Synamedia

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Achieving Consistency and Efficiency
Synamedia Public

Video Quality for Live Adaptive Bit-Rate Streaming: Achieving Consistency and Efficiency

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The video industry is undergoing an unprecedented amount of change. More premium live video content is being distributed and watched across more and more IP-connected devices that are increasingly capable of supporting high-quality video. Today's consumer video experiences are defined by the high video quality standards of traditional linear TV delivery over existing cable, satellite, or telco networks. The rise of online video streaming using adaptive bit-rate (ABR) technology over HTTP presents a challenge to assure equivalent high-quality video experiences without continuous expansion of bandwidth to meet those expectations. Specifically, the implementation of ABR technology today results in constant bit-rate (CBR) streams such that bandwidth is often overprovisioned to deliver video quality. At the same time, traditional ABR implementations deliver inconsistent video quality because the bit rate varies based on fluctuating network conditions.

There is growing interest in the industry to look at new methods to encode ABR streams that can deliver constant video quality as opposed to constant bit-rate streams. These approaches promise to optimize bandwidth utilization, thereby reducing video streaming and storage costs and improving picture quality. At the heart of all these approaches is a level of content awareness that better directs ABR encoding.

Synamedia smart rate control functionality enables Synamedia Virtual DCM encoders to deliver constant quality streams for live video. Smart rate control makes use of content awareness based on patented Synamedia technology to generate an objective measure of video quality, referred to as Stream Video Quality (SVQ). As a lightweight, no-reference metric that performs very well compared to industry video quality benchmarks, the implementation of SVQ makes Synamedia smart rate control ideally suited to deliver constant quality for live video ABR streaming.

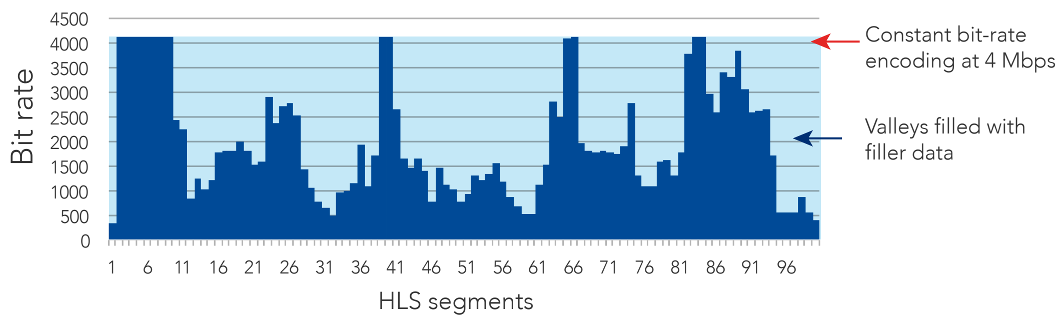
Synamedia smart rate control optimizes bandwidth and reduces operating costs for both wireline and mobile network delivery, though it can be especially significant for mobile delivery because of the higher bandwidth cost in that case.

Contents

The problem with constant bit-rate ABR

Today's ABR deployments are based on the premise that the encoder output profiles are set to constant bit rates with varying picture quality. Such an approach will, in cases where the content is not complex, lead to an overconsumption of bandwidth because it is possible to achieve a similar video quality level at a lower bit-rate setting. Consider the case in Figure 1, where an example of an easy sequence is encoded using a conventional ABR profile with CBR at 4 Mbps. The encoder might not be able to fully utilize the available bandwidth and therefore needs to fill the valleys with filler data to produce a constant bit-rate stream.

Figure 1. Example of conventional ABR encoding



Synamedia smart rate control

Synamedia smart rate control functionality in the Synamedia Virtual DCM encoder platform provides a compelling solution that offers bandwidth savings while maintaining consistent video quality. Smart rate control uses Synamedia's patented SVQ1 metric to continuously steer toward a constant quality for the encoded profile.

