White Paper

Media and Entertainment
Video Streaming Providers, Broadcasters, and Studios

VisualOn Optimizer Delivers Up to 40% Bitrate Reduction with up to 9x Transcoding Efficiency on Intel® Xeon® 6 SoC[1]

Easily integrating into encoding workflows using CPUs or GPUs, Optimizer improves visual quality while reducing delivery and storage costs for media delivery companies.

Key Takeaways:

- Lowers transmission and storage costs without impacting video quality
- Supports live real-time Content Adaptive Encoding on multiple streams without requiring a GPU
- Integrates with standard video codecs: AVC, HEVC, and AV1

Authors

Matt Garrison
Segment Manager, Intel

Surbhi Madan
Platform Solutions Architect, Intel

Savi Shi
Marketing Director, VisualOn

Hanyue Yang
Sr. Engineer Director, VisualOn

Roly Yu
Principal Engineer, VisualOn

Ivy Zhang
Staff Engineer, VisualOn

Dean Zhu
Staff Engineer, VisualOn

Executive summary

Streaming high-resolution video comes with an inevitable trade-off between available bandwidth and quality of experience for the end user. Delivering uncompromised video quality typically results in high bitrates, which can lead to slow starts, video buffering, and high content delivery network (CDN) and storage costs. Traditional solutions that attempt to minimize bandwidth without compromising quality are centered around the development of more intelligent video encoders.

Content Adaptive Encoding (CAE) is an innovative encoding process that is revolutionizing video streaming by reducing bandwidth usage while enhancing quality. Integrated into streaming media service providers' workflows, it enables more efficient usage of content delivery systems and reduces storage requirements, without sacrificing user experiences.

VisualOn Optimizer is an innovative CAE solution that dramatically reduces average bitrates while enhancing visual quality. It is encoder-agnostic to deliver high-quality content with low bitrates.

This white paper describes VisualOn Optimizer and its impact on video encoding performance, compares it against other CAE solutions, and presents test results showing the benefit of combining the Optimizer with the built-in media acceleration of the Intel® Xeon® 6 SoC.

Content Adaptive Encoding

CAE was pioneered by Netflix from 2015 to 2018, with per-title, per-chunk, and per-shot encoding. Using their CAE technology, Netflix achieved over 30 percent bitrate reduction[2,3,4] without degrading visual quality, as measured by the Video Multimethod Assessment Fusion (VMAF) score.[5] The approach requires running hundreds of different encodings with different combinations of parameters to select the best results. Such an encoding regimen can be prohibitively expensive and difficult to scale for many companies, especially those with limited budgets or technical capabilities.

Building on the strides made by Netflix in encoding strategies, CAE takes video compression a step further by adapting the encoding process to the specific content of each video segment. Unlike traditional encoding methods that apply uniform settings across an entire video, CAE analyzes factors such as motion, texture, and complexity within the video to optimize encoding settings dynamically. This results in more efficient compression that preserves quality

while reducing file size and bandwidth requirements. These are benefits that are otherwise only achievable through the introduction of newer, more complex compression standards that will entail high cost, long time to market, and compatibility issues within the broader ecosystem. Heuristic CAE solutions have since emerged that dramatically reduce compute requirements while achieving close to optimal results. Jan Ozer has compared various options for H.264 encoding.[6]

Additionally, innovative AI methods are now being applied to content transcoding to reduce bitrate and improve the visual experience. AI is used to dynamically analyze frames and scenes to tune encoder modes that impact both bitrate and video quality. Bitrate reduction helps lower cost of transmission and storage for media providers.

In encoding, parameter choices are impacted by several factors, such as the type of delivery, including live, video on demand (VoD), and file-to-file (F2F) transfer. Furthermore, media providers use various infrastructures in their data centers for encoding content. These technologies can include specialized software encoders running on CPUs, as well as GPUs with built-in transcoding accelerators.

Intel works with the ecosystem that supports these media providers to apply the power of Intel® technologies, such as Intel Xeon processors and the Intel® Media Transcode Accelerator. Intel's commitment to the ecosystem aims to help lower costs of operations while improving content delivery and thus the viewing customers' experiences.

