VESA Advanced Display Stream Compression

James Goel

This eLetter article calls for proposals to support the perceptual and objective quality assessment of the next generation Video Electronics Standards Association (VESA) Advanced Display Stream Compression (Adv-DSC). VESA is interested in developing academic and industry partnerships to create new techniques for the both the objective and subjective analysis of low-impairment compression of HDR and wide-color gamut images. The VIME group within VQEG would also appreciate the addition of photographs described in this article containing high-dynamic range and wide-color gamut qualities to the VIME Flickr database. Interested universities and companies should contact James Goel (jgoel@qti.qualcomm.com).

"To meet the growing need for visually lossless data compression, the Video Electronics Standards Association (VESA) has issued a new call-for-proposals for the next generation visually lossless display stream compression (DSC) system named Advanced-DSC (Adv-DSC)"

Adv-DSC Applications

Modern displays and mobile electronics must support high-bandwidth video signals within a low-power envelope and severe EMI constraints. The latest European Broadcasting Union (EBU) proposal for an 8K 10 bit 120Hz display format requires a completely new approach to content generation, production, transmission and display. The extreme data bandwidth required for this application is documented in Table 1 - Video Format Bandwidth CalculationTable 1. It is interesting to note the maximum 10240 × 4320 resolution as the

21:9 aspect ratio of the 16:9 FUHD format running at 120 Hz with up to 4:4:4 16 bit RGB pixel formats.

Visually lossless data compression may be used throughout the content delivery chain to meet the constraints mentioned earlier. The rest of this article discusses the visual quality analysis and subjective trial methodology that may be used to assess visually lossless, low-impairment compression codecs for these applications.

Table 1 - Video Format Bandwidth Calculation

Use-Case	Horizontal Pixels	Vertical Pixels	Frame rate	Pixel Format (4:2:0, 4:2:2, 4:4:4)	Comp per Pixel	Bits Per Component	Bits per Pixel	GPixels/ Sec	Bandwidth in Gbits/sec	Bandwidth in GBytes/s
	1920	1080	60	4:2:0	2	8	16	0.12	2.39	0.24
2K Production @60Hz	1920	1080	60	4:4:4	3	12	36	0.12	5.37	0.54
2K Broadcast @60Hz	1920	1080	60	4:2:0	2	10	20	0.12	2.99	0.30
8K Production @120Hz	7680	4320	120	4:4:4	3	12	36	3.98	171.99	17.20
8K Broadcast @120Hz	7680	4320	120	4:2:0	2	10	20	3.98	95.55	9.56
8K Production @60Hz	7680	4320	60	4:4:4	3	12	36	1.99	86.00	8.60
8K Broadcast @60Hz	7680	4320	60	4:2:0	2	10	20	1.99	47.78	4.78
10K Production @60Hz	10240	4320	60	4:4:4	3	12	36	2.65	114.66	11.47
10K Broadcast @60Hz	10240	4320	60	4:2:0	2	10	20	2.65	63.70	6.37

To meet the growing need for visually lossless data compression, the VESA has issued a new call-for-proposals for the next generation visually lossless DSC system named Adv-DSC. The requirements for Adv-DSC are outlined in Table 2.

Consumers expect to access this content on large displays plugged into the wall and on smaller mobile devices. The power and cost constraints placed on the electronics of both large and mobile displays require a compression solution

capable of reducing the video bandwidth from 4:1 up to 6:1 times the original resolution with no perceived loss in visual quality. This last constraint is especially important since this DSC is applied in the last leg of the processing path, right before the data is converted to display pixels.

The first generation DSC succeeded in producing visually lossless results when converting 24 bits per pixel video down to 8 bits per pixel compressed (bpc) constant data rate. VESA adopted the DSC 1.1 standard this year for use in MIPI, embedded DisplayPort and MHL applications. It is based on algorithms optimized for low-cost, high-quality display applications and is described in the following website link (http://www.vesa.org/wp-content/uploads/2014/04/VESA_DSC-ETP200.pdf). DSC 1.1 was optimized for 24 bit to 8 bpc compression and the introduction of the new FUHD 8K standard requires more bandwidth compression to reach power and cost goals for future applications.

The Adv-DSC requirements were selected to give the standard enough capacity to support new products for the next five years, anticipating that in 2020 the Tokyo Olympics will be broadcast in 8K at 120Hz resolution. The large pixel component bit depth is required to maintain visually lossless quality throughout the production chain and support HDR and wide-color gamut.