The SVQ metric offers significant benefits to achieving constant quality inputs that are ideal for live ABR streaming and differentiated from other objective measures of video quality. From a practical point of view, having SVQ as an integral part of the smart rate control algorithm makes it simple to implement at any point in the video-processing chain. SVQ possesses the following characteristics:

- Non-reference measure. This means that only the processed output signal is required to calculate a quality metric for the processed video, simplifying video quality measurement.
- Lightweight and very computationally efficient. This means that it uses a limited amount of processing resources, making it ideal for limiting overhead in real-time/live streams.
- High correlation with subjective quality measurements during very extensive testing across public databases.

The performance of the SVQ metric has been evaluated against multiple commonly used objective measures in the media industry using multiple databases that are known in the research community.

Table 1 shows the Spearman Rank Order Correlation Coefficient (SROCC) of the various metrics for the AVC and MPEG-2 video portions of the University of Texas LIVE database. The SROCC is known to correlate quite well to subjective evaluation, and a measure of unity would indicate perfect correlation. SVQ has shown near state-of-the-art performance on public databases in terms of correlation with human assessment of video quality for all formats (MPEG-2, AVC, HEVC).

1 Quality Metric for Compressed Video, Schoenblum et al., U.S. Patent 9,781,420, Oct. 3, 2017.

Table 1. SROCC for video quality metric on University of Texas LIVE database

Model	AVC	MPEG-2	Source	Full Ref?	Complexity
PSNR	0.43	0.36	–	Yes	Lowest
SSIM	0.65	0.55	University of Texas	Yes	Low to medium
VSNR	0.65	0.59	Oklahoma State University	Yes	Low
SR-SIM	0.64	0.68	Tongji University China	Yes	Low
MS-SIM (DMOS)	0.71	0.66	University of Texas (Video Clarity)	Yes	Medium to high
VQM	0.65	0.78	NTIA	Yes	High
SAM	0.72	0.74	Scientific-Atlanta	Yes	Medium to high
SVQ	0.74	0.76	Synamedia	No	Very low
MOVIE	0.77	0.77	University of Texas	Yes	Too high
ST-MAD	0.91	0.84	Oklahoma State University	Yes	Too high

SVQ is based on a scale from 1 to 10 in which lower values indicate poor video quality and higher numbers indicate higher fidelity of the video quality. Figure 2 shows a frame encoded at different quality settings and the SVQ value associated with each quality level. As shown, the SVQ value tracks well with the subjective quality for each frame.

Figure 2. Example of various SVQ score settings

The Synamedia SVQ metric has been integrated into the Virtual DCM, where an SVQ score is provided for each encoded frame or segment for the purpose of video quality monitoring. The SVQ scores can be displayed on a dashboard using the open-source monitoring tool Grafana, as illustrated in Figure 3.

Figure 3. Virtual DCM output monitoring SVQ

Application of smart rate control in ABR workflows

In a typical ABR workflow, the ABR client is offered multiple CBR encoded profiles from a single video source. The integration of smart rate control within the Virtual DCM ABR encoder outputs constant quality profiles with the SVQ score associated to each segment. The encoder with smart rate control is configured with a maximum bit rate for each profile (cap bit rate), which the encoder will not exceed, and, in addition, a quality level target for each profile is assigned.

The prevailing question for content and service providers is what effects smart rate control has on the entire ABR delivery workflow. Today ABR client players receive a manifest file that describes the profiles available for consumption and then download segments from the relevant profile depending on both network conditions and the client's buffer fullness. How would client players react to variable segment sizes within the same bit-rate profile that would be produced when smart rate control is enabled? Synamedia has tested most commonly known iOS and Android players and validated their performance when smart rate control is enabled. Additional testing with more players is underway.