VisualOn Optimizer suite

VisualOn is a streaming solutions provider that offers a universal, encoder-agnostic, content-adaptive encoding technology. The VisualOn Optimizer suite enables streaming media companies to deliver compelling multimedia content with incredible user experience. VisualOn introduced the Optimizer suite at IBC 2023,[7] and it won the company the Product of the Year award at NAB 2024.[8]

Optimizer provides a single-pass transcoding solution that dynamically adjusts encoding settings on a per-frame basis. Supporting AVC, HEVC, and AV1, the Optimizer suite integrates with any encoder running on CPU- or GPU-based hardware. It supports a wide variety of use cases with product versions for the following deployment types:

- **Optimizer VoD**. For VoD workflows, using FFmpeg's filter complex to transcode the entire adaptive bitrate (ABR) ladder in a single command.
- **Optimizer Live**. For streaming workflows with real-time transcoding. Its efficient implementation allows it to achieve zero additional latency while reducing both average and peak bitrates without compromising visual quality, making it ideal for large events.
- **Optimizer Fidelity**. For visually lossless file-to-file video transcoding to reduce the storage requirements of massive mezzanine video files.
- **Optimizer**. For general purpose file-to-file transcoding to reduce the size of video files.

Optimizing media streaming with advanced dynamic coding technology

The VisualOn Optimizer uses dynamic encoding technology that combines parameter matching, scene recognition, and image quality enhancement. It leverages a one-pass framework based on machine learning to predict and adjust encoder settings, optimizing each video segment based on its features. Based on VisualOn testing, the technology reduces bitrates up to 40 percent,[1] while maintaining or improving video quality, as measured by VMAF scores.

The technology also provides real-time feedback to dynamically adjust parameters based on scene analysis and quality metrics (PSNR, SSIM, and VMAF). It supports optional preprocessing steps such as sharpening and noise reduction, and it has proven efficient and stable in live streaming tests with FFmpeg integration.

Optimizer readily integrates into any streaming workflow through a simple API call before or in parallel with the encoder (Figure 1).

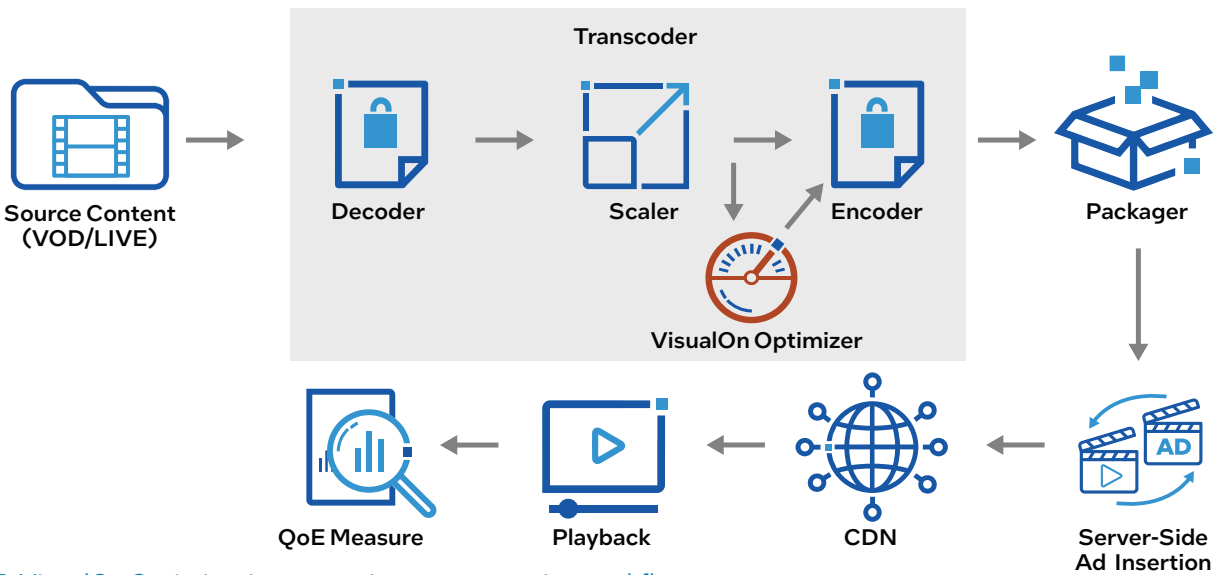

Figure 1. VisualOn Optimizer integrates into any streaming workflow.

