single destination identified by a unique address in the network. Multicast transmission is the delivery of a message or information to a group of destinations simultaneously in a single transmission from a source. In unicast transmission, a sender transmits data frame to a receiver which in turn sends back acknowledgment (ACK) to notify the sender of its successful reception. If the sender does not receive ACK during a fixed time interval, it automatically transmits data again. Thus, the unicast can guarantee reliable data transmission by feedback whereas multicast does not assure reliability as it lacks such ACK process. For this reason, multicast transmission has the lowest data transfer rate in IEEE 802.11[1]. Using multiple unicast transmissions as an alternative for multicasting incurs an overhead problem because of multiple ACKs. In this paper, we propose an efficient method to improve the performance of multicasting by introducing the concept of an assisting station (AS) and radio frequency monitoring (RFMON) module.

The rest of the paper is organized as follows. Section 2 describes background and related work. Section 3 presents the proposed scheme in detail. Section 4 describes performance evaluation and the achieved results. Section 5 concludes the paper.

II. BACKGROUND AND RELATED WORK

A. IEEE 802.11

IEEE 802.11 is a set of standards for implementing wireless local area network (WLAN). Wi-Fi is a wireless communication protocol specification used to exchange data. The 802.11 medium access control (MAC) layer has two major modes of operation, namely, the Distributed Coordination Function (DCF) and the Point Coordination Function (PCF). The DCF is the most popular mode of MAC operation in 802.11. The DCF uses carrier sense multiple access with collision avoidance (CSMA/CA) based scheme for its operation.

In unicast transmission, after channel assignment, a sender transmits a request to send (RTS) frame to reserve access of channel. The receiver replies with a clear to send (CTS) frame. Other stations avoid collision by listening the RTS/CTS and refrain from sending data for a given time. After receiving data successfully, the receiver sends an ACK to the sender. If the data transmission does not take place successfully, the sender retransmits that data.

In multicast, a single sender transmits data packet to multiple recipients at the same time. The multicast is an efficient way to transmit data packets to multiple stations that need them. However, unlike unicast, there is no feedback process, i.e., sending ACK, and therefore it does not guarantee reliability. On the other hand, assuring maximum reliability to multiple recipients causes multicast data to be transmitted at the lowest data transmission speed.

In [2], BMW (Broadcast Medium Window) method is proposed to solve the problems of multicasting by performing multiple time unicast for multicast transmission. In BMW, each station has three lists, i.e., NEIGHBOR, SEND BUFFER and RECEIVER BUFFER lists. The NEIGHBOR is a list of current neighboring stations, SEND BUFFER stores multicast frames to be forwarded and RECEIVER BUFFER maintains the sequence numbers of the data frames received from neighboring stations. After a sender that has multicast data to send takes channel, it sends RTS and receives CTS as a response. After sending the data frame and receiving ACK, it moves on to the next recipient in the NEIGHBOR list. This process is repeated until entire data are transmitted successfully. However, the main drawback of BMW is that if the sender has n neighbors to send, there are n time contention phases per multicast operation, which increases delay.

In [3], the Batch Mode Multicast MAC (BMMM) method is proposed to solve the problem of [2]. In BMMM, in order to send a multicast frame, the sender sends RTS to each station individually and waits for CTS from each of them. Upon reception of CTSs from *all* the intended recipients, the sender starts to send the multicast data. Following this, it sends a special frame called Request for ACK (RAK) to each station, and each station responds to the RAK with an ACK. Upon receiving ACKs from all intended recipients, the transmission is said to be done successfully. If one of ACKs is missed, then the sender again contends for the medium and repeats the above procedure. The RAK frame format is shown in Fig. 1.

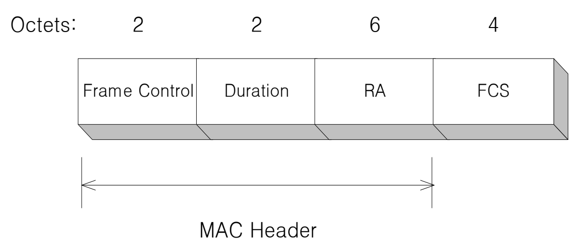

Figure 1. RAK frame format.

