Traffic load aware data control and distributed QoS protection for IEEE 802.11e Wireless LANs

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Abstract: - This paper proposes new data control (best effort rate control) algorithm which changes minimum contention window (CWmin) of best effort traffic with respect to traffic load. By applying new traffic load indication parameter, CWmin of best effort is adaptively controlled. In the result of C++ based network simulation, throughput and drop rate of QoS traffic are guaranteed when proposed algorithm is used.

Key-Words: - WLAN, IEEE 802.11e, QoS, data control, best effort rate control

1 Introduction

Recently, wireless networks are indispensably required to support Quality of Service (QoS) for multimedia application. QoS guarantees bounded delay, jitter, and appropriate throughput for real time application. The IEEE 802.11e [1] provides QoS support for the wireless LAN by two access mechanisms: HCF Controlled Channel Access (HCCA) and Enhanced Distributed Channel Access (EDCA). These two access schemes are developed to overcome limitation of 802.11 legacy MAC.

To guarantee QoS, letting EDCA related parameters statically is not sufficient [2][3]. When best effort traffic is too heavy, supporting QoS is difficult with insufficient bandwidth. Even though network has few best effort traffic, it might decrease throughput or increase drop rate of QoS traffic. This is why data control, which is also called best effort rate control, is developed. In data control, CWmin of best effort is changed with collision ratio [2][3]. This data control prohibits QoS performance degradation from best effort traffic [2].

In this paper, new parameter Traffic Load Indication (TLI) is introduced and used to determine CWmin of best effort category. When overall traffic load is heavy, the chance to access channel for best effort traffic is reduced by proposed algorithm. For the sake of efficient channel use, best effort traffic can be transmitted frequently when channel is not quite busy. These advantages come from new TLI which well represents traffic load and makes proposed algorithm adaptively change CWmin of best effort.

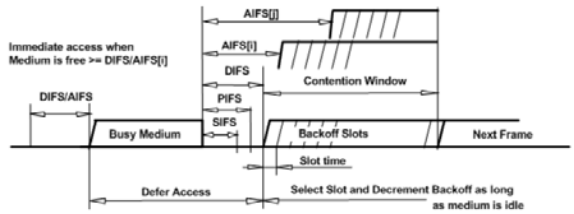

Fig. 1: Some IFS relationships.

This paper is organized as follows: In Section 2, related works are shortly summarized. Traffic load aware data control and distributed QoS protection are presented in Section 3. In Section 4, proposed data control is simulated. Finally, section 5 concludes this paper.

2 EDCA in IEEE 802.11e

EDCA has enhancement of DCF in 802.11 legacy MAC such as separated the data type by access category (AC), se0arted the Inter Frame Space (IFS), and Transmission Opportunity (TXOP). In addition, HCCA has enhancement of PCF in 802.11 legacy MAC, superframe with CFP and CP period, and polled TXOP. In EDCA, all stations which have data to be sent transmit data by waiting Arbitration Inter Frame Space (AIFS) and counting random back off slots which are called as Contention Window (CW) after wireless medium changes state from busy to idle in Fig 1. If channel is idle, the station which has any packet to be transmitted waits for AIFS[i](i=0,...,3).These AIFSs are different for access categories: Best Effort

(AC_BE, i=0), Background (AC_BK, i=1), Video (AC_VI, i=2), and Voice (AC_VO, i=3). During AIFS time, the station checks whether channel is still idle or not. If channel is still idle within AIFS time, the station generates random back off number and counts that number checking channel idle. When back off number is fully counted until 0 and channel is idle, the station transmits packet frame over the air channel.

According to the access category, the different priority is given for channel use by means of AIFS, CWmin, and CWmax (Table. 1). Four different access categories have different range of random back off number. Lower AIFS, CWmin, and CWmax mean higher possibility to transmit packet than other stations. The access categories which are involved in QoS support, AC_VO and AC_VI have small CWmin. This low CWmin gives priority real time traffic over non real time traffic. Furthermore, different inter frame space (AIFS) is used for ACs (Table. 1). The lower priority ones such as best effort and background categories have more AIFS than higher priority ones such as video and voice categories. These differentiated CW and AIFS help stations support QoS.

