MobiCom Poster Abstract:
S-EDCA: EDCA based on SuperSlot and Pseudo Collision *

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The IEEE 802.11e EDCA mechanism cannot guarantee the QoS of high-priority traffic as the bandwidth consumption of low-priority traffic increases. Also, the existence of high priority traffic undermines link utilization of low priority traffic. To solve these problems, we propose the S-EDCA *scheme that extends IEEE 802.11e EDCA by introducing a* SuperSlot *and* Pseudo Collision*. Compared to IEEE 802.11e EDCA,* S-EDCA *has two advantages: (a) Higher priority traffic achieves QoS regardless of the amount of low priority traffic, and (b) Low priority traffic experiences a higher throughput with the same amount of high priority traffic.*

I. Basic Idea

To date, the IEEE 802.11 [1] has become the de facto standard for wireless LANs. It is based on carrier sense multiple access/colllision avoidance (CSMA/CA). In IEEE 802.11 DCF, a station transmits a packet if it has observed an idle medium during a DIFS interval. Otherwise, it chooses a backoff time in the range of [0, cw-1], where cw is the contention window size. Then it starts to decrease the backoff timer. If the medium becomes busy during the backoff, the backoff timer is frozen. When the medium become idle after a DIFS interval, the node unfreezes the backoff timer and starts to decrease it again. When the backoff timer expires, the node transmits its packet. If the backoff timers of more than one stations expire at the same time, they will experience a packet collision. This kind of collision will make these stations double their contention windows and start the backoff process again, which wastes the wireless link bandwidth. As the number of competing stations increases, there will be more collisions, hence resulting in severe performance degradation.

IEEE 802.11e EDCA proposed in [2] is designed to offer QoS differentiation in wireless LANs. However, it cannot differentiate prioritized traffic absolutely. If low priority traffic increases, the perceived QoS (e.g., delay) of high priority traffic is hindered. Also, in IEEE 802.11e EDCA, the existence of high priority traffic undermines the aggregate throughput of low priority traffic, which decreases the overall link utilization. To solve these problems, we introduce the concepts of *SuperSlot* and *Pseudo Collision*, on which the proposed *S-EDCA* is based.

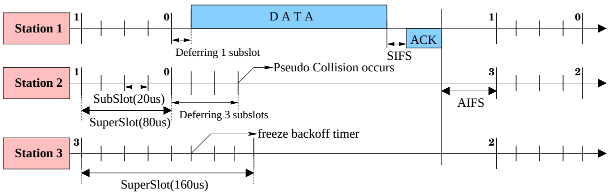

Figure 1: The basic operation of *S-EDCA*

$$sCW_{min} = aCW_{min}/D_{AC} \quad (1)$$
$$sCW_{max} = aCW_{max}/D_{AC} \quad (2)$$
$$sBT = random[(0,\ aCW_{min}/D_{AC})] \quad (3)$$
$$sDT = random[0,\ D_{AC}-1] \quad (4)$$

Fig. 1 illustrates the basic operation of S-EDCA, where a *SuperSlot* consists of multiple *SubSlot*s. Each *SubSlot* is equal to a slot (20μs for IEEE 802.11b) defined in IEEE 802.11 DCF. Thus, the duration of a *SuperSlot* is 20$\mu s \times D$, where D is an integer, a predefined system parameter. For sake of convenience, the contention window sizes such as aCW_{min} and aCW_{max} in IEEE 802.11 DCF are the multiples of the *SuperSlot* size, which is again D *SubSlot*s. The backoff process is the same as IEEE 802.11 DCF except that a *SuperSlot* is used as the decreasing time unit instead of the *SubSlot*. When the backoff timer (sBT, in Eq.(3)) expires, the station does not transmit a packet immediately but it chooses another random *deferring* time (sDT, in Eq.(4)), which is $k\times$ *SubSlot* ($0 \le k < D$). If the medium is idle until the chosen *deferring* time expires, the station transmits the packet. Otherwise (if any other station transmits a packet ahead), it regards this attempt as a *Pseudo Collision*. Therefore, it doubles its cw and starts a new backoff process with the same rule as IEEE 802.11