Table 2 - VESA Advanced Display Compression Requirements

Attribute	Requirement	Comments
Resolutions	Up to 10240x4320	No interlaced format
Frame Rate	Up to 120 Hz	
Component Type	RGB, YCbCr; full-range, i.e. each component ranges from 0 to 2bpc - 1 in integer format	Input type to the encoder shall match the output type of the decoder. Internal color space conversion is permitted, but if used, it shall be specified as

Attribute	Requirement	Comments
		part of the proposal and included in the model.
Max Components	3	
Component bit depth	8, 10, 12, 14, or 16 bits	Referred to as bits per component (bpc) in this document
Sampling	4:4:4, 4:2:2 , 4:2:0	

Table 3 - Advanced DSC Coding Requirements

Attribute	Requirement	Comments
Coding across frames	No, intra-frame only	
Required coded bit rate that ensures visually lossless coding of source content with no chroma sub-sampling (4:4:4)	8 bpc source: 4.8 – 6 bpp 10 bpc source: 6 bpp 12 bpc source: 6 – 9 bpp 14-16 bpc source: 9 bpp	The encoding process shall guarantee that the specified bpp rate is met for all content. This requirement applies for all values of image attributes. For cases where a range of bpp values are given, the lower bpp target may involve some compromises (e.g., additional cost/memory, higher viewing distance for visually lossless quality, etc.) Visually lossless quality shall be maintained through at least two generations (coding/decoding cycles).
Required coded bit rate that ensures visually lossless coding of source content with chroma subsampling (4:2:2 or 4:2:0)	4:2:2: 10% lower than 4:4:4* 4:2:0: 20% lower than 4:4:4*	Bit rate reduction is measured relative to the bit rate required for visually lossless coding of 4:4:4. * Refer to the bit rate targets specified in the previous row of this table.

The most important requirement of Adv-DSC is the constant bit-rate (CBR) that must be maintained throughout the encoding and decoding stages. This CBR requirement requires a lossy compression system capable of appearing visually lossless to ensure consumer adoption and acceptable visual quality. The challenge of evaluating this low-impairment quality requires selecting difficult content that stresses the entire codec. The following Adv-DSC content types are identified by the call-for-technology:

Adv-DSC Section A.3 Content Types

Many types of still images will be evaluated:

- Continuous tone images
- Landscapes
- People portraits
- Animals
- Fine text, web pages and graphics
- Computer screen captures with or without sub-pixel rendering, etc.
- Test patterns such as noise and zone plates will be evaluated, but some visual loss may be tolerated on certain patterns.

Video tests will include movies, television, computer games, graphics, etc. Source video may be compressed using a standard broadcast compression algorithm before compression testing (e.g., MPEG-2, AVC, HEVC, etc.).

Adv-DSC Section A.4 High Dynamic Range (HDR) Testing

Figure 2 - Examples of Challenging DSC Test Material

Testing will include high dynamic range displays and content. Content will include BT.2020 10 and 12 bpc source as well as content sourced from other optical-electrical transfer functions (OETF). To cover different color gamut usage modes, content with sRGB, BT.709, and BT.2020 primaries will be tested.

The following example content is suggested by the ISO 291720-2 low-impairment standard.

The ISO 29170-2 Standard Protocol Description

Advanced DSC methodology follows the ISO/IEC 29170-2 subjective test methodology. This dual stimulus protocol alternates the reconstructed image with the original on one side while the other side remains static. The subject chooses either the left or right image as the image with a perceived flicker. If the subject cannot detect any flicker, they are asked to try their best and select either left or right image. The test cannot advanced unless a choice is made. Over a large number of observers, typically 40, the statistical analysis indicates whether a reconstructed image is visually lossless or not. The protocol uses a visually lossless JND threshold of 75%—in other words, if all 40 users are below the 75% detection threshold, the reconstructed image is deemed visually lossless.