3 Related Works

Changing CWmin of best effort is dealt in many papers in order to increase QoS performance [2][3]. The reasons why data control needs are as follows. First, too many transmission attempts of best effort may severely degrade QoS performance and raise collision rate. In that case, CWmin[0] (CWmin of best effort) should be increased. Second, when the small amount of total traffic, there is no need to use large CWmin[0] which causes high transmission delay. Oppositely, CWmin[0] should be decreased for this low traffic load. Unfortunately, 802.11e draft only exponentially increases CWmin when collision occurs. However, it has no difference between increase of CWmin of best effort and increase of CWmin of others. Thus, we cannot expect more QoS benefit from the exponentially increased CWmin in 802.11e draft. Otherwise, changing CWmin[0] algorithm is called data control (or best effort rate control) and studied by many works. One of the most well known works is Derivative Tendency (DT) [2] and the other is Adaptive EDCF (AEDCF) [3].

3.1 Derivative Tendency

In the Derivative Tendency (DT) scheme, transmission collision ratio (CR) is defined to indicate traffic load. CR is defined as the ratio of the number of failed transmission attempt to all transmission attempts.

$$CR(t) = \frac{N\_FTA(t)}{N\_FTA(t) + SFC(t)} \qquad (1)$$

N_FTA(t) and *SFC(t)* are the number of failed transmission attempts and successful transmission attempts at *t* th beacon interval. *CR(t)* is the transmission collision ratio during *t* th beacon interval. Based on the CR, CWmin[0] is adaptively adjusted to regulate transmission attempts of best effort traffic.

Table 1: Default EDCA parameters for Access Categories.

	AC_VO	AC_VI	AC_BE	AC_BK
AIFS[i] *us*	34	34	43	79
CWmin	3	7	15	15
CWmax	7	15	1023	1023

$$CW\min[0](t+1) = \begin{cases} CW\min[0](t), & if\ CR(t) < \delta(predefined\ value) \\ \min(\theta \times CW\max[0] \times [CR(t) - CR(t-1)] + \\ \quad CW\min[0](t),\ CW\max[0]), & otherwise \end{cases} \qquad (2)$$

$$CW\max[0](t+1) = CW\max[0] \qquad (3)$$

$$AIFS[0](t+1) = AIFS[0] \qquad (4)$$

where θ is embedded in the beacon frames. When the difference of CR(t) and CR(t-1) is large, CWmin[0] is increased to prevent stations from further collision. Also, assured bandwidth which comes from increased CWmin[0] is used for transmission of QoS traffic. In result, DT has better throughput of QoS traffic than 802.11e which has the default static CWmin[0] parameter. However, this work overlooked how to efficiently change θ. If θ adjusts dynamically in accordance with traffic load, QoS performance may be better.

3.2 Adaptive EDCF

In the Adaptive EDCF (AEDCF), CWmin is updated for the access category and the ratio of the number of collision to the total number of packets sent during the constant period.

$$f_{curr}^{j} = \frac{E(collision_j[p])}{E(data\_sent_j[p])} \qquad (5)$$

$$MF[i] = \min((1+(i+2)) \times f_{avg}^{j},\ 0.8) \qquad (6)$$

Traffic indication parameter and Multiplying Factor (MF) for AEDCF are defined as above equation.
Multiplying Factor MF[i] represents both the collision ratio and the priority for the access category.

$$CW_{new}[i] = \max(CW_{\min}[i],\ CW_{old}[i] \times MF[i]) \qquad (7)$$

CW for all access categories (i=0,...3) are updated with multiplying CWold by MF[i]. This AEDCF changes all CW[i] (i=0,...,3) with respect to collisions. However, the increase of CW of QoS traffic may cause high drop rate at the expense of low collision.

