Video represents the majority of wireline and wireless data traffic. Infrastructure is deployed worldwide for cable and satellite to deliver broadcast and video on-demand. Costly, rapidly increasing traffic is driving the need to reduce storage and transmission capacity demands. Video compression alone decreases video quality. A solution is needed for video compression without degradation of video quality—the answer is video prefiltering by HP SpeedVideo Optimizer.

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Video traffic explosion impacts costly infrastructures

As more advanced forms of compression are developed, services providers and content producers expend significant investment to upgrade video compression encoders and decoders. This is necessary, as storage and transmission bandwidth is costly, whether it’s satellite transponder or broadband wirelines or wireless. At the same time, there’s an explosive growth in the volume and variety of video content that consumers demand.

HP SpeedVideo Optimizer drives bandwidth savings

You can take a significant bite out of these costs with HP SpeedVideo Optimizer—without requiring changes to the architecture or encoder/decoder infrastructure. Through a combination of several patented processes, it takes video input and performs an advanced form of “prefiltering” before encoding to remove compression artifacts, noise, and other common artifacts. HP SpeedVideo Optimizer’s removal of these enables a standard, already-installed video encoder and decoder infrastructure to realize a substantial gain in bitrate and bandwidth efficiency resulting in a 20% to 30% or more bandwidth savings with no impact to the visual quality. HP SpeedVideo Optimizer:

• Removes excess film grain
• Removes digital camera “shot-noise” artifacts
• Eliminates excess chroma noise added from upstream tape duplication processes
• Removes high-frequency “mosquito noise” and ringing artifacts from upstream compressors
• Reduces noise and compression artifacts from upstream sources before retransmission

This results in:

• Considerable bandwidth reduction required to encode HDTV and SDTV at the same quality
• No required changes to the existing encoder or decoder infrastructure
• No motion-blurring or color-banding artifacts are introduced into the video, unlike other bandwidth reduction processes
• Suitable use in an HD-SDI broadcast chain or CDN or IPTV environment
• Immediate return on investment

Patented process makes it possible

The advantages of prefiltering video content before encoding are well known, but all other current state-of-the-art prefiltering processes actually degrade the source video in significant ways. Examples of these include blurring of detail and texture, reduction of real resolution, motion blurring and motion echoes, and significant color banding and color degradation.

Several patented processes enable HP SpeedVideo Optimizer to remove these with no degradation of the original source. The combination of advanced motion estimation called “optical flow,” wavelet-domain, and image-structure analysis makes this seemingly impossible goal possible. HP SpeedVideo Optimizer is the result of image and video research that goes back more than 20 years, culminating with several patents from 1993 to today. Additionally, well over 1 million minutes of video tests were conducted in order to fine-tune and perfect the process.
Figure 1. The original video snapshot on the left is from a live broadcast aircheck source. The HP SpeedVideo Optimizer preconditioned H.264/AVC TS stream snapshot on the right shows a realized 50% reduction in encoded bandwidth.

Noise corruption in the source video significantly degrades the bitrate performance of all encoders. By leaving actual scene detail and objects in the video alone—and treating only the noise—storage and considerable transmission cost reductions are achievable by using the latest broadcast class—H.264 and VC1 video encoders. This may seem like a case of getting something for nothing. However, HP SpeedVideo Optimizer is, in fact, removing information from the source video, namely noise. To explore more fully how HP SpeedVideo Optimizer achieves such bitrate savings, a primer on today's video compression and prefiltering methods covers some important facts.

A primer on video compression

Video compression techniques work by removing redundant information in the pixel information of a video. There are two main types of video compression—lossless and perceptual. Lossless video compression techniques take advantage of things like repeated pixel patterns in the individual images of a video in order to transmit them more efficiently.

Perceptual codecs, such as H.264 and VC1, compress video by removing information that the human visual system (HVS) will not notice or perceive under ideal circumstances. For example, the HVS is much more sensitive to changes in flesh tones of imagery and video, and less so for dark blue colors. So, it makes more sense to spend more bitrate encoding flesh tones accurately than spending equivalent bitrate for dark blue colors. Contemporary video encoders work by accounting for HVS in this way, along with the fact that most video frames are correlated to each other by motion. If a video frame changes from one to the next, it’s only necessary to encode the changes, and even then, only the changes most important to HVS. The implication is: The more things that are moving in a video, the less efficient motion-driven encoding schemes such as H.264 have become.

A primer on video prefiltering

Prefiltering is a common feature in almost every professional and broadcast encoder. It is well known that any noise or artifact in the source video that includes fast changes will degrade the performance of any motion-driven encoder. A good prefiltering process removes quickly changing noise such as film grain and chroma noise, while leaving subtle textures, fine details, and the fast motion of real objects in the video alone.

Telling these things apart is challenging and primarily relies on being able to perform very accurate motion estimation of the objects in the video. This by itself is challenging, as noise tends to frustrate even state-of-the-art motion estimation systems. This type of preconditioning is also known as “temporal denoising” or “motion-compensated denoising.” The effectiveness of a prefiltering process is measured by how much it “misses” and degrades the motion and fine detail of the video, and how much actually results in reduced bitrates for the final encoded video bitstream. Typical side effects of a prefiltering process are “missing” and degrading video quality, which include blurring of fast motion objects, blurring of texture and details, and color-banding artifacts. Existing prefiltering processes suffer from these artifacts and are ineffective at significantly reducing bitrate. A savings of 2% to 5% is common in the industry today, while others claim more severely degraded video quality.
**Process overview**

HP SpeedVideo Optimizer removes noise and artifacts without degrading motion, detail, color, or resolution of the final video, no matter which encoder is used—H.264, VC1, or MPEG2. To accomplish this, it performs sophisticated motion analysis called optical flow, then processes the video to remove film cadences, interlacing artifacts, and upstream compression artifacts such as blocking and mosquito noise. Existing edge, detail, and statistical information from previous frames are extracted, and the image portions that comprise the high-frequency noise are intelligently removed.