In BMW, nodes contend for channel assignment to send a control frame to each station. The sender transmits RTS and receives CTS, after which it transmits the data. Upon receiving the data, the receiver sends back ACK. Above procedure is repeated for all intended receivers, which causes overhead. In BMMM, after taking a channel, the sender sends RTS and the receiver which receives the RTS sends back CTS. This RTS/CTS procedure is repeated for all intended receivers. After finishing the RTS/CTS procedure, the sender transmits the data, by multicast, to those stations from which it has received CTS. In this way, BMMM tries to solve the delay and overhead problem of BMW and also improves multicast reliability by sending RAK. However, BMW and BMMM use multiple unicast transmissions and multiple RTS/CTS procedures respectively for multicasting, which increases reliability but incurs delay and overhead.

In other case of studies, they proposed some methods to improve multicast efficiency based on ad-hoc networks [4]-[6].

III. PROPOSED SCHEME

In this paper, we propose an efficient method to overcome the aforementioned problems of multicasting. The proposed method has an assisting station (AS) and the stations that intend to receive the multicast data and have the RFMON mode.

For multicasting, AP transmits unicast data to AS through the fixed IP address and stations in the multicast group can also receive the data with the help of RFMON mode. Stations with RFMON mode as a way of monitoring WLAN can collect the entire WLAN packets and monitor the existence of network effectively [7]-[9]. It is receive-only mode for data.

A. Assisting station (AS)

The AS receives multicast frames from AP and sends back ACK which ensures reliability. It has the fixed known IP destination address. Usually AP transmits multicast data to multiple recipients. However, in the proposed method, AP sends the multicast data to AS by using the fixed IP address. The stations that want multicast data can also receive that data simultaneously by using the RFMON mode. Because of that, the proposed method can solve the overhead problem. The AS can be located at the edge of AP radio coverage, which can guarantee that every station can receive the data if AS responds to data by ACK.

In the proposed method, even though AS is a special station, AP recognizes it as an ordinary station. Therefore, the proposed method can be used while compatible with IEEE 802.11 without any change in its infrastructure. The AP sends the multicast data to the AS by using a fixed IP address. If the AP assigns IP address to the other stations except the AS, the AP assigns one of the remaining IP addresses except the IP address assigned to the AS.

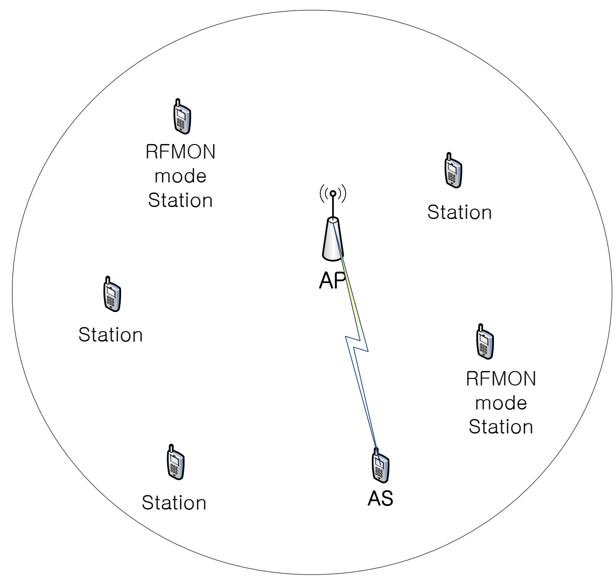

Figure 2. The AS receives multicast data from the AP by using the proposed method.

B. Use of RFMON mode

In the proposed scheme, in order to become a member of multicast group, a station should be equipped with a module or dongle that supports the RFMON mode. The module or dongle is programmed to monitor the packets in the network which AS joins. In this way, the stations equipped with the RFMON module can also receive and process the multicast data. If a station does not want to receive the multicast data, the RFMON mode can be disabled. Thus, owners of the stations can make a decision about data reception by either installing or removing the RFMON mode.