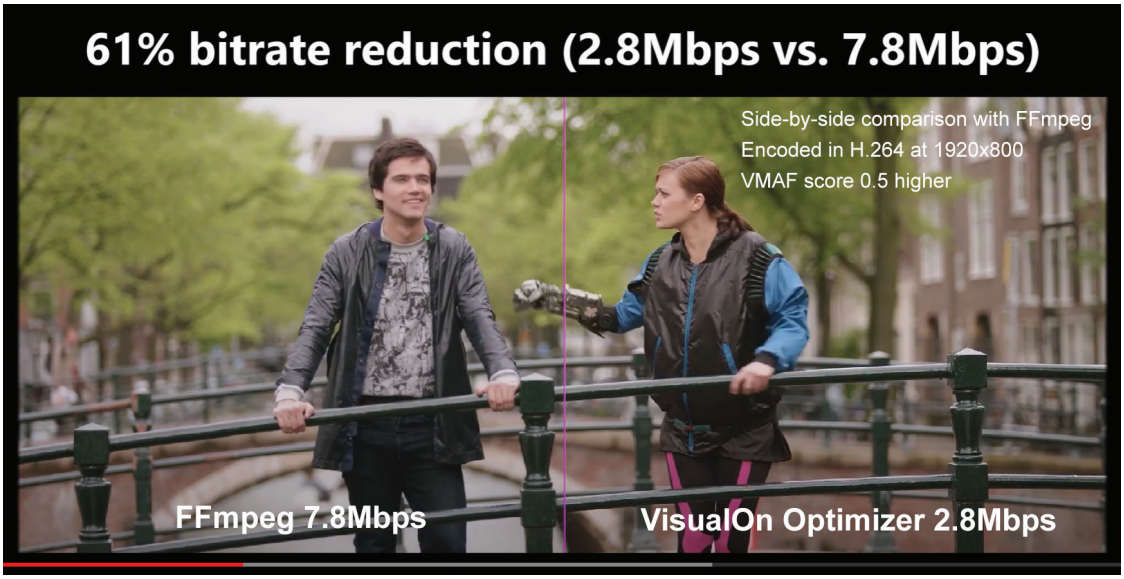

Figure 2. VisualOn Optimizer significantly reduces bitrate for more efficient content delivery and reduced storage requirements.[9]

Figure 3. VisualOn Optimizer (right) improves visual quality, compared to FFmpeg only (left).[10]

Enhancing video efficiency and quality

VisualOn Optimizer is tightly embedded within the FFmpeg ecosystem. It can be readily integrated with a video encoder through FFmpeg's APIs, regardless of the video compression format or whether the encoder is CPU-based or GPU-based. Additionally, it has been integrated with Intel® Quick Sync Video in Intel® Core™ processors for AVC, HEVC, and AV1 transcoding.

Reduced bitrates

Extensive benchmark results, as well as actual production deployments, reveal how Optimizer significantly reduces the average video bitrate. Figure 2 illustrates one such test compared to FFmpeg based on VisualOn's testing.[9]

Bit rate reduction leads to improved operational efficiency by reducing bandwidth requirements and delivery and storage costs, plus it helps lower energy consumption.

Better visual quality

The Optimizer drastically improves visual quality without increasing video bitrate, as illustrated in Figure 3 based on VisualOn's testing.[10] Higher quality enhances user experience and improves key performance indicators (KPIs).

Seamless integration

Other CAE solutions are typically tightly bound to a particular encoder. The Optimizer is encoder-agnostic, seamlessly integrating into existing streaming workflows without disrupting operations. Since VisualOn Optimizer runs on CPUs and GPUs, often no additional hardware is required. This makes it suitable for wide deployment across multiple use cases.

