

Per-Title Encoding Comparison:

Crunch Video Optimization Technology
compared to:

Brightcove CAE,
Capped CRF,
Capella Systems SABL,
JWPlayer,
and Mux Video

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Executive Summary

This report details my comparisons of the Crunch Video Optimization technology against five other technologies. As shown in the table, as applied in these tests, Crunch's technology produced substantially lower bitrates than all other tested technologies while producing similar quality as measured by the Structured Similarity Index metric (SSIM).

	Data Rate	Crunch SSIM	Other SSIM	SSIM Delta
Brightcove	-24%	0.9648	0.9734	-0.0086
Capped CRF	-37%	0.9648	0.9687	-0.0039
Capella	-27%	0.9648	0.9624	0.0024
JW Player	-26%	0.9648	0.9695	-0.0046
Mux	-49%	0.9648	0.9751	-0.0102

Table 1 - Overall data rate and SSIM comparisons

Background

Video is a bulky medium even after compression using modern codecs like H.264, HEVC, and VP9. Traditionally, video has been encoded using a single encoding ladder, producing a relatively similar data rate for all encoded videos irrespective of encoding complexity. This necessarily encodes some videos at a higher data rate than is necessary, which wastes bandwidth and limits the viewing quality of experience (QoE) of remote viewers. Fixed ladders also encode some videos at too low a data rate, limiting video quality and reducing QoE.

Optimization technologies (also called per-title encoders) analyze each video file and encode at a data rate and configuration that optimizes quality for that video. These technologies encode easy to compress videos at lower data rates, saving bandwidth and allowing high resolution videos to be distributed to those on slower connections. Conversely, hard to encode videos are encoded at a higher data rate, improving quality and QoE.

How We Tested

For these tests, we encoded fifteen videos ranging in duration from one minute to eight minutes and compared the top quality clip in the encoding ladder produced by each technology. Specifically, we measured the video data rate and quality using the SSIM metric.

SSIM	MOS	Quality	Impairment
≥ 0.99	5	Excellent	Imperceptible
$[0.95, 0.99)$	4	Good	Perceptible but not annoying
$[0.88, 0.95)$	3	Fair	Slightly annoying
$[0.5, 0.88)$	2	Poor	Annoying
< 0.5	1	Bad	Very annoying

Table 2 - Mapping SSIM scores to subjective ratings

By way of background, SSIM is a video quality metric that produces a score that can be used to approximate subjective quality ratings. The table above is from a research paper entitled, SSIM-based Video Admission Control and Resource Allocation Algorithms

(http://bit.ly/ssim_map). As you can see in Table 2, scores between 0.95 - 0.99 may contain perceptible, but not annoying impairments.

As a practical matter, and as you'll see in more detail below, it's almost impossible to achieve a score of 0.99 when encoding at data rates necessary for streaming delivery. For this reason, most producers target encoding configurations that can achieve an average SSIM score of 0.95 or above to avoid annoying impairments.

Here were the encoding procedures deployed for the various technologies.

Crunch encoding - The Crunch encoder algorithm analyzes video to determine the best tradeoff between quality and bit rate size for a specific use case. In this case, we supplied the test files and Crunch produced optimized results while tuning the system to produce quality that equaled or exceeded an SSIM rating of 0.96. One strength in the Crunch system is to target a specific SSIM level which the system will undertake to achieve. As you can see in Table 1, in the fifteen test files, Crunch averaged an SSIM rating of 0.9648.

Brightcove - Brightcove's Context Aware Encoding (CAE) is a feature of the Brightcove online video platform and Zencoder cloud encoding platform (bit.ly/BC_CAE). CAE offers multiple configuration options and we used settings that had delivered competitive performance in previous per-title encoding comparisons that did not involve Crunch.

Capped CRF - Capped CRF (for Constant Rate Factor) is an encoding technique available using the x264 codec and FFmpeg. For these tests, we encoded the files using a CRF value of 23, which is the FFmpeg default. There are multiple configuration options that could be modified with Capped CRF and we used settings that had delivered competitive performance in previous per-title encoding comparisons that did not involve Crunch.

Capella - Capella Systems is the developer of the Cambria FTC encoder which offers a feature called Source Adaptive Bitrate Ladder (SABL) that we used to produce the comparative clips (bit.ly/CS_SABL). Like Capped CRF, SABL offers several configuration options and we deployed commercially reasonable settings that had delivered competitive results in previous comparisons that did not involve Crunch.

