Modified EDCF to Improve the Performance of IEEE 802.11 e Contention-based Channel Access

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Keyword: WLAN, EDCF, Wireless, QoS, 802.11e

Abstra

In this paper we propose a modified EDCF scheme, M-EDCF, to improve the Quality of Service (QoS) of the IEEE 802.11e wireless network. The IEEE 802.11e standard is presented to support QoS at medium access control level using a priority scheme by differentiating the inter-frame space and the initial window size. In addition to providing relative priorities by adjusting the size of the Contention Window (CW) of each traffic class, our proposed scheme, M-EDCF, also consider the effect of a back_off_timer to avoid unnecessary collisions. Our study shows that in either in heavy or light traffic load our proposed scheme can provide better quality for both high priority and low priority packets than either the AEDCF [1][14].

1. Introduction

The 802.11 legacy MAC [2] does not support the concept of differentiating frames with different priorities. Basically, the DCF is supposed to provide a channel access with equal probabilities to all stations contending for the channel access in a distributed manner. However, equal access probabilities are not desirable among stations with different priority frames. The emerging EDCF [3] is designed to provide differentiated and distributed channel access for frames with 8 different priorities (from 0 to 7) by enhancing the DCF As distinct from the legacy DCF, the EDCF is not a separate coordination function. Rather.Each frame from the higher layer arrives at the MAC along with a specific priority value. Then, each QoS data frame carries its priority value in the MAC frame header. An 802.11e STA shall implement four access categories (ACs), where an AC is an enhanced variant of the DCF 0. Each frame arriving at the MAC with a priority is mapped into an AC.

EDCA (contention-based-EDCF)

Basically, an AC uses AIFS[AC], CWmin[AC], and CWmax[AC] instead of DIFS, $CW_{\min}$, and $CW_{\max}$, of the DCF, respectively, for the contention process to transmit a frame belonging to access category AC The AIFS[AC] is determined by

$$AIFS[AC]=SIFS+AIFS[AC]*SlotTime \quad (1)$$

,where AIFS[AC] is an integer greater than zero. Moreover, the backoff counter is selected from [1, 1+CW[AC]].

2. Related Improved Schemes for the IEEE 802.11e

Up to date, there are a lot of researches about 802.11 wireless networks supply with instant information as quality guarantee. They are classified into two groups, one is station-based improvement [4,5,13], and the other one is queue-based improvement [7,8,9]. The former one represents that each working station has its own special parameter, and the latter one represents that each working station has many queues which served as simulated working stations, and each queues has its own parameter.

After each successful delivery, the EDCF will reset its contention window to $CW_{\min}$ regardless of present network condition. However, after collision takes place, the chance of having the second collision would be higher within the short time, thus, the method mentioned ADECF in [1] is based on the network condition, and gradually lessens the contention window instead of resetting windows value to $CW_{\min}$ directly to avoid the chance of having continuous collision.-[10,12]

The formula of collision rate f^j_{curr} in jth period is given by

$$f^{j}_{curr} = \frac{E(collisions_j[p])}{E(data\_sent_j[p])} \quad (2)$$

,where the E (collision$_j$ [p]) is the average number of collisions of the jth period for a user P and E (data_sent$_j$ [p] is the average number of frames sent by the user.

In order to create different contention window for various priority class, the AEDCF uses Multiplicator Factor (MF) to control its speed, based on moving averaging of f^j_{curr} and

$$MF[i] = \min((1 + (i * 2)) * f_{avg}^{j}, 0.8) \qquad (3)$$

With

$$f_{avg}^{j} = (1 - \alpha) * f_{curr}^{j} + \alpha * f_{avg}^{j-1} \qquad (4)$$

,where i represents different priority class. The smaller the i, the smaller the MF, i.e., the higher priority class, the smaller MF. The contention window after successful transmission should not be greater than the original one.

Then the contention window for various priority class after successful delivery is given by

$$CW_{new}[i] = \max(CW_{\min}[i], CW_{old}[i] * MF[i]) \qquad (5)$$

The above formula guarantees the new contention window to be greater than or equal to $CW_{\min.}$

On the other hand, the contention window after each collision is given by

$$CW_{new}[i] = \min(CW_{\max}[i], CW_{old}[i] * PF[i]) \qquad (6)$$

where high priority traffic flow has smaller value of PF [i] for more chance of competition.

3. The Improvement Method of AEDCF : M-EDCF

In the IEEE 802.11e standard, if channel is idle continuously for (AIFS+X) time slots, back_off timer can reduce X time slots, and system can start frame delivery after the back_off timer becomes zero. However, if the system detects a busy channel during back_off time period, then it must stop back_off procedure and sets up the virtual carrier sense (NAV).

The problem is that a user only needs to wait for sufficient scattered idle time slots and then transmits after back_off timer counts down to zero. For a low priority user, it accumulates some idle time slots, and may get the same privilege as a high priority user. This will result in higher collision rate. Especially if channel loading is very high, then enormous collisions can not be avoided.