Optimizer on Intel Xeon 6 processors

The Intel Xeon 6 SoC is based on a power-efficient microarchitecture that delivers performance and flexibility for video processing workloads. It incorporates Intel Media Transcode Accelerator, a built-in media accelerator based on a dedicated ASIC module and Intel® AI Accelerator engines, including Intel® Advanced Vector Extensions 512 (Intel® AVX-512). The Intel Media Transcode Accelerator delivers hardware accelerated video encoders that operate alongside the CPU cores, increasing throughput dramatically while consuming less power. Intel AVX-512 extends vector processing capabilities with wider vectors, extensible syntax, and rich functionality. With ultra-wide 512-bit vector operations, Intel AVX-512 can handle extremely demanding computational tasks while reducing the energy needed to complete them. Within its 512-bit vectors, applications can pack up to eight double-precision (64-bit) floats (FP64), or 16 single-precision (32-bit) floats (FP32), or 32 half-precision floats (16-bit, FP16 or BF16), doubling the number of elements processed per vector compared to FP32. AVX-512's wide-vector register width and mixed-precision capability make it ideal for workloads in AI/machine learning, video/media processing, signal processing, and other data-parallel domains, maximizing compute and memory efficiency per clock cycle.

The Intel Xeon 6 SoC supports up to 72 Performance cores built on Intel 3 process technology, up to eight channels of DDR5 memory operating at up to 6400 MT/s, and integrated Intel® Ethernet supporting up to 200 Gbps through up to eight ports for low-latency network connectivity. An optimized software ecosystem and component integration lower server costs, with dramatic performance and energy efficiency improvements compared to predecessor processors. Additional information about the built-in Intel Media Transcode Accelerator can be found in the solution brief, "Revolutionizing Live Streaming: Built-in Media Transcode Accelerator Delivers 14x Performance per Watt Gains and Ultra Low-Latency."[11]

Benchmarks and testing

Extensive testing by VisualOn shows how Optimizer performs compared to other CAE solutions and how it enhances video encoding on Intel CPUs and the built-in Intel Media Transcode Accelerator. All the benchmarking below was conducted by VisualOn.

Comparative results: Other CAE solutions

Compared to results from other CAE per-title encoding solutions from the Netflix Technology Blog,[5] VisualOn Optimizer delivers much lower average bitrate (Figure 4) and higher average VMAF (Figure 5).[12]

Comparative results: Intel Xeon 6 SoC

The following benchmarks show comparative results of CPU-based encoding running without and with VisualOn Optimizer averaged across different content categories over all ABR ladder rungs, and for the top rung of an ABR ladder. The benchmark was completed on a single-socket server based on the Intel Xeon 6 SoC. The input test suite is the same as used in the Netflix Technology Blog,[5] using an average of results across all content types for the top-rung results.