Fig. 2 illustrates multicast transmission using the proposed method. The AP sends the multicast data to one destination, i.e., AS using the fixed IP address, while the

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multicast group equipped with RFMON module receives the data simultaneously together with AS. Other stations that are not in the multicast group cannot receive the data because they are not equipped with the RFMON module.

IV. PERFORMANCE EVALUATION

To evaluate the proposed scheme, we conducted simulations in QualNet 5.0, which provides a platform to test protocol design, analysis and verification prior to implementing the system in practice. The complete set of simulation parameters is shown in Table 1.

TABLE I. PARAMETERS FOR SIMULATION

PARAMETERS FOR SIMULATION	
Parameters	***Values***
PHY/MAC	IEEE 802.11g
Packet Size	512 bytes
Antenna model	Omnidirectional
Total number of station	50
RFMON mode station	5, 10, 15, 20, 25, 30
Assisting Station	1
Application data type	CBR
Simulation time	500sec
Number of total packets	100

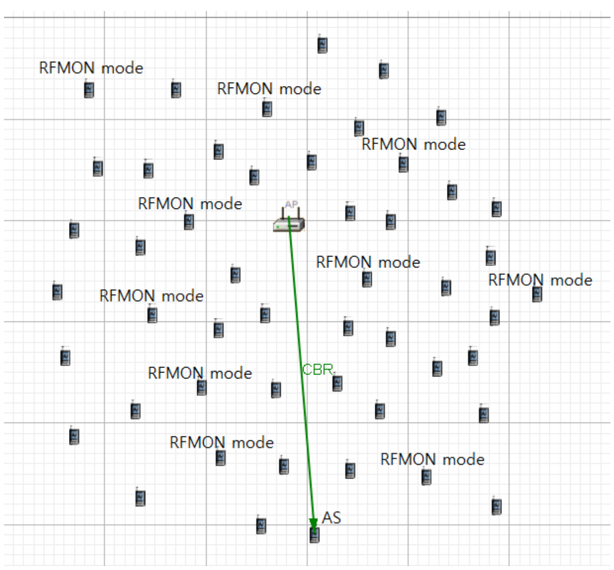

Figure 3. Network model for simulation.

The network model for simulation is shown in Fig. 3. Simulation shows that there are 10 RFMON-mode stations. RFMON-mode stations are randomly chosen and the number of them is increased from 5 to 30. The AS is located around the edge of AP radio coverage.

Fig. 4 shows the average end-to-end delay for the legacy multicast of IEEE 802.11 protocol and the proposed scheme. Evidently, IEEE 802.11 multicast performs poorly in comparison with the proposed scheme.

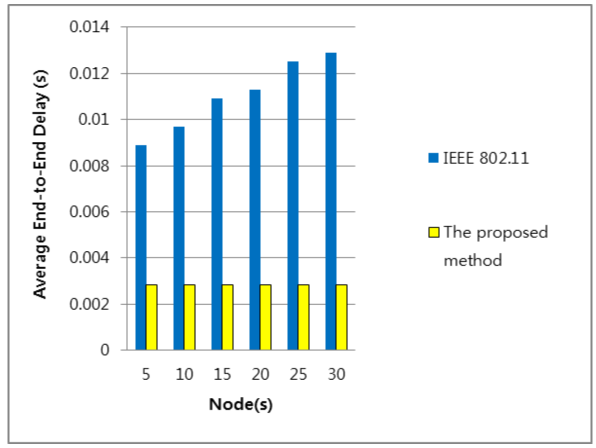

Figure 4. Average end-to-end delay.

V. CONCLUSION

Delay and overhead are major issues in multicast transmission in IEEE 802.11. This paper proposes an efficient method to overcome these issues. The simulation results show that the proposed scheme has 70~80% less delay than IEEE 802.11 multicast and there is no packet loss in the proposed scheme. Thus, it ensures reliability in multicast transmission without incurring overhead. Furthermore, it does not need to set up or replace the infrastructure but simply needs to change the IP address assignment. The stations can decide to receive multicast data by either enabling or disabling the RFMON mode.

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