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H.264 Video Traces for Network Performance Evaluation

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Multimedia networking applications and, in particular, the transport of compressed video are expected to contribute significantly to the traffic in the future Internet and wireless networks. In order to efficiently transport video with its stringent playout deadlines and bursty traffic characteristics, the multimedia networking research community is developing and evaluating a plethora of transport protocols. The use of video bit streams in networking experiments requires typically substantial computational resources and expertise in video coding. Alternative representations of video for multimedia networking researchers are video traffic models and video traces. Video traffic models, such as [1], strive to capture the essential properties of the real traffic in mathematical models that are typically based on the statistical properties of samples of the real traffic, or, in many cases, video traces. Video traces represent the traffic and quality of the videos in simple files that contain the number of bits, e.g., of a video frame, and the quality level (e.g., in PSNR) of the encoding. This article presents a brief overview of available video traces for video coding standards ranging from MPEG-1 through H.264 SVC.

Traces for MPEG-1 through MPEG-4. Video traces for MPEG-1 encoded video emerged in the mid-1990s and spurred significant research efforts in multimedia networking [2-4]. As video coding advanced to MPEG-4, traces for MPEG-4 encoding video became available, both for single-layer (non-scalable video) [5] and scalable video [6]. These traces allowed multimedia networking researchers to conveniently incorporate realistic traffic characterizations of MPEG encoded video into their network protocol evaluations. The MPEG encoded video traffic is typically quite bursty with coefficients of variation (standard deviation normalized by mean) of the frame sizes in the range from 0.8 to 1.4. The traffic also exhibits long range dependency as characterized by Hurst parameters close to one.

Traces for Non-scalable H.264. The H.264 standard brought significant advances over MPEG-4 with average encoded traffic bit rates for a given PSNR quality typically dropping to half compared to MPEG-4. The creation and analysis of video traces for H.264 focused initially on single-layer encoded video employing the H.264/AVC codec and the H.264 SVC codec operating as a single-layer codec [7]. The statistical analysis of the traces revealed that significant savings in the average bit rate with the H.264 codec come at the expense of significantly higher variability of the H.264 video traffic with coefficients of variation well above two and even exceeding three for some encodings. A comparison between classical B frames (default in H.264/AVC) and hierarchical B frames (H.264 SVC) found that hierarchical B frames outperform classical B frames in rate-distortion (RD) encoding performance at the expense of higher traffic bit rate variability.

Depending on the application scenario, it may be possible to smooth the video traffic before sending it into the network, thus reducing the traffic variability at the expense of introducing smoothing delay. We found that smoothed H.264/AVC and H.264 SVC video traffic exhibits variabilities at the same level or above the level of unsmoothed MPEG-4 Part 2 video traffic, indicating that even when smoothing is employed, the transport mechanisms for H.264 encoded video will need to be designed to accommodate substantial traffic variabilities.

H.264 SVC with hierarchical B frames (i.e., B frames being used as references for B frames) has more complex dependencies between the B frames compared to the classical B frames used in MPEG-4; these dependencies need to be carefully considered when timing the playout. A comprehensive analysis of the delays due to hierarchical B frames is provided in [8].

Traces for Scalable H.264 Video. H.264 SVC provides a wide range of options for scaling an encoded bit stream. We are currently creating and analyzing traces for the Coarse Grain Scalability (CGS) and Medium Grain Scalability (MGS). Initial results indicate that CGS can provide a relatively small number (e.g., two or three) of quality increments while staying within about 10% of the RD performance of the corresponding single-layer H.264 encodings [10]. Ongoing work indicates that MGS can provide relatively fine grained quality increments while staying within 10% (often even closer) of the single-layer RD performance by selectively dropping different numbers of MGS sublayers. Traces for MGS encoded video will become available in January 2010 at http://trace.eas.asu.edu.

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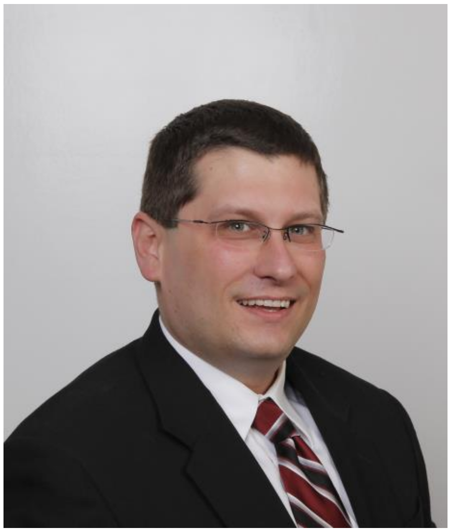
Tutorials. He maintains an extensive library of video traces for network performance evaluation, including frame size traces of MPEG-4 and H.264 encoded video, at http://trace.eas.asu.edu. He is a member of the ASEE and a senior member of the ACM and the IEEE.



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