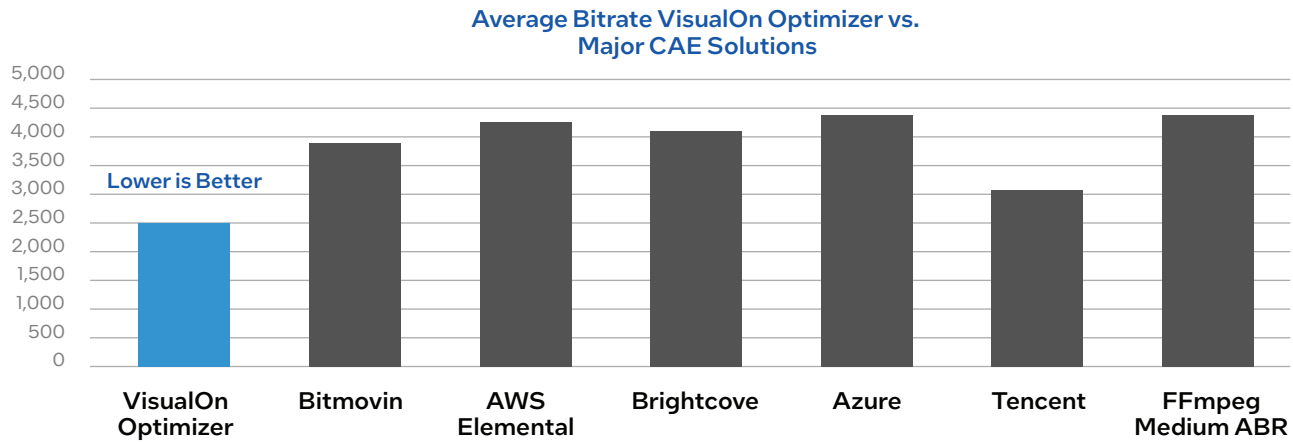

Figure 4. VisualOn Optimizer delivers lower average bitrate compared to other per-title CAE solutions.[12]

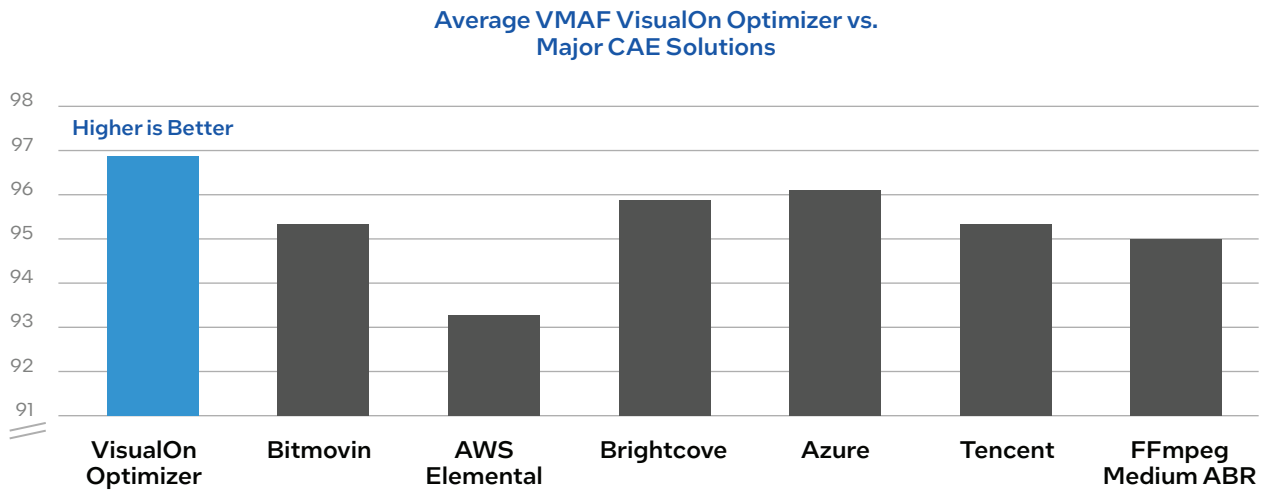

Figure 5. VisualOn Optimizer delivers higher average VMAF compared to other per-title CAE solutions.[12]

Data was collected for the software (CPU) and hardware accelerated video acceleration API (VAAPI) versions of the AVC, HEVC, and AV1 encoders. The results (Table 1) show the bitrate and VMAF score for encoding using FFmpeg only and FFmpeg with Optimizer. The results reveal that bitrate is reduced by at least 12 percent and up to 44 percent, while VMAF scores generally improve.[13] Table 2 shows the results for the number of maximum parallel encoding sessions that can run in real-time on the "Tears of Steel" 1080p video clip on the Intel-based server without and with VisualOn Optimizer. Data is shown for the encoder running on the CPU alone and on the Intel Media Transcode Accelerator alone. Optimizer's efficient implementation running on Intel hardware reduces bitrates, allowing jobs to scale easily without impacting the number of streams that can be processed.

Comparing results in Table 2 from previously measured data on 4th Gen Intel Xeon Scalable Processors,[14] the Intel Xeon 6 SoC provides an efficiency improvement of 29 to 46 percent, depending on the encoder. With the built-in acceleration of media IP, the transcoding density of the system improves dramatically, driving up the efficiency of the system by 3x to 9x, creating a highly efficient transcoding platform that is optimized for TCO.