Therefore, we hope to wait continuously during the whole idle period and the system starts delivering after back_off timer count down to zero. Wherever busy channel situation is detected in a backoff state, we must increase contention window based on the average collision rate given by *Eq.(*4) and choose new back_off time and start backoff procedure.

However, if we inflexibly increase contention window, then the following situation may happen:

If the contention windows increase a little, it still results in severe collisions when channel loading is high.

If the contention windows grows too much, this results in much idle period when channel loading is low.

Therefore, we must adjust contention window dynamically according to traffic load which is based on the average collision rate. Thus as the average collision rate increases, that means traffic loading increase. The formula of average collision rate follows *Eq.(*4).

We present new contention windows as the following formula.

Where

Temp=min(β*avg_coll_rate, rate,2.0) (7)

New_cw[pri]=old_cw[pri]*max(temp, 1.0) (8)

In order not to increase contention window rapidly, we limit the maximum value of the parameter “temp” to 2.0. In the meanwhile, we do not want the parameter “temp” to be less than 1, so that the contention window decreases instead. The parameter β is called a scaling factor, which is used to control the increasing speed of contention window when channel loading is between low and high level. To describe our proposed scheme completely, a flow chart is presented in Figure 1.

4. Simulation Model Description and Numerical Results

The simulation is base on the infrastructure mode of the 802.11e where each working station generates three traffic flows(i.e. video, voice and background) delivered to the AP, and start delivering at random time. When the number of working station increases, then channel loading increases. The traffic parameters in this scenario are showed in Table 1. Voice traffic is generated by the on/off model build in NS2 module, while video is simulated by VBR (Variable Bit Rate) base on the trace produced by H.261 coding technology and QCIF resolution and we use CBR to simulate the Background traffic.

As shown in Figure 3, our method M-EDCF can provide the better performance than the EDCF and the AEDCF in terms throughput, channel utilization and collision rate.

Figure 4 and Figure 5 show that the mean delay in the EDCF and the AEDCF scheme both raise quickly because of increasing collision rate when the traffic load is high. But the curves of M-EDCF show that mean delay is much smaller and growing gradually.

When the buffer is overflowed in Scenario II, the dropping rate of voice data is also zero, so we present the results of background traffic and video traffic in Figure 6, respectively. We can see the dropping rate bye our method is also lower than the EDCF and the AEDCF.

Base on the simulation results showed that ,we can conclude that our proposed scheme, M-EDCF, and the AEDCF scheme outperforms the EDCF. Using the adaptive Back_off_timer, the M-EDCF gets much higher goodput than the ADCF scheme. Moreover, the M-EDCF scheme can improve the performance both for high priority and low priority traffic.

5. Summary

Although there are several articles addressed the performance enhancement of the IEEE 802.11e EDCF, they are either too complex or generate a great collisions under overload which results in poor performance. In this article, we provided a simple and effective method to reduce collisions, which can also distinguish between high priority and low priority traffic. Under the condition of high traffic load, the throughput of high priority flow is protected. In the meanwhile, because of the dynamically adjusting contention parameter, low priority traffic flow increases contention window to lessen collisions under overloading condition. Compared with the EDCF and the AEDCF scheme, even low priority traffic flow can also obtain the relatively better performance by our proposed scheme.

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Table 1 The parameter of traffic in Scenario I

Voice	Agent	exponential
	packet interval	20ms
	packet size	160bytes
	data rate	64kbps
	burst_time	400ms
	idle_time	600ms
Video	Agent	VBR
	Mean packet interval	26ms
	mean data rate	200kbps
	mean packet size	660bytes
Background	Agent	CBR
	packet interval	20ms
	packet size	1600bytes
	data rate	640kbps

