

High-Definition Video Transmissions for Medical Applications and Education

Petr Holub^{a,c} and Miloš Liška^{b,c}

^aInstitute of Computer Science and ^bFaculty of Informatics, Masaryk University Brno, Czech Rep.
^cCESNET, Czech Rep.

Introduction: Enabled by current high-speed networks, high-definition (HD) video transmissions have become an essential tool for many applications. The HD video brings resolution, which is more than 4x larger than common PAL resolution, thus capturing more details and increasing the image quality dramatically. In this paper, we focus on using the HD video for two classes of medical applications: *synchronous* (real-time, interactive, collaborative) applications, which require low latency to provide perception of interactivity, and *asynchronous* (non-interactive, unidirectional, streaming, broadcasting, video-on-demand) applications, where the latency is not that restrictive. Because of high demands of HD video, these two classes of applications bring about distinct sets of problems. While complex processing and efficient compression schemes may be applied for asynchronous applications, the synchronous applications may include only very simple processing or no processing at all, which imposes huge demands on performance of underlying infrastructure.

Available technologies: The full HD video with effective resolution of 1920x1080 requires as much as 1.485 Gbps with 3 color planes (YUV), 10 bits per color plane, interlaced 60 Hz field rate, and 4:2:2 sampling resulting in 2/3 data reduction. This is commonly known as raw 1080i HD video, usually transmitted over Serial Digital Interface (SDI).

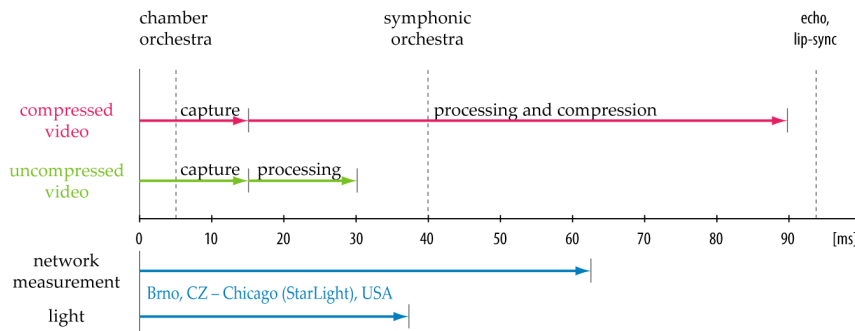


Figure 1: Latency limits and video processing latencies. [1]

For real-time perception, the end-to-end latency of video capturing, processing, network transmission and displaying should take less than 100 ms (Fig. 1). This ideal environment is clearly unreachable for intercontinental network transmissions, because in many cases just the network latency exceeds this limit. For transmissions spanning hundreds of kilometres, the latency over optical network is in order of milliseconds and therefore almost ideal environments may be created provided processing is fast enough. This is usually implemented by sending raw uncompressed video in RTP/UDP/IP packets over the networks. There are several systems available [2,3], and the one developed by CESNET and Masaryk University based on UltraGrid features capture-to-display latency between 41 – 55 ms (not including network transmission). However, the whole system requires not only extreme network bandwidth, but also very fast capture and display computers and very costly low-latency HD-SDI capture cards.

When latency of the transmission is not limiting, advanced compression techniques may be employed to reduce necessary bandwidth. Most commonly HD video is compressed using MPEG-2 standard with 19.2 Mbps bandwidth, known as HDTV. Recently a new MPEG-2-based format by SONY called HDV has emerged, having 30 Mbps requirements, intentionally very close to DV for standard definition (SD) video, with affordable equipment readily available. Developed again at the Masaryk University and CESNET and utilizing open-source software VideoLAN [4] for displaying, there is a prototype of application for transmission of HDV over IPv4 and IPv6 protocols that can run on commodity hardware. The price paid for efficient

network transmission is latency increase – such systems usually have capture-to-display latency ranging between 500 and 2000 ms.

Use Cases: The synchronous transmissions are suitable for remote consulting and virtual councils, where image quality is substantial, e.g. in pathology. Complemented with haptic interaction (force feedback), it can be used even for remote training of medicine students, so that professor can lead the hand of a student during virtual operation to teach him/her the exact movements. The asynchronous transmissions are ideal as a supplement for remote education of students in areas with high demands on image quality. Furthermore utilising either native or virtual network multicast [6] for unidirectional transmissions, it is possible to reach rather broad audience with the technologies already available.

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