JWPlayer - JWPlayer is an online video platform that offers per-title encoding. We uploaded the clips to the JWPlayer platform and downloaded the highest quality file in the encoding ladder for comparison. The JWPlayer encoder is a black box with no customer facing configuration options at our level of service, though these may be available for larger customers.

Mux Labs - Mux Labs has encoding service that uses a machine-learning based per-title encoding algorithm (bit.ly/mux_pt). We uploaded the clips to Mux and downloaded the highest quality video file in the encoding ladder for comparison. The Mux Labs encoder is a black box with no customer facing configuration options at our level of service, though these may be available for larger customers.

This report was sponsored by Crunch Media Works who had input into the selection of test clips and test procedures, though positive results were in no way guaranteed.

Comparison with Brightcove

Table 3 shows the test clips in four categories, Animation, Movie-ish, Other Business and Sports. On the right, SSIM scores with a green background exceed the 0.95 threshold discussed above; those with a red background fall below that threshold (see next page). As you can see, neither Crunch nor Brightcove fell beneath this threshold.

	Crunch vs. Brightcove					
	Data Rate			SSIM		
	B-Cove	Crunch	Delta %	B-Cove	Crunch	Delta
Animation						
El_Ultimo	1,683	1,128	-33%	0.9815	0.9605	-0.0210
Sintel	4,185	3,396	-19%	0.9763	0.9633	-0.0130
Sponge Bob	4,506	3,307	-27%	0.9626	0.9573	-0.0053
Tears of Steel	4,355	3,110	-29%	0.9727	0.9630	-0.0097
Average	3,682	2,735	-27%	0.9733	0.9610	-0.0122
Movie-ish						
Elektra	3,641	2,554	-30%	0.9658	0.9610	-0.0048
Freedom	3,306	1,677	-49%	0.9770	0.9645	-0.0126
Haunted	4,476	2,311	-48%	0.9672	0.9584	-0.0088
Zoolander	4,521	5,063	12%	0.9599	0.9600	0.0001
Average	3,986	2,901	-29%	0.9675	0.9610	-0.0065
Other Business						
Epiphan	2,035	2,133	5%	0.9889	0.9834	-0.0055
New	4,417	2,869	-35%	0.9807	0.9712	-0.0095
Talking head	2,330	1,480	-36%	0.9766	0.9728	-0.0039
Test	2,870	3,059	7%	0.9704	0.9696	-0.0008
Average	2,913	2,385	-15%	0.9792	0.9742	-0.0049
Sports						
Basketball	4,522	3,062	-32%	0.9748	0.9605	-0.0143
Soccer	4,510	3,787	-16%	0.9743	0.9622	-0.0121
Hockey	4,555	3,446	-24%	0.9727	0.9649	-0.0079
Average	4,529	3,432	-24%	0.9740	0.9625	-0.0114
Total average	3,727	2,825	-24%	0.9734	0.9648	-0.0086

Table 3 - Crunch compared to Brightcove

Overall, the Crunch encoded clips had a data rate 24% lower than Brightcove while the SSIM score was only .0086 lower.

Comparison with Capped CRF

Table 4 shows how Crunch compared with Capped CRF. As you can see, the Capped CRF encoding of the Sponge Bob trailer shows a red background, indicating a score lower than the 0.95 threshold set for perceptible but not annoying impairments in Table 2.

	Crunch vs. Capped CRF					
	Data Rate			SSIM		
	CCRF	Crunch	Delta %	CCRF	Crunch	Delta
Animation						
El_Ultimo	2,486	1,128	-55%	0.9776	0.9605	-0.0171
Sintel	4,608	3,396	-26%	0.9677	0.9633	-0.0044
Sponge Bob	4,524	3,307	-27%	0.9471	0.9573	0.0102
Tears of Steel	4,713	3,110	-34%	0.9636	0.9630	-0.0006
Average	4,083	2,735	-35%	0.9640	0.9610	-0.0030
Movie-ish						
Elektra	4,603	2,554	-45%	0.9576	0.9610	0.0034
Freedom	5,403	1,677	-69%	0.9736	0.9645	-0.0091
Haunted	5,721	2,311	-60%	0.9693	0.9584	-0.0109
Zoolander	5,692	5,063	-11%	0.9526	0.9600	0.0074
Average	5,355	2,901	-46%	0.9633	0.9610	-0.0023
Other Business						
Epiphan	2,207	2,133	-3%	0.9855	0.9834	-0.0021
New	3,367	2,869	-15%	0.9685	0.9712	0.0027
Talking head	3,656	1,480	-60%	0.9721	0.9728	0.0007
Test	4,603	3,059	-34%	0.9636	0.9696	0.0060
Average	3,458	2,385	-28%	0.9724	0.9742	0.0018
Sports						
Basketball	5,868	3,062	-48%	0.9790	0.9605	-0.0185
Soccer	5,379	3,787	-30%	0.9767	0.9622	-0.0145
Hockey	5,606	3,446	-39%	0.9758	0.9649	-0.0110
Average	5,618	3,432	-39%	0.9772	0.9625	-0.0146
Total average	4,562	2,825	-37%	0.9687	0.9648	-0.0039