4 Traffic Load Aware Data Control

Refer to [4], the idle period is inversely proportional to and collision period is proportional to traffic load. Accordingly, Traffic Load Indication (TLI) is defined as follows.

$$TLI(t) = \begin{cases} 1 & if\ T_{col} \le T_{idle} \\ 1 + \tau \dfrac{T_{col}}{T_{idle}} & otherwise \end{cases} \qquad (8)$$

,where τ is constant value and Fig.2 defines T_{col}, T_{idle}, and T_{succ}. Because T_{col} and $\dfrac{1}{T_{idle}}$ are proportional to traffic load, *TLI(t)* is steeply increases when traffic load grows. With *TLI(t)*, CWmin[0] ,which is minimum contention window of best effort traffic, is adjusted as follows.

$$CW\min[0](t+1) = \begin{cases} CW\min[0](t), \quad if\ CR(t) < \delta(predefined\ value) \\ \min(TLI(t) \times CW\max[0] \times [CR(t) - CR(t-1)] + \\ \quad CW\min[0](t),\ CW\max[0]), \qquad otherwise \end{cases} \quad (9)$$

On the ground that *TLI(t)* varies with traffic load, proposed algorithm is different from DT (equation(2)). Also, only changing CWmin of best effort traffic should be carefully compared with AEDCF (equation (7)).

5 Simulation

Through computer simulation, the performance of proposed scheme is evaluated by C++ based network simulator.

5.1 Simulation Environment

In our simulation, we have two classes: video (AC 1) and data (AC 0). EDCA parameters are AIFS[1] = 25us; AIFS[0] = 34 us; CWmin[1] = 16; CWmin[0] = 32; CWmax[1] = 1024; CWmax[0] = 8192; beacon interval is 100ms. For DT, θ and δ values are the same as [2], 0.9 and 0.1 respectively. The simulation scenario is as follows. Initially, there is a video station and ten best effort stations. A station has only one access category traffic. For every 3 sec, a video station arrives to the network until there are total of 30 video stream arrivals. Offered load of each video flow is 2Mbps, which is generated by a constant interarrival time with a constant payload size 512 Byte. Each best effort flow is generated by exponential distributed interarrival time with a constant payload size 300 Byte and 2.5 ms mean interarrival time. Video flow is dropped if delay is larger than 200 ms. Additionally, simple admission control is used. When transmission budget is larger than threshold interval, new video station is admitted to transmit traffic. RTS/CTS scheme is used to resolve hidden node problem. And 54 Mbps transmission rate is used for all stations.

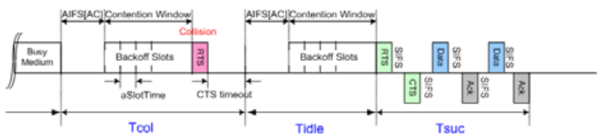

Fig. 2: the definition of TLI related parameters.

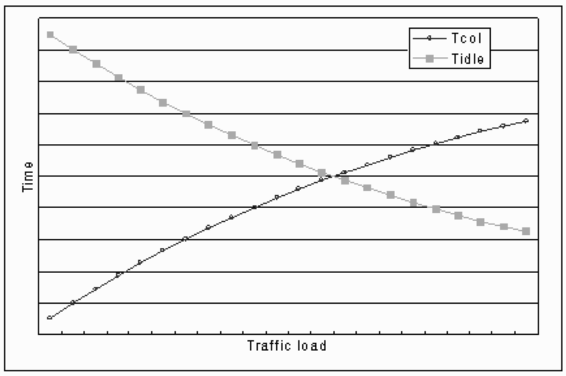

Fig. 3: Tcol and Tidle periods.