Table 1. Encoding results without and with VisualOn Optimizer on Intel Xeon 6 SoC and on the built-in Intel® Media Transcode Accelerator.[13]

	Hardware	Codec	FFmpeg		VisualOn Optimizer			
			Bitrate	VMAF	Bitrate	Delta	VMAF	Delta
Overall ABR Rungs	CPU	x264	1712	68.19	966	-44%	73.62	7.96%
		x265	1214	66.42	736	-39%	72.60	9.30%
		SVT AV1	775	66.08	621	-20%	72.41	9.58%
	Intel® Media Transcode Accelerator	H.264 VAAPI	1685	68.56	1381	-18%	74.27	8.33%
		H.265 VAAPI	1173	67.70	960	-18%	73.36	8.36%
		AV1 VAAPI	816	62.87	726	-11%	69.61	10.72%
ABR Top Rung (1080p)	CPU	x264	4429	94.95	2588	-42%	96.89	2.04%
		x265	3150	95.10	1872	-41%	96.78	1.77%
		SVT AV1	2006	94.56	1581	-21%	95.62	1.12%
	Intel Media Transcode Accelerator	H.264 VAAPI	4374	94.37	3539	-19%	95.82	1.54%
		H.265 VAAPI	3043	94.60	2430	-20%	96.11	1.60%
		AV1 VAAPI	2167	90.73	1904	-12%	93.51	3.06%

Table 2. Maximum number of real-time parallel encoding sessions on 1080p content without and with VisualOn Optimizer.[13]

Hardware	Codec[15]	FFmpeg		VisualOn Optimizer	
		Max Instances	Bitrate (kbps)	Max Instances	Bitrate (kbps)
CPU	x264	24	4162	26	1873
	x265	12	3059	13	1576
	SVT AV1	5	2203	7	1266
Intel® Media Transcode Accelerator	H.264 VAAPI	27*2	4365	27*2	2450
	H.265 VAAPI	27*2	3022	26*2	1672
	AV1 VAAPI	24*2	2146	24*2	1492

Summary

Video encoding technologies and solutions have evolved rapidly over the last few years, with CAE paving the way for more efficient content delivery. CAE uses AI to analyze content on a frame-by-frame and scene-by-scene basis to adapt encoder parameters, resulting in dramatically reduced bitrates while enhancing visual quality.

Intel is working with the ecosystem that supports media delivery companies to address their challenges, using advanced Intel technologies, processors, and GPUs. VisualOn provides an innovative, AI-powered solution that reduces bitrates up to 40 percent on CPU and up to 20 percent on the built-in Intel Media Transcode Accelerator, while improving overall viewer experience. VisualOn Optimizer suite is encoder-agnostic and seamlessly integrates into encoding workflows, irrespective of the encoder being used or the infrastructure it runs on — CPUs or GPUs. The Optimizer easily integrates with Intel Quick Sync Video, dramatically reducing bitrate and allowing more encoding sessions on the same platform.

With the variety of infrastructures used across media provider data centers, at the edge, and in the cloud, VisualOn Optimizer combined with the Intel Xeon 6 SoC can help reduce the cost of operations and storage of encoded content through lower bitrates, while enhancing visual quality.

More information

- www.visualon.com/index.php/visualon-optimizer/
- www.intel.com/xeon

[1] As shown in Table 1.

[2] https://netflixtechblog.com/per-title-encode-optimization-7e99442b62a2, 12/14/2015 (per title).

[3] https://netflixtechblog.com/more-efficient-mobile-encodes-for-netflix-downloads-625d7b082909, 12/1/2016 (per chunk).

[4] https://netflixtechblog.com/dynamic-optimizer-a-perceptual-video-encoding-optimization-framework-e19f1e3a277f, 3/5/2018 (per shot).

[5] https://netflixtechblog.com/toward-a-practical-perceptual-video-quality-metric-653f208b9652, 6/1/2016 (VMAF).