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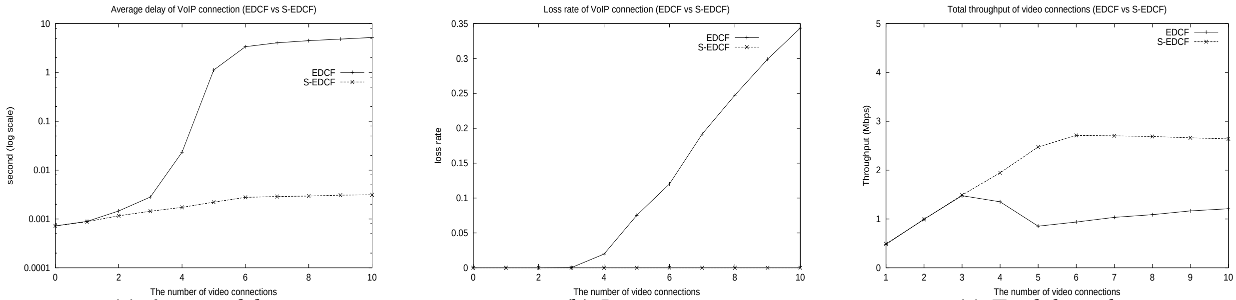

(a) Average delay (b) Loss rate (c) Total throughput

Figure 2: EDCA vs. S-EDCA

DCF. Both *SuperSlot* and *Pseudo Collision* concepts decrease the real collision probability and hence increase the aggregate throughput.

II. Performance Evaluation

We use the NS-2 simulator to evaluate *S-EDCA* with the *SuperSlot* of each access category (AC) consisting of D_{AC} *SubSlot*s, where D_0, D_1, D_2 and D_3 are set to 4, 8, 16, and 16, respectively. Note that in Table 1, CW_{min} has two *SuperSlot*s in all categories. When the backoff timer (for *SuperSlot* unit) expires, a *deferring* time is chosen randomly in the range of [0, D_{AC}-1]. If the medium is idle until the deferring timer expires, it transmits the packet. Otherwise, it deems this situation as a *Pseudo Collision*, so that it performs an exponential backoff. In *Pseudo Collision*, the retry counter is not increased since nothing has been really transmitted.

Table 1: Basic Parameters for IEEE 802.11e EDCA

Flow Type	AIFS(μs)	aCW_{min}	aCW_{max}
Voice	50	8	16
Video	50	16	32
Data	150	32	1024

In simulation experiments, there are 10 connections for voice and v connections for video, where v varies from 1 to 10. Under various network conditions, we observed the average delay and loss rate for voice traffic, and the throughput for video traffic. Basic parameters for the IEEE 802.11e EDCA are given in Table 1, depending on the priority (access category) of each flow type. Each VoIP traffic generates at 64 Kbps, and the average rate of video traffic is about 500 Kbps.

Fig. 2(a) and 2(b) show the average delay and the average packet loss rate for 10 voice connections. If the *S-EDCA* is used, it prevents the average delay from increasing as the number of video connections increases. When there are 10 video connections, the average delay experienced by voice connections is about 3 ms with *S-EDCA* while it is 5 seconds with EDCA. In EDCA, as there are more than 5 simultaneous video connections, the average delay experienced by voice connections becomes unacceptable. In case of *S-EDCA*, there is no voice packet loss regardless on the number of video connections. However, in EDCA, voice packet loss rate continues to increase as the number of video connections increases. Fig. 2(a) and 2(b) show that the *S-EDCA* can guarantee the QoS for high priority traffic despite increasing low priority traffic.

Fig. 2(c) shows the aggregate throughput of v video connections. IEEE 802.11e EDCA and *S-EDCA* achieve the same aggregate throughput until the number of video connections become larger than 3, after which EDCA's aggregate throughput is much lower than that of *S-EDCA*. This signifies that low priority traffic utilizes the network resource more efficiently with *S-EDCA*.

III. Conclusion

We introduce the concepts of *SuperSlot* and *Pseudo Collision* that constitute *S-EDCA*, which enhances IEEE 802.11e EDCA. Unlike EDCA, *S-EDCA* provides more strict QoS for high-priority traffic regardless of amount of low-priority traffic. *S-EDCA* is also able to achieve more efficient resource utilization for low-priority traffic even with high-priority traffic.

References

[1] IEEE Computer Society. 802.11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications, June 1997.

[2] IEEE WG, “IEEE 802.11e/D13.0, Draft Supplement to Part 11: Wireless Medium Access Control (MAC) and Physical Layer (PHY) specifications: Medium Access Control (MAC) Enhancements for Quality of Service (QoS),” January 2005.