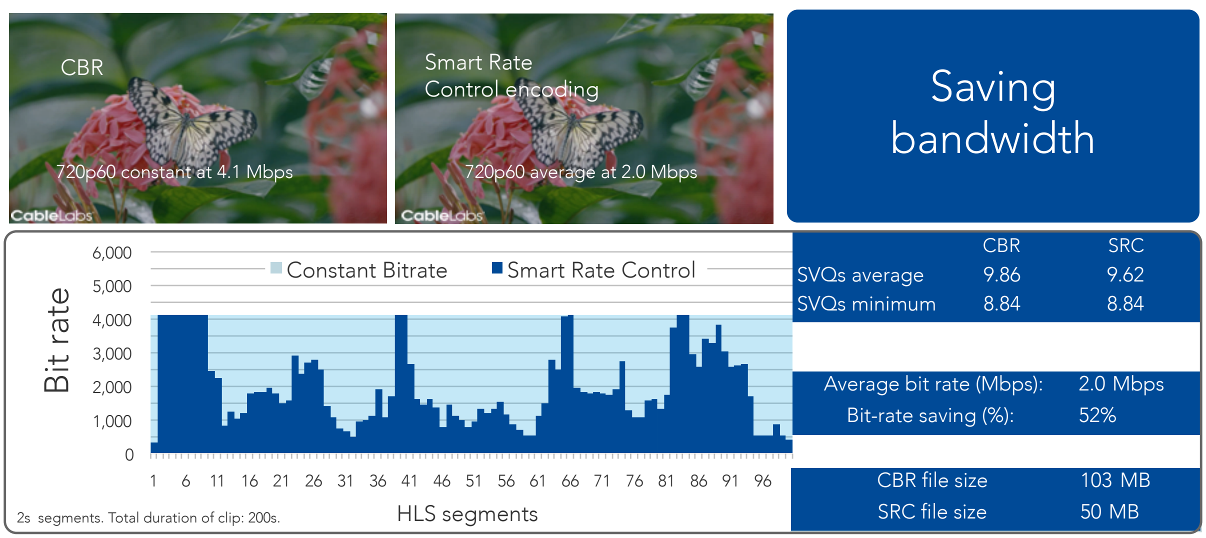
Smart rate control use cases

How can content providers and service providers benefit from enabling smart rate control technology in their ABR workflows?

There are two main use cases for applying smart rate control functionality in ABR streaming environments. First, smart rate control can be implemented to provide bandwidth savings for transport and storage. Second, smart rate control can be implemented to enable better quality of experience for consumers while maintaining the current bit-rate budget used in conventional ABR. In both cases, video quality of experience is more consistent compared to conventional ABR.

In the case of bandwidth savings, the aim is to keep the peak bit rate for each profile the same and use it as a cap bit rate while relying on saving bits over less complex content. Based on the configured SVQ measure, the perceived video quality remains the same as for conventional ABR. Service and content providers benefit from cost savings resulting from optimized bandwidth utilization. Figure 4 shows an example of the benefit of smart rate control as compared to a CBR profile encoded at 4 Mbps. While achieving very similar SVQ scores across both approaches, using smart rate control leads to an average bit rate of 2.0 Mbps and bandwidth savings of around 52 percent.

Figure 4. Example of bandwidth optimization use case



Smart rate control can also be utilized to provide better video quality experiences without spending more bandwidth. This is achieved by relaxing the cap bit rate for each profile to deal with temporary complex scenes. Figure 5 highlights the case where the cap bit rate could go as high as 6 Mbps to maintain the SVQ scores even at complex scenes. As a result, the minimum SVQ for smart rate control is higher than that for the CBR case. This is achieved with a bandwidth saving of 14 percent.