Table 4 - Crunch compared to Capped CRF

Overall, Crunch produced an average data rate 37% lower than Capped CRF with an SSIM rating that was just 0.0039 points lower, making the clips visually indistinguishable.

Comparison with Capella Systems

Table 5 shows how Crunch compares with Capella's Source Adaptive Bitrate Ladder, which fell below the 0.95 threshold twice. While it's possible that a different configuration would eliminate these red marks, they would also likely increase the overall data rate, which is already 27% higher than Crunch.

	Crunch vs. Capella					
	Data Rate			SSIM		
	Capella	Crunch	Delta %	Capella	Crunch	Delta
Animation						
El_Ultimo	1,784	1,128	-37%	0.9705	0.9605	-0.0100
Sintel	4,360	3,396	-22%	0.9622	0.9633	0.0011
Sponge Bob	4,424	3,307	-25%	0.9451	0.9573	0.0122
Tears of Steel	3,873	3,110	-20%	0.9539	0.9630	0.0091
Average	3,610	2,735	-26%	0.9579	0.9610	0.0031
Movie-ish						
Elektra	3,546	2,554	-28%	0.9505	0.9610	0.0105
Freedom	4,515	1,677	-63%	0.9670	0.9645	-0.0025
Haunted	4,226	2,311	-45%	0.9613	0.9584	-0.0029
Zoolander	4,489	5,063	13%	0.9448	0.9600	0.0152
Average	4,194	2,901	-31%	0.9559	0.9610	0.0051
Other Business						
Epiphan	3,109	2,133	-31%	0.9824	0.9834	0.0010
New	3,556	2,869	-19%	0.9664	0.9712	0.0048
Talking head	2,235	1,480	-34%	0.9634	0.9728	0.0094
Test	3,566	3,059	-14%	0.9575	0.9696	0.0121
Average	3,117	2,385	-25%	0.9674	0.9742	0.0068
Sports						
Basketball	5,781	3,062	-47%	0.9690	0.9605	-0.0084
Soccer	4,498	3,787	-16%	0.9714	0.9622	-0.0092
Hockey	4,510	3,446	-24%	0.9712	0.9649	-0.0064
Average	4,930	3,432	-29%	0.9705	0.9625	-0.0080
Total average	3,898	2,825	-27%	0.9624	0.9648	0.0024

Table 5 - Crunch compared to Capella Systems

Despite the 27% lower data rate, Crunch's average SSIM score is actually 0.0024 of a point higher. Obviously indistinguishable visually, but impressive nonetheless.

Comparison with JWPlayer

JWPlayer fell below the 0.95 threshold once, but the overall data rate was 26% higher than Crunch, while the average SSIM score was only 0.0046 of a point higher, which would be clearly indistinguishable to viewers.

	Crunch vs. JWPlayer					
	Data Rate			SSIM		
	JWP	Crunch	Delta	JWP	Crunch	Delta
Animation						
El_Ultimo	1,951	1,128	-42%	0.9664	0.9605	-0.0059
Sintel	3,889	3,396	-13%	0.9741	0.9633	-0.0108
Sponge Bob	3,713	3,307	-11%	0.9585	0.9573	-0.0011
Tears of Steel	4,084	3,110	-24%	0.9719	0.9630	-0.0089
Average	3,409	2,735	-22%	0.9677	0.9610	-0.0067
Movie-ish						
Elektra	4,182	2,554	-39%	0.9678	0.9610	-0.0068
Freedom	4,657	1,677	-64%	0.9783	0.9645	-0.0139
Haunted	4,862	2,311	-52%	0.9680	0.9584	-0.0096
Zoolander	4,789	5,063	6%	0.9597	0.9600	0.0003
Average	4,623	2,901	-37%	0.9684	0.9610	-0.0075
Other Business						
Epiphan	1,958	2,133	9%	0.9783	0.9834	0.0051
New	2,829	2,869	1%	0.9764	0.9712	-0.0052
Talking head	2,984	1,480	-50%	0.9444	0.9728	0.0283
Test	3,872	3,059	-21%	0.9749	0.9696	-0.0053
Average	2,911	2,385	-15%	0.9685	0.9742	0.0057
Sports						
Basketball	5,026	3,062	-39%	0.9755	0.9605	-0.0150
Soccer	4,547	3,787	-17%	0.9739	0.9622	-0.0117
Hockey	4,898	3,446	-30%	0.9739	0.9649	-0.0090
Average	4,824	3,432	-28%	0.9744	0.9625	-0.0119
Total average	3,883	2,825	-26%	0.9695	0.9648	-0.0046

