Chapter 4
Codec Adaptation for Wireless Multimedia Streaming

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ABSTRACT

Due to the time-varying nature of wireless channels and the Internet backbone traffic, it is a challenging task to maintain the quality of wireless multimedia streaming throughout the transmission. An effective solution is to adapt the codec setting based on the wireless channel condition or the Internet backbone state. In this chapter, we present three cross-layer codec adaptation algorithms that adjust the codec setting in real-time based on media access control frame error rate, received signal strength indication, and path bandwidth respectively. Results show that the algorithms are effective in achieving good video quality for wireless multimedia streaming over wireless links.

INTRODUCTION

In the past decade, high-speed wireless data services have become increasingly popular following the explosive growth of the *Wireless Local Area Network* (*WLAN*) technology and the development of various mobile broadband technologies such as *3rd-Generation* (*3G*) and *Worldwide Interoperability for Microwave Access* (*WiMAX*) (Andrews, 2007). The ability to support high data rates in such wireless data services makes real-time wireless multimedia streaming a practical application nowadays. However, wireless channels are notorious for their time-varying nature due to the fading effect resulted from the multipath nature of wireless transmissions. Researchers of the physical layer technology have been working hard for decades to provide reliable data transmissions over time-varying wireless channels. Nevertheless, due to various compression techniques applied to multimedia data before transmission, wireless multimedia streaming is more sensitive to channel variation than typical data transmissions. As

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a result, it is a very challenging task to provide wireless multimedia streaming service with good video quality in wireless environments.

To provide good video quality in time-varying wireless environments, it is clear to see that the video codec setting has to be optimally adjusted in real-time according to channel variation. The optimality here is defined in the sense that the *Peak Signal-to-Noise Ratio* (*PSNR*) (Huynh-Thu, 2008) performance at the receiver side be maximized by adapting the codec setting. In wireless communications, the *Media Access Control* (*MAC*) *Frame Error Rate* (*FER*) is directly related to the channel quality. The FER statistic is also generally accessible which makes it desirable to design codec adaptation scheme according to the FER variation. In this chapter, we first demonstrate a novel FER based codec adaptation scheme which takes the dynamic of channel variation into consideration and chooses the setting that can achieve the best possible expected PSNR performance in the future, as opposed to existing schemes which generally choose the setting that works best only for the moment without considering the channel variation in the future. To find the optimal codec switching thresholds for FER based codec adaptation, we start by developing a new theoretical framework for analyzing the PSNR of multimedia streaming over wireless channels. Then the optimal codec switching thresholds can be found accordingly by maximizing the PSNR. The proposed FER based codec adaptation is shown to achieve great performance with PSNR gain of 3 to 5 dB.

In addition to the FER statistics at the MAC layer, the performance of multimedia streaming is also closely related to the channel *Received Signal Strength Indication* (*RSSI*) of the wireless link (physical layer information) and the bandwidth of the end-to-end communication path (network layer information). To further demonstrate the benefits of using cross-layer information for codec adaptation, we also present two heuristic schemes in this chapter for the server to adapt its codec setting based on channel RSSI and path bandwidth accordingly. Evaluation results show that codec adaptation using cross-layer information can effectively enhance the performance of multimedia streaming over time-varying wireless environments.

BACKGROUND

In the literature, there have been several works proposed for multimedia streaming over time-varying wireless channels. Different cross-layer approaches are designed to improve the PSNR performance for wireless multimedia streaming as summarized in the following.

Bucciol et al. (2004) propose that video packets that contain perceptually important frames should have higher priority during retransmission. The proposed scheme improves the resulting PSNR by 1.5 dB compared to the conventional *Automatic Repeat reQuest* (*ARQ*) schemes. However, the priority of every packet has to be calculated beforehand, which makes it impractical for real-time multimedia streaming. Also the perceptually important packets still suffer from the channel variation during transmission. Khan et al. (2006) consider the case of a multimedia server serving multiple clients. The distortions experienced by the different clients under different combinations of *Physical Layer* (*PHY*)/codec settings at clients' ends are simulated. By finding the combination that jointly optimizes the PSNR for everyone, the PHY/codec settings of all clients are determined. However, the scheme requires extensive simulations for all *PHY*/codec settings of all clients. This makes it difficult to be applied when the number of clients increases. Ruiz et al. (2002) adapt the codec settings according to the *Quality of Service* (*QoS*) report fed back from the client. The codec setting is upgraded when the QoS report is good, and downgraded when receiving a bad QoS report. Haratcherev et al. (2006) propose an algorithm where the codec setting is adjusted for the resultant bit-rate to match the