Figure 5. Example of video quality optimization use case

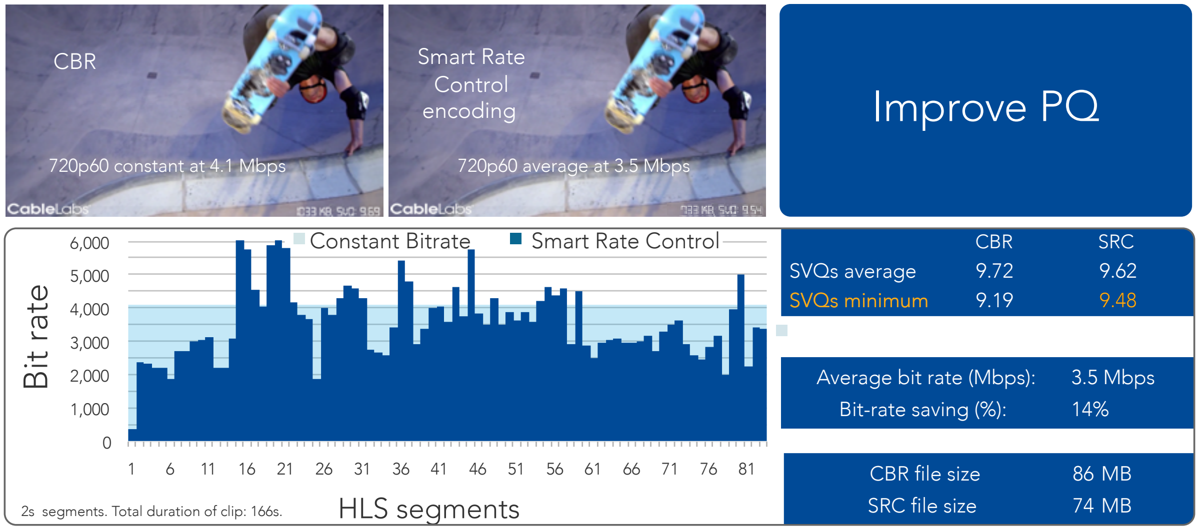


Figure 6 shows a snapshot of a frame that is encoded using CBR and the smart rate control. Note the increased details and improved overall picture quality in the smart rate control case.

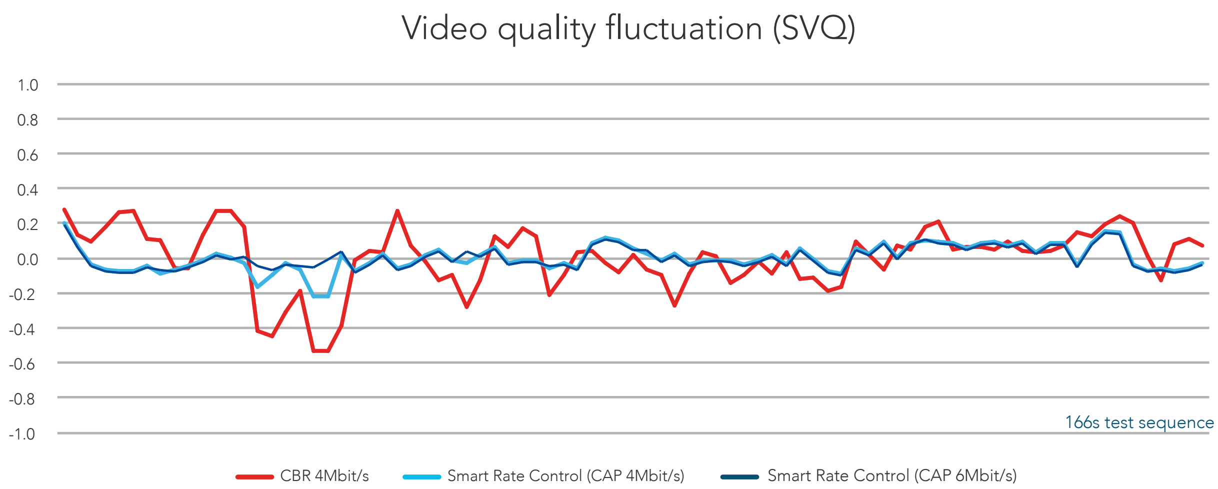
Figure 6. Snapshot of frames for video quality optimization use case: (a) CBR; (b) Smart Rate Control

a b

Consistent video quality with smart rate control

To validate that the encoded output using smart rate control provides consistent video quality in terms of SVQ scores, we computed the SVQ fluctuation between consecutive segments. Figure 7 illustrates SVQ score fluctuations for three use cases: smart rate control with the cap of 6 Mbps, smart rate control with the cap of 4 Mbps, and CBR at 4 Mbps. As expected, the SVQ scores for CBR display wild fluctuations that indicate wide variations in video quality between segments. Smart rate control with a cap of 4 Mbps achieves better performance because the SVQ score fluctuations are close to zero except for a section where the SVQ score has undergone variations caused by complex scenes in a 4 Mbps bit rate cap. This issue was addressed in the case where smart rate control with a cap of 6 Mbps is used, allowing the SVQ scores to be maintained given that higher bandwidth was allocated during the complex section.