**Figure 3.** The HP SpeedVideo Optimizer process simplified

HP SpeedVideo Optimizer intelligently analyzes the video and makes some contextual decisions for every pixel and every object, in every frame of the video—in real time. On the next page are three examples of this.
Optical flow analysis

Critical information about the objects and background that make up a scene can be calculated if these objects ever move, and if there is an accurate and precise estimation of the true motion. The HP SpeedVideo Optimizer optical flow computation system achieves real-time, per-pixel dense motion estimation with a wide and precise spatial dynamic range of 0.01 to 500.00 pixels. A motion vector is calculated for every pixel, in every image; it tells how much the pixel has moved. One way to view a motion-vector field is to let the hue represent the direction and the brightness represent the magnitude, as shown in Figure 4.

Figure 4. Original frame (left); hue saturation value representation on the optical flow field (right)

HP SpeedVideo Optimizer does not just use the motion between the current frame and the last one, it uses motion from up to the last 16 frames, enabling unprecedented accuracy, with no processing delay.

Figure 5. HP SpeedVideo Optimizer uses up to 16 previous frames and their optical flow to perform highly accurate noise reduction

Accurate calculation of motion is important. How objects hide and reveal pixels from other objects and the background behind them is difficult to figure out, but also extremely important. Called occlusion, it helps distinguish actual motion, from impulse noise—noise that changes rapidly from frame to frame, like film grain. Together, these enable HP SpeedVideo Optimizer to calculate which pixels are likely to be more influenced by noise.
**Fine image details or noise**

To a computer, actual fine-scale scene detail and sensor noise look virtually identical. The ability to distinguish these two is critical. By using multiscale wavelet analysis for several optical-flow-compensated frames, and looking at very finely intertwined statistical properties of detail and noise, HP SpeedVideo Optimizer is able to sort them out and remove the noise while leaving fine scene detail and texture alone.

**Actual object edges or compression artifacts**

Another example is the phenomenon of “blocking,” which is sometimes known as “JPEG artifacts.” These manifest as a distinct “blockiness” look to video frames that have been treated with a compression process. However, it is very difficult to tell whether the edges of such blocks are actual edges in the scene or compression artifacts. Optical-flow-compensated wavelet analysis enables individual characteristics of each artifact in the image to be identified spatially—where in the image, and by scale and frequency—how big they are. With this information, real scene edges are distinguished from compression artifacts in the image.
**Figure 8.** HP SpeedVideo Optimizer easily distinguishes between real object edges by blocking artifacts.

**Figure 9.** This is an example of HP SpeedVideo Optimizer de-banding and de-blocking; the original video is on the left. On the right, HP SpeedVideo Optimizer fixes the blocky edges and color contours while scene detail is left alone in the rest of the picture.

**Algorithms deliver quality**

Why hasn’t this type of work been done before? It has—only manually. Processes similar in results to HP SpeedVideo Optimizer have existed in the motion picture industry’s visual effects production for some time. It entails a visual effects artist tweaking each frame of the video, one-by-one. It’s expensive, costing thousands of dollars per footage minute, and definitely not done in real time—a one-hour program takes weeks or months to deliver. HP SpeedVideo Optimizer accomplishes this in real time for live, linear TV with a latency of less than 250ms.

Other real-time video prefiltering technologies do exist, but their effectiveness has been limited to miniscule gains in efficiency—2% is typical. These same prefiltering processes can be set up to save more bandwidth, but always at significant expense to the visual artifacts such as color banding, loss of detail, and motion blurring.

HP SpeedVideo Optimizer is very different in the application of very computationally complex algorithms via GPU supercomputing to solve the problem without manual intervention, and without visible artifacts to the viewer. This means significant savings for any service provider who stores, transmits, or delivers vast amounts of video with no compromise in video quality or customer satisfaction.
Real return on investment

Besides the obvious advantages of video quality plus viewer and user satisfaction, HP SpeedVideo Optimizer provides significant savings of bit-rate using existing infrastructure and transmission standards and enables the following benefits:

• Instantaneous increase in channel capacity for broadcast video distribution plants, with no forklift upgrade of head-end operations and customer premise equipment
• Incremental increase of VoD and CDN storage capacity over time
• Instantaneous reduction in backhaul transponder sublease costs—or alternatively, an increase of apparent transponder capacity for direct leaseholders for broadcasters and programmers
• Immediate increase in wireless spectrum capacity for video content distribution—already comprising more than 50% of wireless traffic and growing—for 4G and LTE and wireless providers

HP SpeedVideo Optimizer technology has been developed as a batch-mode appliance suitable for CDN and VoD ingest deployment, and IP stream or HD-SDI baseband video signal conditioning appliance. It’s suitable for live video distribution from head-end operations such as SHO, VHO, and satellite distribution operations.

Figure 10. HP SpeedVideo Optimizer deployed in an IPTV or cable delivery chain

Figure 11. HP SpeedVideo Optimizer deployed in a satellite TV delivery chain

Your solution is HP SpeedVideo Optimizer

Explosive growth in the volume and variety of video content and rapidly increasing traffic requires more storage and transmission bandwidth, which is costly. You need to decrease storage and transmission capacity demands to reduce costs. But how? Video compression alone decreases video quality. Prefiltering with HP SpeedVideo Optimizer is the answer. You get bitrate reduction while maintaining video quality, saving storage and transmission bandwidth.

Learn more at hp.com/cms