Chapter 8.6
A Cross-Layer Model for Video Multicast Based TCP-Adaptive FEC over Heterogeneous Networks

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ABSTRACT

In this article, we present a simple cross-layer model that leads to the optimal throughput of multiple users for multicasting MPEG-4 video over a heterogeneous network. For heterogeneous wired-to-wireless network, at the last wireless hop there are bit errors associated with the link-layer packets that are arising in the wireless channel, in addition of overflow packet dropping over wired links. We employ a heuristic TCP function to optimize the cross-layer model of data link and physical (radio-link) layer. An adaptive Forward-Error-Correction (FEC) scheme is applied at the byte-level as well as at the packet-level. The corresponding optimal video quality can be evaluated at each client end. The results show that a server can significantly adapt to the bandwidth and FEC codes to maximize the video quality of service (QoS) in terms of temporal scaling when a maximum network throughput for each client is reached.

INTRODUCTION

Video multicasting has become increasingly deployed in many multimedia applications (e.g.,
Telemedicine systems, Video on Demand, etc.), which involve point to multi-point communication, i.e. a video sequence stored or generated (captured live) at a server is simultaneously delivered to a group of receivers distributed in a network (Bajie, 2006; Martini et al., 2007; Liu et al., 2007). In such a network, packet loss is inevitable. In order to provide good video quality, it is important to recover most of the loss so that the resultant end-to-end recover error rate after correction, i.e., the residual loss rate, is kept below a certain value (Chan et al., 2006).

Fortunately, video multicast is an efficient way to deliver one video simultaneously to many users over homogeneous and/or heterogeneous wired-to-wireless networks, such as in wireless IP applications where a mobile terminal communicates with an IP server through a wired IP network in tandem with a wireless network as in Figure 1. Compared to unicast, it improves bandwidth efficiency by sharing video packets delivered through network. However, it suffers some particular problems arising from the use of wireless network applications. For example, a multicasting wireless network is often characterized by having a physical channel that is highly error-prone and time-varying. In addition, users in such a network can often have diverse channel conditions (Liu et al., 2007; Lo et al., 2005; Lee et al., 2002; Pei et al., 2004).

On the other hand, many popular multimedia networks cannot provide a guaranteed quality of service (QoS) for video traffic. MPEG-4, however, is still a video compression standard adopted by most mobile and wireless networks because of its good quality at bits rates of these networks (Lo et al., 2005). To this end, it is essential to rely on QoS metrics of a connection (flow or session) in terms of data throughput, packet error/loss rate, and delay performance especially over heterogeneous networks. In practice, for QoS guarantees in high-rate multimedia applications, many major challenges of video traffic are faced on heterogeneous wired and wireless Internet links (Lee et al., 2002; Pei et al., 2004; Liu et al., 2004; Zhang et al., 2006; Chiasserini and Meo, 2002). Some of these challenges deal with high packet loss rate due to the congestion of buffer overflow over wired networks; and others are mainly faced by the characteristic of wireless links, which is mostly suffering from low bandwidth and high bit error rates due to the noise, interference, unpredictable user mobility (Doppler effects) and multi-path fading. Specifically, the “bottleneck”

Figure 1. Video multicast system over heterogeneous wired-to-wireless Network