Chapter XXIV
Content-Based Video Streaming Approaches and Challenges

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ABSTRACT

Video streaming poses significant technical challenges in quality of service guarantee and efficient resource management. Generally, it is recognized that end-to-end quality requirements of video streaming application can be reasonably achieved only by integrative study of advanced networking and content processing techniques. However, most existing integration techniques stop at the bit stream level, ignoring a deeper understanding of the media content. Yet, the underlying visual content of the video stream contains a vast amount of information that can be used to predict the bit-rate or quality more accurately. In the content-aware video streaming framework, video content is extracted automatically and used to control video quality under various manipulations and network resource requirements.

INTRODUCTION

Video has been an essential element for communications and entertainment for many years. Initially video was captured and transmitted in analog shape. The emergence of digital integrated circuits and computers led to the digitization of video, and digital video enabled a revolution in the compression and communication of video. Video compression (Mitchell, Pennebaker, Fogg, & LeGall 1996) and transmission became an important area of research in the last two decades and enabled a variety of applications including video storage on DVD and Video-CD, video broadcasting over digital cable, satellite and terrestrial digital television (DTV), high definition TV (HDTV), video conferencing and videophone over circuit-switched networks. The drastic growth and popularity of the Internet motivated video communication over best-effort packet networks. Video over best-effort packet networks is com-

plicated by a number of factors including unknown and time varying bandwidth, delay, and packet losses, as well as many additional issues such as how to fairly share the network resources amongst many flows and how to efficiently perform one-to-many communication for popular content "congestion control," and so forth. The Internet disseminates enormous amounts of information for a wide variety of applications all over the world. As the number of active users on the Internet has increased, so has the tremendous volume of data that is being exchanged between them, resulting in periods of transient congestion on the network. On the transmitted data over the internet regards, some researchers estimates (Chandra, & Ellis 1999; Ortega, Carignano, Ayer, & Vetterli, 1997) about 77% of the data bytes accessed on the Web are in the form of multimedia objects.

This chapter examines the challenges that face simultaneous delivery and playback, or streaming of video on a content awareness basis. We explore *approaches and systems* that enable streaming of pre-encoded or live video over packet networks such as the Internet in content aware manner.

First, we try to describe and discus some of the basic approaches and key challenges in video streaming. Generally the most straightforward approach for video delivery in the Internet is by an approach similar to a file download, but we refer to it as video download to keep in mind that it is a video and not a general file type. Specifically, video download is similar to a file download, but it is a very large file. This scheme allows the use of established delivery mechanisms, for example TCP as the transport layer, FTP, HTTP, or HTTPS at the application layers. However, this scheme has a number of drawbacks. Since videos generally correspond to very large files, the download approach usually requires long download times and large storage spaces. These are all crucial practical limitation. In addition, the entire video file must be downloaded before viewing can start. This requires patience on the client part and also reduces flexibility in certain scenarios. In one scenario, if the client is unsure of whether he wants to view the video, he must still download the entire video before viewing it and making a decision. In another scenario, the user may not be aware about the exact disk space on his machine, therefore he might start to download a large video file which takes few hours, then an error message would pop up stating disk insufficiency. The user wasted hours for nothing. These scenarios and other scenarios cause great obstacles in the video file download scheme. Video delivery by video streaming attempts to overcome the problems associated with the video file download scheme, and also provides a significant amount of additional capabilities "viewing flexibility." The basic idea behind video streaming is to make "make simultaneous delivery and playback" which splits the video into portions, transmits these portions in succession, and enabled the receiver to decode and playback the video as these parts are received, without having to wait for the entire video to be delivered. Video streaming enables simultaneous delivery and playback of the video. This is in contrast to file download where the entire video must be delivered before playback can begin. In video streaming there usually is a short latency (usually on the order of 10-15 seconds) between the start of delivery and the beginning of playback at the client. Video streaming provides a number of advantages including low delays before viewing starts, and low storage requirements since only a small portion of the video is stored at the client at any point in time. The storage issues can be enhanced by deploying some caching strategies as well. For video streaming data, any data that is lost in transmission cannot be used at the receiver. Furthermore, any data that arrives