Achieving Per-Stream QoS with Distributed Airtime Allocation and Admission Control in IEEE 802.11e Wireless LANs

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Outline

• Introduction
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Introduction

- *To support the transmission of (high-rate and often bursty) multimedia data with performance guarantees in an IEEE 802.11e WLAN, it is crucial to design judicious algorithms for admission control and resource allocation.*
Introduction of 802.11e

• The MAC protocol in the 802.11e standard
  – Enhanced Distributed Channel Access
    • Contention-based channel access mechanism
    • Prioritized QoS service
  – HCF Controlled Channel Access
    • Polling-based channel access mechanism
    • Parameterized QoS service
Mechanism of EDCA

The CSMA/CA is executed for each queue. High AC value becomes short frame transmission interval because the fluctuation time is set to be short time.

Frame transmission interval

If the frame transmission timing collides among several frame transmission queues, the queue of high AC value can be sent frames preferentially.

Received frames are classified into a suitable frame transmission queue according to AC value.

<table>
<thead>
<tr>
<th>AC value</th>
<th>Service category</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Background</td>
</tr>
<tr>
<td>1</td>
<td>Best Effort</td>
</tr>
<tr>
<td>2</td>
<td>Video</td>
</tr>
<tr>
<td>3</td>
<td>Voice</td>
</tr>
</tbody>
</table>

Figure 1. Mechanism of EDCA.
Mechanism of HCCA

Received frames are classified into a suitable frame transmission queue which is set for each QoS requesting terminal.

Each frame transmission queue is sent frames to be satisfied with the negotiated QoS requirements for each terminal.

Figure 2. Mechanism of HCCA.
Airtime-based Admission Control

• EDCA need admission control to determine how much traffic a wireless LAN can handle so that the prescribed QoS for each traffic stream can be maintained.

• Of course, an admission decision should be made according to both admission policies and QoS requirements supplied by a higher-layer entity of a wireless station, usually the application layer.
QoS Requirement

• These requirements are specified in the TSPEC element in the IEEE 802.11e standard and are submitted to the admission control unit (ACU) by stations carrying the streams.
Parameters of TSPEC

- The Mean Data Rate \( (p) \)
- The Peak Data Rate \( (P) \)
- The Maximum Burst Size \( (\sigma) \)
- The Minimum PHY TX Rare \( (R) \) field
- The Delay Bound \( (d) \)
- MSDU Size \( (L) \)
Admission Policies

• The ACU may decide to admit a stream only if its peak data rate can be supported (for the best QoS) or may simply admit the stream as long as the mean data rate is available.
Fig. 3. The dual-token bucket filter for traffic policing.
Guaranteed Rate

Fig. 4. Arrival curve at the entrance of MAC buffer and the guaranteed rate for a traffic stream.
Airtime-based admission control for EDCA

1. Arrival of a stream’s admission request from the station to the AP

2. AP passes the TSPEC parameters to the ACU

3. ACU extracts the Mean and Peak Data rate, Maximum burst size and Delay Bound from the TSPEC and derives the guaranteed rate

4. ACU checks if Eq. (7) satisfied?
   - NO: Reject the stream
   - YES: Admit the stream and pass the negotiated Minimum PHY TX rate parameter to the requesting station
Controlled Airtime Usage in EDCA

• To control a station’s airtime usage in EDCA, one may choose to control
  1. the TXOP limit of each station
  2. the frequency of a station’s access to the wireless medium.
Controlling the Accessing Frequency

• Several EDCA parameters can be used for controlling AF, including minimum/maximum contention window size and arbitration inter-frame space (AIFS)
Fig. 9. Signaling and exchange of messages when a QoS traffic stream is added to an HC-coordinated 802.11 wireless LAN.
Performance Evaluation

Fig. 11. Comparison of system efficiency, in terms of the total throughput, between HCCA and EDCA. A new station carrying a single stream is added to the wireless LAN about every 5 seconds and transmits at 54 Mbps. The height of each “stair” in the figure is equal to a stream’s guaranteed rate = 5 Mbps.
Fig. 12. Comparison of throughput between controlling stations’ TXOP limits and $CW_{min}$ values. The figures show that in EDCA, controlling stations’ TXOP limits and controlling the $CW_{min}$ values result in the same performance in terms of streams’ throughput.
Delay analysis

Fig. 13. Comparison of delay between controlling stations’ TXOP limits and $CW_{min}$ values. The figure shows that in EDCA, controlling $CW_{min}$ values may result in a large delay variance but still satisfy all streams’ delay bound.
Conclusions

• Based on the traffic profile given in the TSPEC and the dual-token bucket regulation, a guaranteed rate is derived for our airtime-based admission control.

• The admission control is integrated with the contention-based Enhanced Distributed Channel Access (EDCA), which together can provide so-called "parameterized QoS".