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701 E. Chocolate Avenue, Hershey PA 17033-1117, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com
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Chapter IX

Network Dimensioning for MPEG-2 Video Communications Using ATM

Bhumip Khasnabish
Verizon Labs, Inc., USA

This chapter discusses various issues related to the shaping of Motion Picture Experts Group (MPEG) video for generating constrained or controlled variable bit rate (VBR) data streams. MPEG-2 defines a set of standards for coding and compression of digital video. VBR video can offer constant picture quality without incorporating too much processing overhead in the network or transmission system's architecture. In addition, they can offer substantial (20% to 50%) savings in both storage and transmission bandwidth requirements compared to constant bit rate (CBR) video. Either source coding or encoder's output shaping or a combination of both can be used for adapting the MPEG-2 video streams for transmission over real-time VBR (rt-VBR)-type asynchronous transfer mode (ATM) channel.

For experimental purposes, the VBR video traces are produced by defining peak and average bit rates over the group of pictures (GOP) and the entire clip, respectively. Specification and development of the traffic contract parameters for transmission of VBR MPEG-2 video using rt-VBR-type ATM service are then presented. The traffic parameters are determined for (i) different values of sustained cell rate (SCR) where SCR is varied from the average rate to within a few percent of the peak cell rate (PCR), and (ii) number of different 'averaging intervals' ranging from one frame (i.e., 1/30-th of a second for 30 frames/sec video) to an entire GOP (e.g, 0.5 sec when GOP length is 15 frames in a 30 frames/sec video). The burstiness of MPEG-2-encoded video streams varies widely depending on the category of video encoded. The 'averaging interval' has a significant impact on the values of the traffic contract parameters. Typically, values of the maximum burst size (MBS) are higher and PCR values are lower when traffic is averaged over an entire GOP structure as opposed to averaging over a few frames. As the SCR value is increased from the average value, the MBS values decrease and reach a minimum asymptote. The decrease is sharpest when the rates are averaged over a few frames as opposed to an entire GOP. PCR/SCR ratios

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are highest for rates averaged over a sub-GOP. It is possible to determine the conforming effective bandwidth (EBW) or equivalent capacity (EC) needed for transmitting the VBR video maintaining the same perceptual quality as in CBR but with less transmission bandwidth. These can be achieved using the current configurations of the commercially available ATM switches.

The results presented in this chapter can be utilized not only for network and nodal (buffer) capacity engineering, but also for delivering the user-defined quality of service (QoS) to the customers. These are very useful for cost-effective design, engineering and operations of video service offerings using wireline (e.g., HFC, xDSL and FTTN/C) and wireless (e.g., L/M-MDS) networks. For example, when CBR video is used, bandwidth allocation is usually performed at approximately 6 Mbps per video stream, but for VBR video the effective bandwidth requirements per stream could be as low as 3 Mbps. This directly translates to approximately doubling the transmission capacity of the video delivery system.

INTRODUCTION

A large number of emerging telecommunications and video service providers are currently planning to offer digital video services[1] to both residential and business customers. For any real-time service like voice and video, the applications level quality of service (QoS) requirements are more stringent compared to those for non-real-time services like data and image transmission where it is possible to retransmit the erroneous segment(s) of a file.

Real-time full-motion digital video (Chariglione, 1997) is bursty in nature, and the burstiness depends on the frequency of changes in the background and the movements of the foreground objects. Therefore, without rate control the output bit stream of a video encoder will be of variable rate, since it depends on the complexity of the scene, the degree of motion and the number of scene changes. Although it is possible to statistically multiplex the bursty sources to achieve bandwidth savings, *uncontrolled* burstiness may lead to wastage of both storage and transmission bandwidth. Since the uncompressed real-time entertainment quality video is bursty, and of high bit rate (in the order of tens of Mega-bits/sec), it is not unlikely that at times excessively high processing, storage (buffering) and transmission capacities are demanded from the network. However, both dynamic allocation of bandwidth and use of exceptionally high bandwidth are expensive propositions for cost-effective delivery of entertainment video to the masses. These motivated the early implementers and providers of digital video services to use a scaled-down (compressed) and constant bit rate channel for delivering real-time video to the customers, even if it meant acceptable-quality (instead of high-quality) of video, and inefficient utilization of the channel. The digital video encoder manufacturers accordingly implemented additional bit stuffing and rate-control buffer in the encoder so as to generate a constant-bit rate stream for transmission and distribution applications. This is achieved by using (i) coarse quantization-which generates a smaller number of bits/picture– when excessive scene changes or motion occurs, or (ii) finer quantization and/or bit stuffing when less than desired amount of bits/picture are produced. These rate adaptations not only lead to variable video quality, but also at times may cause wastage of bandwidth because the encoder may use stuffing bits to maintain the constant bit rate.

Now, if the burstiness of the video can be *controlled* using either some pre-specified source coding constraints and/or some constraints as dictated by the transmission service category-e.g., ATM supports both constant and variable bit rate channels (ATM Forum,