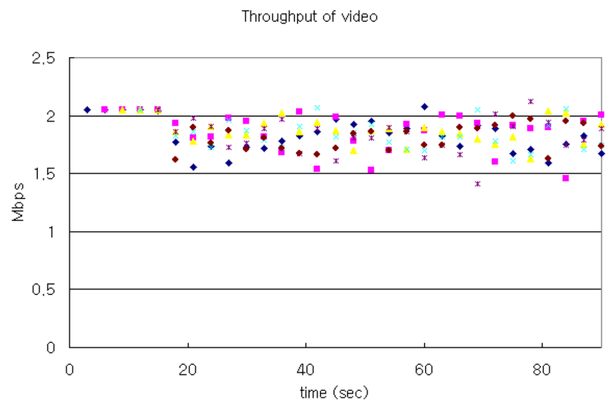

Fig. 4: Throughput of video traffic by DT scheme

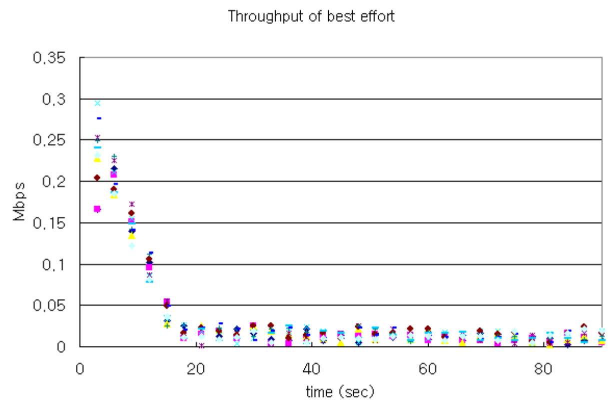

Fig. 5: Throughput of best effort traffic by DT scheme

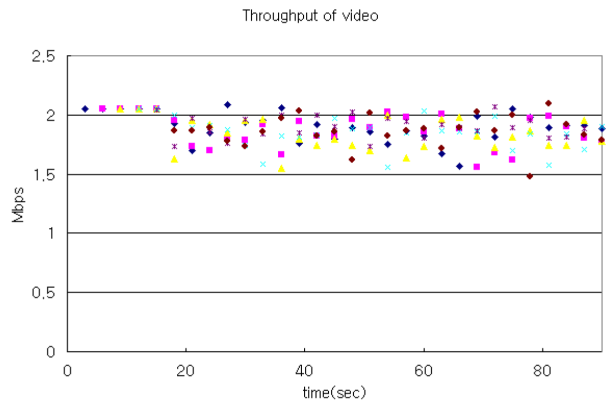

Fig. 6: Throughput of video traffic by proposed scheme

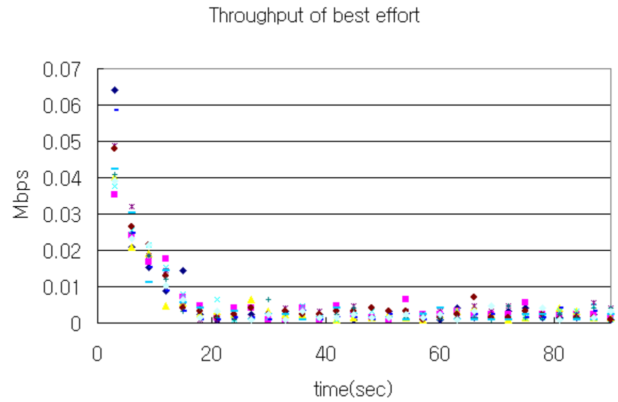

Fig. 7: Throughput of best effort traffic by proposed scheme

5.2 Simulation Results

Throughput is plotted every 3 sec and new video station is added at the same time. At 15 sec, overall video throughput is about 12 Mbps which is maximum EDCA throughput for 54 Mbps transmission rate. In comparison throughput of proposed scheme (Fig. 3, 4) with that of DT scheme (Fig.5, 6), proposed scheme more adaptively controls the amount of best effort traffic. As a result of assured bandwidth, throughput of video traffic with proposed scheme is better than throughput of video traffic with DT scheme.

6 Conclusion

In sum, we designed traffic load based on new data control scheme for Quality of Service for IEEE 802.11e Wireless LANs. Proposed scheme extended the default parameters in 802.11e EDCA draft and DT scheme but more QoS performance gained at the expense of non-QoS performance. Simulation results demonstrated the validity of proposed scheme and QoS performance and non-QoS performance. As a result, proposed scheme outperforms DT scheme.

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