

## Chapter 20

# Cross-Layer Optimization for Video Transmission over WLAN: Cross-Layer Prioritization

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### ABSTRACT

*As IEEE 802.11 wireless devices have become increasingly widespread, providing Quality of Service in the context of H.264/AVC, the video coding standard for future multimedia networking, has become an important issue in the fields of communication and networking. Cross-Layer Adaptive Video Prioritization (CAVP) is a cross-layer framework that prioritizes video frame transmission according to the application-layer information and the MAC layer transmission condition. In this chapter, a **Peak Signal-to-Noise Ratio (PSNR)** estimation method is proposed to sort out different priorities of H.264/AVC (Advanced Video Coding) video frames at the application layer to provide user-centric media quality estimation. Compared to previous heuristic algorithms, the authors also investigate a theoretic access delay estimator to monitor the wireless medium access delay at the MAC layer. In addition, an admission control is employed to serve the delay-sensitive video application and to give higher priority to those critical video frames. Video packets are dynamically classified into different 802.11e **access categories** according to the level of wireless medium access delay and the priority of the video frames.*

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*The myths of naïvely prioritizing video packets based on I/P/B types as well as naïvely assign packets to high priority access categories in 802.11e are resolved. Rather than creating complex scheme that is unable to be implemented in practical scenarios, the authors design the proposed scheme with practical implementability in mind. The proposed scheme is implemented with Click kernel module and the MadWifi WLAN driver. The performance of proposed CAVP design is evaluated by both NS-2 simulations and real testbed experiments, and results show that it enhances receiving video quality in error-prone wireless networking environments.*

## INTRODUCTION

High-quality video streaming and video-on-demand services have increasingly burgeoned these years; however, the problems of video traffic being error-sensitive and network capacity consuming still remain. Therefore, IEEE 802.11e is introduced to achieve **Quality of Service (QoS)** in 802.11-based system; moreover, H.264/AVC (Advanced Video Coding), an emerging video coding standard is used to delivering videos over a wide variety of networks, of which the advanced video coding standard introduces several mechanisms, such as independent slice decoding and flexible NAL structures to improve content network delivery. Combining the advantages of both techniques, the delivery of H.264/AVC video content over IEEE 802.11e wireless networks can satisfy the rising demands of network multimedia applications.

## BACKGROUND

### IEEE 802.11 WLAN

The basic medium access mechanism of the IEEE 802.11 Distributed Coordination Function (DCF) is Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). An 802.11 wireless station senses the wireless medium before transmitting any packet. If the medium is busy, it applies a random backoff mechanism to defer the wireless medium access. The backoff counter is a random value between 0 and the current **Contention**

**Window (CW)** value, which is initialized to the minimum window size. When the 802.11 station senses that the medium is free for at least the time duration DIFS (DCF Interframe Space), it begins to decrease the backoff counter. When the backoff counter value is 0 and the medium is still idle, the station can begin transmitting packets. After the packet transmission is done, the station which successfully received the data should send an Acknowledgement (ACK) frame back to the sending station. A Short Interframe Space (SIFS) waiting time is applied before replying the ACK message. The whole transmission procedure ends when the sending station successfully receives the ACK frame. If a data transmission is detected failed (no ACK is received), the backoff counter CW is doubled, until it reaches the maximum contention window size ( $CW_{max}$ ). The CW value is reset to  $CW_{min}$  after successful data transmission.

In basic IEEE 802.11 operation, no quality of service is supported. All traffic contends for channel access with the same DIFS, CW,  $CW_{max}$ , and  $CW_{min}$ . Therefore, there is no difference between each packet. IEEE 802.11e (IEEE, 2005) is developed for QoS support in wireless LAN. The Enhanced Distributed Channel Access (EDCA) provides differentiated QoS support (IEEE, 2005; Mangold, et al., 2003). In EDCA, there are four Access Categories (AC): AC\_VO for voice transmission, AC\_VI for video transmission, AC\_BE for best effort traffic, and AC\_BK for background traffic. Each AC has different  $CW_{max}$ ,  $CW_{min}$ , Arbitration Interframe Space (AIFS), which is similar to DIFS, and duration of Transmission Opportunity

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