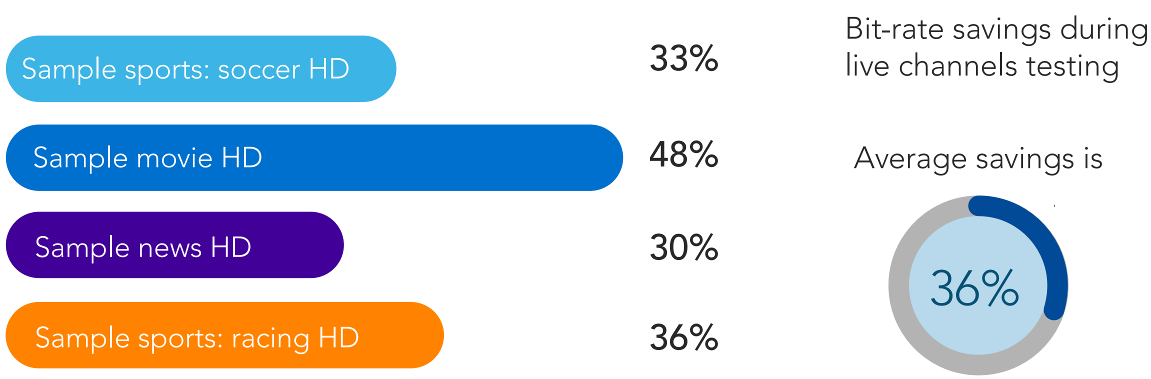
Figure 7. Video fluctuation for CBR, smart rate control for bandwidth optimization and smart rate control for improved video quality



Real-world performance

Synamedia smart rate control methodology has been tested on live channels with different types of content to assess bandwidth savings that can be achieved. The channels were encoded with a single ABR profile at 720p50 with a cap bit rate of 5 Mbps, and the target SVQ score was set at 9.3. As shown in Figure 8, bit-rate savings vary depending on the content, with a 48 percent bit-rate reduction achieved for the movie channel. The average bit-rate savings across the four channels reached 36 percent.

Figure 8. Synamedia smart rate control on sample live channels



Smart rate control cost savings

Transport use case

The bit-rate optimizations that result from smart rate control would typically lead to a significant cost reduction. Consider the use case shown in Figure 9. A service provider that serves 1 million subscribers with an offering of 20 channels and with typical 6 percent peak live concurrency at an ABR of 4 Mbps for wireline delivery would consume up to around 300 million gigabytes per month. This volume level, using an estimate of $0.008 per gigabyte that accounts for the content delivery network cost as well as the wire-line access network, would lead to an expenditure of $2.4 million per month. Using smart rate control that results in an average savings of 30 percent, the service provider can achieve a cost reduction of more than $8.7 million over one year.