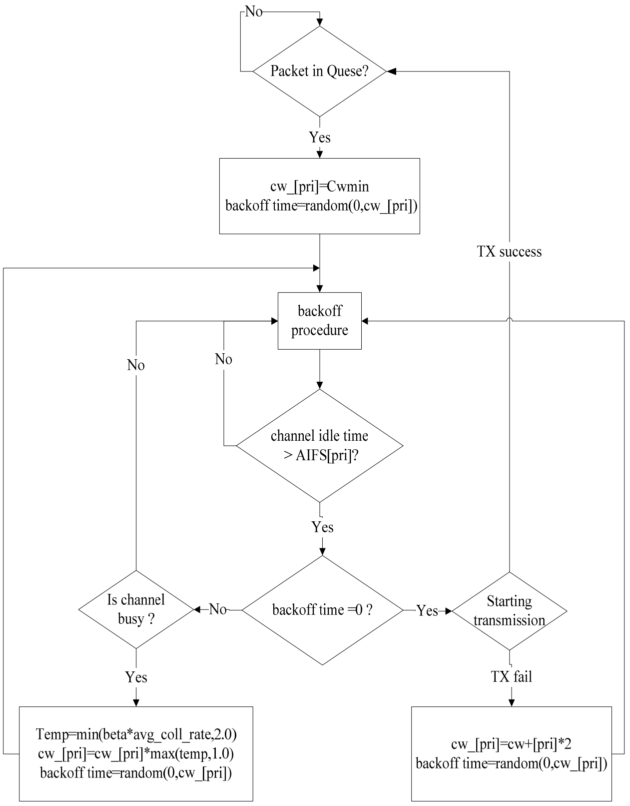

Figure 1 The flowchart

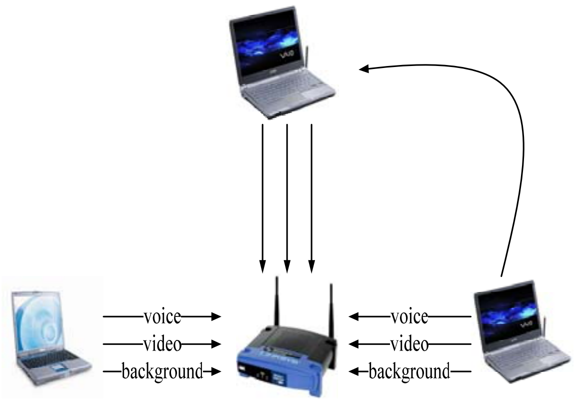

Figure 2 Simulation topology

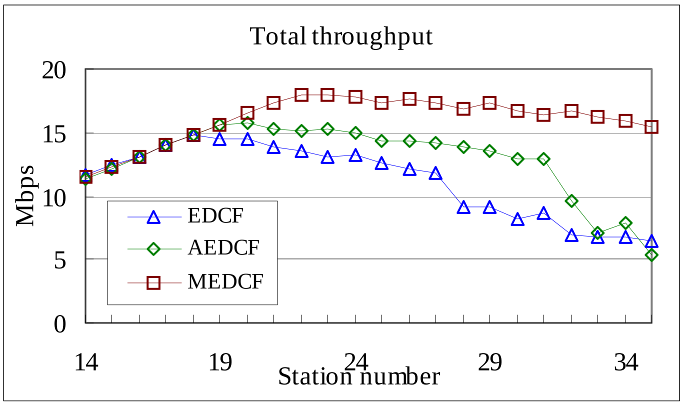

Figure 3 total throughput

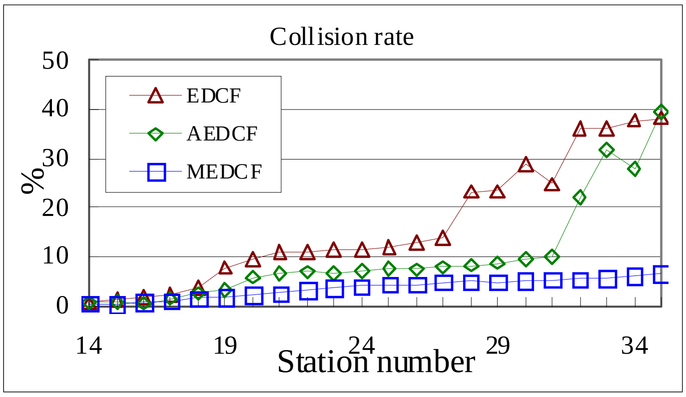

Figure 4 Collision Rate

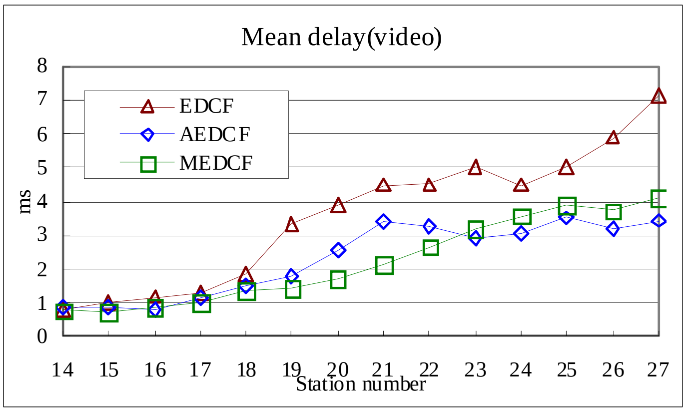

Figure 5 Mean delay of video traffic

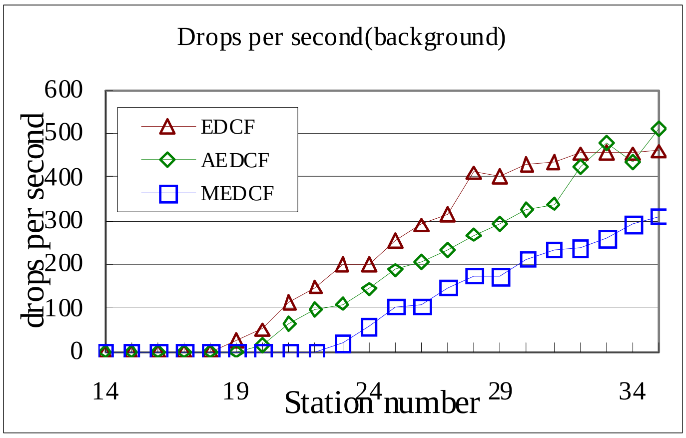

Figure 6 Drops per second of background traffic