A Study on QoS Support for Multi-hop Wireless LAN System using Channel Estimation Method

Phuc Khanh Kieu, Shinichi Miyamoto
Graduate School of Engineering, Osaka University
2-1 Yamada-oka, Suita, Osaka 565-0871, JAPAN
kpkhanh@wireless.comm.eng.osaka-u.ac.jp, miyamoto@comm.eng.osaka-u.ac.jp

Abstract—The widespread use of multimedia networking applications has created the need for QoS support in the WLAN systems. The coverage area of WLAN systems is limited, so multi-hop WLAN system is a solution. However, in home or office environments, due to the multi-path effect, the performance of multi-hop WLAN system is degraded. Therefore, QoS cannot be guaranteed in multi-hop WLAN systems. In this paper, we propose a multi-hop WLAN system with channel estimation method for QoS support. The numerical simulation results have shown that by using this proposed system, QoS can be guaranteed over a wide coverage area.

Key words: QoS support, multi-hop WLAN system, fading environment, channel estimation

1. INTRODUCTION

In recent years, IEEE 802.11 wireless LAN (WLAN) systems have been widely established on campuses, in public places and in indoor environments to provide convenient data transmission between mobile devices and the Internet. The widespread use of multimedia networking applications has created the need for QoS (Quality of Service) guarantee in WLAN systems. The support of video, audio, real-time VoIP and other multimedia applications over WLAN with QoS requirements is the key to success for 802.11 WLAN in multimedia home networking and future wireless communications. Therefore, the IEEE 802.11 Working Group is currently developing a new standard called IEEE 802.11e, which enhances the original MAC protocol to support QoS transmission in WLAN systems. IEEE 802.11e adds a new function called HCCA (Hybrid Coordination Function Controlled Channel Access) which supports parameterized QoS [1]. With this function, video streaming data transmission such as SDTV (Standard Definition Television) can be guaranteed in WLAN systems. However, due to range attenuation, the coverage area of WLAN systems is limited. It has been reported that in home or office environments, because of the multi-path effect, the performance of multi-hop WLAN system is degraded. For this reason, in WLAN systems, QoS cannot be guaranteed over a long distance. This paper proposes a multi-hop WLAN system, as a solution, to guarantee QoS transmission over a long distance.

2. PROPOSED SYSTEM

In order to guarantee parameterized QoS in this proposed system, IEEE 802.11e HCCA mechanism has been applied. Also in this system, we use the Block ACK mechanism [2] to improve throughput efficiency. We consider only the downlink of the SDTV transmission. SDTV data is transmitted from the transmitter Tx to the receiver Rx by using relay stations. The systems mechanism is described below.

As Figure 1 shows, at the beginning of each superframe, Tx sends data packets to the relay station STA1. The HCCA mechanism defines a transmission opportunity (TXOP), during which the transmitter station can transmit packets to the receiver station without contention with other stations. During TXOP 1, Tx sends multiple packets to STA1 separated by SIFS duration. At the end of TXOP 1, Tx sends a frame called Block ACK Request (BAR) asking if these packets have been transmitted correctly or not. STA1 will reply with a Block ACK frame. When packet error occurs, STA1 will retransmit the error packets in the next superframe if the delay at successfully transmitted time is limited under the designated delay bound. Otherwise, error packets will not be retransmitted.

After transmitting data to STA1, Tx polls STA1 and grants a TXOP2. During TXOP2, STA1 sends packets received from Tx to STA2 also using Block ACK mechanism. The next step will be the same, during TXOP3 granted from Tx, STA2 sends these packets to the destination station Rx. As shown here, by using relay stations, data packets are transmitted from the transmitter Tx to the receiver Rx over hops. This data...
packet transmission process will be repeated in the next superframe.

Because of the multi-path propagation effect, the performance of the wireless LAN system is degraded when a fixed transmission rate is used. As a solution, we propose an adaptive transmission rate protocol. In this proposal, the transmission rate is adaptively selected based on the channel state. At the beginning of each TXOP, the transmitter station estimates the channel state and selects the appropriate transmission rate. This transmission rate is used for all data packet transmission within this TXOP. Duration TXOP is decided by $T_s$ at the beginning of each superframe. In a superframe, the total throughput transmitted over each hop should be equal. So that, duration $TXOP_i$ of the next superframe will be decided based on transmission rate $Rate_i$ of the previous superframe as below.

$$TXOP_i = \frac{\text{Superframe}}{Rate_i \times \sum V_i / Rate_i}$$

The efficiency of adaptive transmission rate method depends on superframe length. If the stations close to each other, a long superframe would be the good choice. However, if the stations are far from each other, a short superframe would be better. The optimum superframe length will increase with the relay station number. So, with difference hop distance and relay station number, an optimum superframe must be decided to give the best performance.

3. PERFORMANCE EVALUATION

In this section, we use computer simulation to evaluate the performance of the proposed system under fading environment. Table 1 shows the simulation parameters employed in this paper.

<table>
<thead>
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<th>Table 1: Simulation Parameters</th>
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<td>PHY Layer</td>
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<td>SIFS</td>
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<td>PIFS</td>
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<td>Video Stream</td>
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<td>Data Size</td>
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<td>Doppler Frequency</td>
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Figure 2 shows the end-to-end distance versus maximum achievable throughput performance of 3-hop WLAN system in case adaptive transmission rate protocol is used. For comparison, performance of each fixed rate mechanism is also shown. As Figure 2 shows, compared to fixed rate protocols, adaptive rate protocol give the best throughput at every distance. We can say that, adaptive transmission rate mechanism can follow the variation of channel state, and therefore appropriate transmission rate can be selected.

Figure 3 shows the end-to-end distance versus throughput performance in case SDTV video stream (6Mbps of throughput) is transmitted over multi-hop WLAN system. As Figure 3 shows, at 1-hop WLAN system, 6Mbps transmission can be guaranteed over a coverage area of about 30m. However, when using 5-hop WLAN system, coverage area can be extended to about 110m. So, we can say that by using proposed multi-hop WLAN system, QoS transmission can be guaranteed over a long distance.

4. CONCLUSION

In this paper, we have proposed a multi-hop wireless LAN system for QoS support. We employed a channel estimation method to the proposed system therefore suitable transmission rate can be selected. Numerical results have shown that, by using proposed system, QoS can be supported over a long distance.

REFERENCES