Table 6 - Crunch compared to JWPlayer

In Movie-ish clips, Crunch proved particularly strong, posting a 37% lower data rate than JWPlayer with an SSIM average score only 0.0075 lower.

Comparison with Mux

Mux is the newest service in the group, and it appears more tuned for viewing quality than bandwidth savings. Like Crunch, Mux never fell below the 0.95 threshold, but Crunch averaged about 50% the bandwidth of the Mux files and averaged only 0.0124 of a point behind in SSIM quality.

	Crunch vs. Mux					
	Data Rate			SSIM		
	Mux	Crunch	Delta	Mux	Crunch	Delta
Animation						
El Ultimo	5,438	1,128	-79%	0.9836	0.9605	-0.0230
Sintel	5,367	3,396	-37%	0.9818	0.9633	-0.0185
Sponge Bob	5,761	3,307	-43%	0.9649	0.9573	-0.0076
Tears of Steel	5,455	3,110	-43%	0.9754	0.9630	-0.0124
Average	5,505	2,735	-50%	0.9764	0.9610	-0.0154
Movie-ish						
Elektra	5,576	2,554	-54%	0.9707	0.9610	-0.0097
Freedom	5,531	1,677	-70%	0.9795	0.9645	-0.0150
Haunted	5,661	2,311	-59%	0.9691	0.9584	-0.0107
Zoolander	5,723	5,063	-12%	0.9640	0.9600	-0.0040
Average	5,623	2,901	-49%	0.9708	0.9610	-0.0099
Other Business						
Epiphan	5,287	2,133	-60%	0.9924	0.9834	-0.0090
New	5,331	2,869	-46%	0.9815	0.9712	-0.0103
Talking head	5,301	1,480	-72%	0.9836	0.9728	-0.0108
Test	5,367	3,059	-43%	0.9779	0.9696	-0.0083
Average	5,322	2,385	-55%	0.9838	0.9742	-0.0096
Sports						
Basketball	5,828	3,062	-47%	0.9803	0.9605	-0.0198
Soccer	5,592	3,787	-32%	0.9778	0.9622	-0.0156
Hockey	5,591	3,446	-38%	0.9763	0.9649	-0.0114
Average	5,670	3,432	-39%	0.9781	0.9625	-0.0156
Total average	5,521	2,825	-49%	0.9772	0.9648	-0.0124

Table 7 - Crunch compared to Mux

Summary and Conclusion

With this as background, let's take another look at Table 1. As you can see, Crunch delivered substantial savings compared to all other technologies while remaining visually indistinguishable as measured by SSIM scores with anecdotal subjective verification.

	Data Rate	Crunch SSIM	Other SSIM	SSIM Delta
Brightcove	-24%	0.9648	0.9734	-0.0086
Capped CRF	-37%	0.9648	0.9687	-0.0039
Capella	-27%	0.9648	0.9624	0.0024
JW Player	-26%	0.9648	0.9695	-0.0046
Mux	-49%	0.9648	0.9751	-0.0102

Table 1 (redux) - Summary of results

The ability to tune the Crunch algorithm for a specific SSIM result allows publishers to achieve their own targeted quality/bandwidth tradeoff. This is another strength of the Crunch technology.

About Jan Ozer and Streaming Learning Center

Jan Ozer is a leading independent expert on H.264, H.265, and VP9 encoding for live and on-demand video production. He owns Streaming Learning Center and blogs at www.streaminglearningcenter.com. Ozer is also a contributing editor to [Streaming Media Magazine](#) where he reviews codecs, on-premise and cloud encoders, and ancillary tools like QoE and QoS monitoring services.