[6] Ozer, Jan. "Report: Cloud-based Per-Title H.264 Encoding Benchmark Report" https://streaminglearningcenter.com/encoding/slc-releases-cloud-based-hevc-and-h-264-pertitle-quality-and-opex-reports.html 6/6/2022.

[7] https://www.visualon.com/index.php/press/visualon-introduces-first-universal-content-adaptive-encoding-solution-for-video-streaming/.

[8] https://www.visualon.com/index.php/press/visualon-wins-2024-nab-show-product-of-the-year-award/.

[9] Testing performed by VisualOn on 7/25/2023. Source video: http://ftp.nluug.nl/pub/graphics/blender/demo/movies/ToS/ToS-4k-1920.mov. FFmpeg command line for x264: ffmpeg -i input -b:v 7.8M -maxrate 7.8M -bufsize 15.6M output.mp4, and for x264 with Optimizer: ffmpeg -vo_optimizer -i input -vo_vmaf 98 output.mp4. Full data available at https://www.visualon.com/wp-content/uploads/2024/09/side-by-side-comparison.pdf.

[10] Testing performed by VisualOn on 9/05/2023. Source video: http://ftp.nluug.nl/pub/graphics/blender/demo/movies/ToS/ToS-4k-1920.mov. FFmpeg command line for x264: ffmpeg -i input -b:v 2.3M -maxrate 2.3M -bufsize 4.6M output.mp4, and for x264 with Optimizer: ffmpeg -vo_optimizer -i input output.mp4. Full data available at https://www.visualon.com/wp-content/uploads/2024/09/side-by-side-comparison.pdf.

[11] Intel Corporation, February 22, 2025. "Revolutionizing Live Streaming: Built-in Media Transcode Accelerator Delivers 14x Performance per Watt Gains and Ultra Low-Latency." https://www.intel.com/content/www/us/en/content-details/846191/revolutionizing-live-streaming-built-in-media-transcode-accelerator-delivers-14x-performance-per-watt-gains-and-ultra-low-latency.html.

[12] Based on testing performance by VisualOn on 8/19/2025. System configuration details: Intel® Xeon® 6553P-B (36 cores per socket), 128GB (4x32GB DDR5 6400 MT/s), 512GB SAMSUNG MZVL2512HCJQ-00A00 SSD. OS: Ubuntu 24.04.2 LTS with 6.8.0-63-generic kernel. Configuration details and full data available at https://www.visualon.com/wp-content/uploads/2026/01/benchmarks-H.264.pdf, configuration in the "H.264 Test Setup", results in the "H.264 top rung comparison" tab, with Optimizer's results extracted from the "x264 results" tab. Results from other encoders are from the report referenced in footnote 6.

[13] Tested by VisualOn on 10/21/2025. System configuration details: Intel® Xeon® 6553P-B (36 cores per socket), 128GB (4x32GB DDR5 6400 MT/s), 512GB SAMSUNG MZVL2512HCJQ-00A00 SSD . OS: Ubuntu 24.04.2 LTS with 6.8.0-63-generic kernel. For full data details, see https://www.visualon.com/wp-content/uploads/2026/01/Performance.pdf.

[14] Intel Corporation, September 13, 2024. "VisualOn Optimizer Reduces Encoding Bitrate Up to 40 Percent While Enhancing Visual Quality." https://www.intel.com/content/www/us/en/content-details/833276/visualon-optimizer-reduces-encoding-bitrate-up-to-40-percent-while-enhancing-visual-quality.html.

[15] Encoder presets and compression settings used in the benchmarks are as follows: for CPU-based encoding, x264 and x265 use the medium preset, and SVT-AV1 v1.4.1 uses preset 6. For hardware-accelerated encoding via VAAPI, H.264 uses compression_level 2, H.265 uses compression_level 4, and AV1 uses compression_level 3.

Intel technologies may require enabled hardware, software, or service activation. No product or component can be absolutely secure. Your costs and results may vary. Performance varies by use, configuration, and other factors. Intel does not control or audit third-party data. You should consult other sources to evaluate accuracy.

0226/MAG/MESH/PDF 361930-002US