Chapter 2
Adapting Multimedia Streaming to Changing Network Conditions

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ABSTRACT
Providing a satisfactory multimedia service in networking environments requires an effective media delivery mechanism. However, the Internet does not provide a guaranteed network bandwidth to accommodate multimedia service in a reliable fashion. The Internet is a heterogeneous networking environment, in which resources available to multimedia applications are changing. In the last decade, the research community has proposed both networking techniques and application layer techniques, which adapt to the changes in network conditions. This chapter focuses on the application level techniques, including methods based on compression algorithm features, layered encoding, rate shaping, adaptive error control, and smoothing. The chapter also discusses operating system methods to support adaptive multimedia.

INTRODUCTION
Multimedia streaming over the Internet has received tremendous attention from academia and industry due to the increasing demand for multimedia information on the web. The current best-effort Internet does not offer any quality of service (QoS) guarantees to streaming video. Adaptive streaming applications have the capability to stream multimedia data over heterogeneous networks and adapt media transmission to network changes. Adaptation of multimedia applications can be done at several layers of the network protocol stack. This chapter presents techniques for adaptation based on compression methods. In particular the chapter discusses techniques for achieving adaptation at the application layer including layered encoding, receiver driven multicast, rate shaping, error control, adaptive synchronization, and smoothing. In addition, the chapter discusses operating system methods to support adaptive multimedia.

High-speed technologies such as ATM (asynchronous transfer mode), gigabit Ethernet, fast
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Ethernet, and frame relay support real-time multimedia applications such as video-on-demand, video broadcasting and Internet telephony (Kanellopoulos, 2009). QoS refers to the capability of a networked system (e.g., a distributed multimedia system) to provide scalable service to selected network traffic. Various multimedia applications have different QoS requirements. For example, continuous media types such as audio and video require hard or soft bounds on the end-to-end delay, while discrete media such as text and images do not have any strict delay constrains. Multimedia streaming services impose new QoS requirements on the Internet (Li & Yin, 2007; Kanellopoulos et al., 2008). Multimedia applications use application streaming for sending multimedia data streams. The Real-time Streaming Protocol (RTSP) (Schulzrinne et al., 1998), the Real-time Transport Protocol (RTP) (Schulzrinne et al., 1987) and the Real-time Transport Control Protocol (RTCP) were specifically designed to stream media over networks. The latter two are built on top of UDP. On the Internet, the available network resources provided to a multimedia application are changing dynamically. Network conditions may change due to difference in link speeds or variability in a wireless environment caused by interference and mobility (Kanellopoulos et al., 2006). To provide end-to-end QoS guarantees, an intensive effort is necessary from all subsystems, including end-subsystems, network hardware, and communication protocols of a multimedia system. If multimedia applications are capable of adapting to changing network conditions, then network resources can be used efficiently. Adaptation of multimedia applications can be done at several layers of the network protocol stack (Vandalore et al., 2001). At the physical layer, adaptive power control techniques can be used to alleviate variations in a wireless environment. At the data link layer, error control and adaptive reservation techniques can be used to protect against variation in error and available rate. At the network layer, dynamic re-routing mechanisms can be used to avoid congestion and mitigate variations in a mobile environment. At the transport layer, dynamic re-negotiation of connection parameters can be used for adaptation.

At the application layer, the multimedia application can adapt to changes in network conditions using several techniques including efficient compression, hierarchical encoding, smoothing of the video information transmitted, rate shaping, error control, and adaptive synchronization (Vandalore et al., 2001). These methods can be classified into reactive and passive according to their approach towards adaptation. In reactive methods, the application modifies its traffic to suit the changes in the network. In passive methods, the application aims to optimize the usage of network resources. Smoothing of stored video and rate shaping are example applications of passive and reactive methods respectively.

This chapter presents techniques for adaptation based on compression methods. In addition, it discusses techniques for achieving adaptation at the application layer including layered encoding, receiver driven multicast, rate shaping, error control viz. forward error correction (FEC) techniques for Internet audio and video, adaptive synchronization, and smoothing.

- In **layered encoding**, the video information is encoded into several layers. The base layer carries important video and critical timing information. The higher layers improve the quality of video gradually. The receiver can get a reasonable quality with the base layer, and quality improves with reception of higher layers. The encoder allocates priorities to the encoded layers, with the base layer having the highest priority. When the network transmits layered video, it can drop lower priority (higher) layers in the event of congestion.
- The **Receiver driven Layered Multicast (RLM)** technique describes how layered video can be transmitted and controlled.
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