Figure 9. Smart rate control: wireline delivery ROI use case

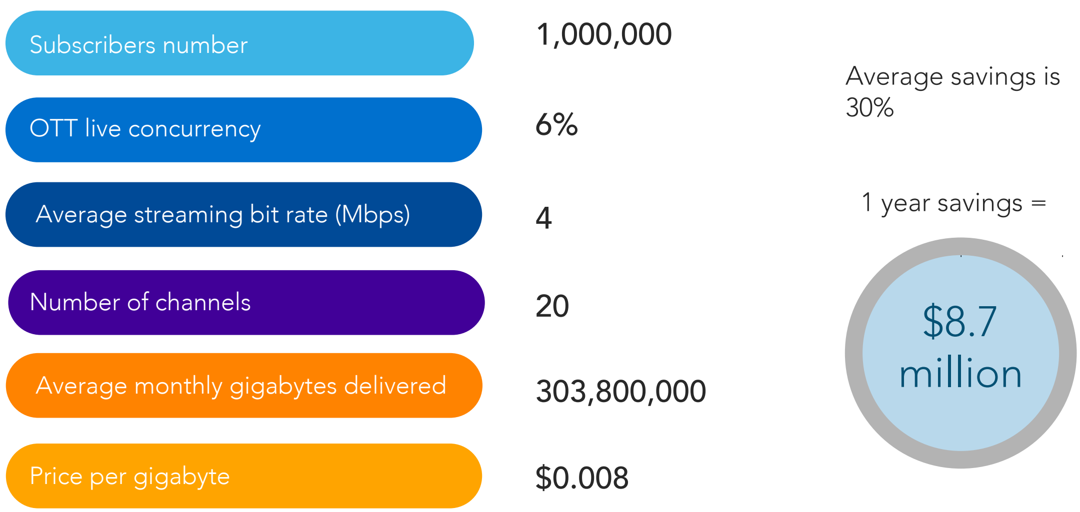
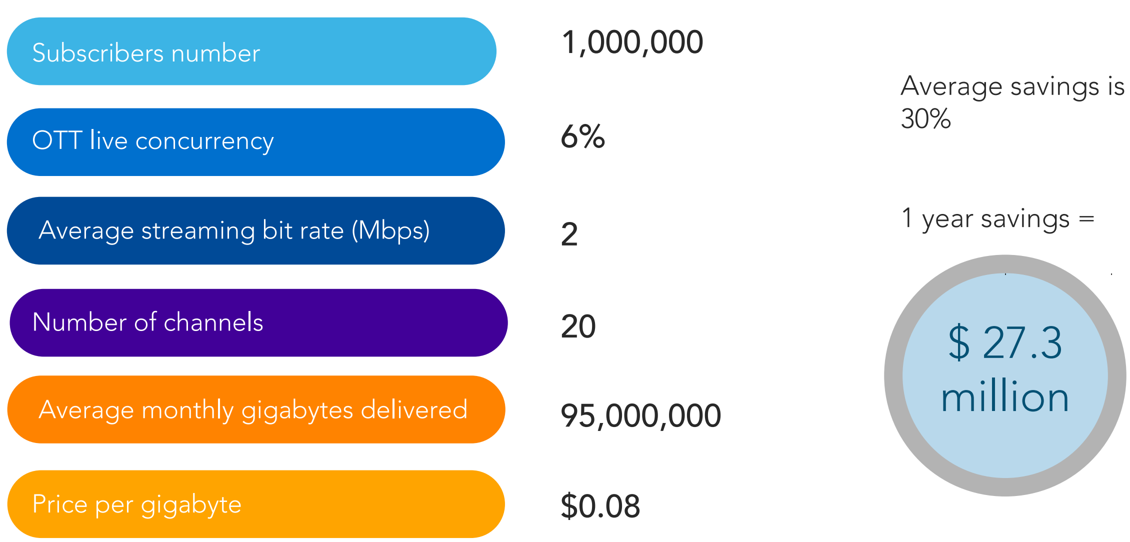


Figure 10 shows a similar use case, but for delivery over mobile networks. Using smart rate control, the service provider can significantly benefit from bandwidth reduction given that the cost for delivery to mobile devices per gigabyte is typically a lot higher (an estimate of $0.08) than that for wireline access networks. In this use case, a cost reduction of more than $27 million over one year can be achieved.

Figure 10. Smart rate control: wireless delivery ROI use case



Storage use case

Take another application such as cloud DVR, where a unique copy of a recorded program for every subscriber is mandatory. In the case of a high number of subscribers, the unique copy requirement results in a high infrastructure cost for disk storage and playout. In a typical cloud DVR deployment, 75 percent of the infrastructure cost, related to storage and just-in-time packaging, could be directly affected by bandwidth. Hence, with smart rate control, which generally leads to ~30 percent bandwidth optimization, a cloud DVR provider will be able to achieve 22.5 percent cost reduction of the current cloud DVR infrastructure cost.

Conclusion

In the face of an increased focus to optimize bandwidth utilization for ABR delivery and to improve subscriber quality of experience, Synamedia smart rate control, based on the patented SVQ technology, provides a compelling solution to optimize bandwidth savings while improving picture quality. This approach can result in a significant reduction in bandwidth translating into costs savings for operator OpEx and CapEx and in an improvement in video quality and the subscriber's quality of experience.

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