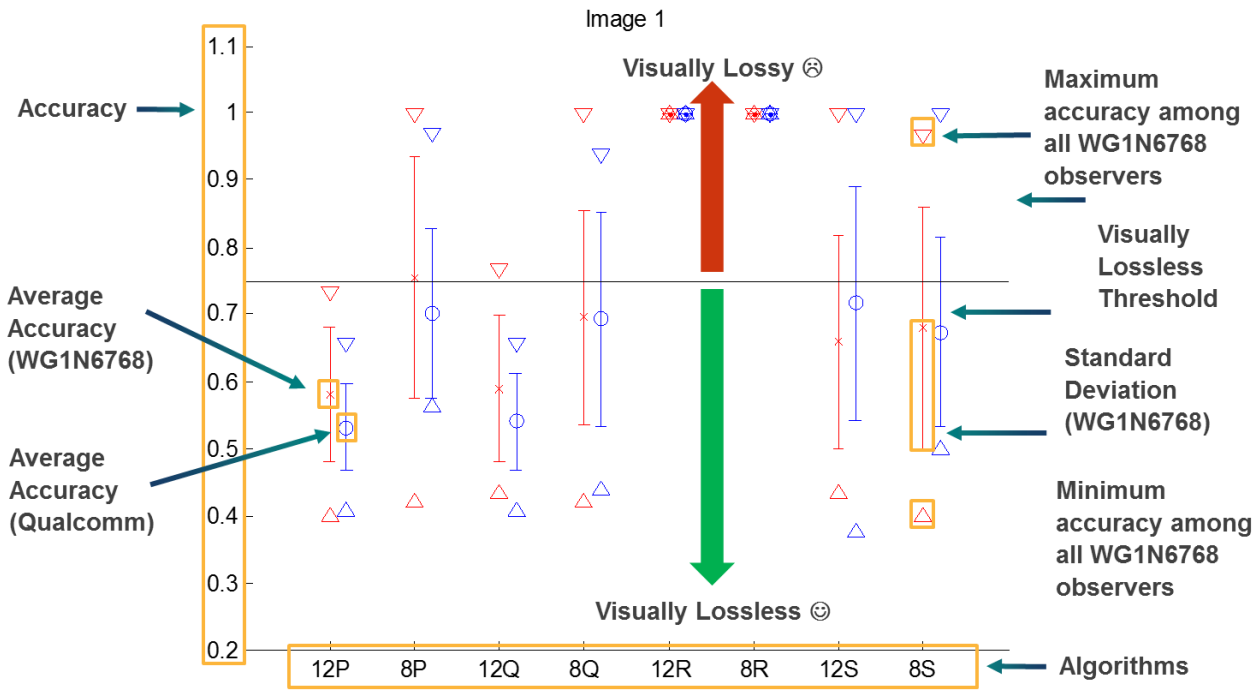

Figure 3 - Visually Lossless Subjective Trial Results

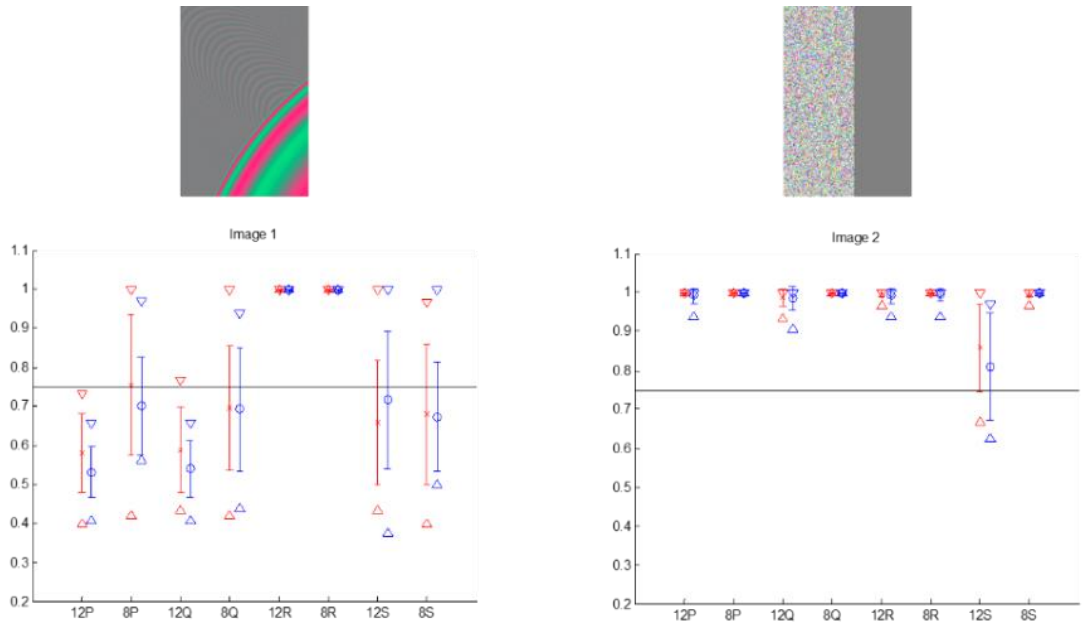

Figure 4 -- Challenging Subjective Trial Material

The selection of test material is the most important factor to ensure accurate results. The images range from artificial test patterns, natural images, faces and a mixture of computer

graphics with text and text on natural backgrounds. This wide variety of material is required in many formats (10, 12, 14, and 16 bit; 4:4:4, 4:2:2, and 4:2:0 formats) to cover all requirements of the standard.

The VIME has established a new Flickr group to contain images that can be used for the Adv-DSC standard validation. The following list of HDR images are required to properly test the complete range of use cases. (see table above). VQEG invites all members to submit images from the list to the VIME Flickr group. Qualcomm is also extending an invitation to interested VQEG members who wish to participate in Adv-DSC subjective trials following this protocol.

Please Join the VIME Group and Upload your Photos

The test protocol requires HDR and high-colour 10/12/14 and 16-bit images and video from the following scenarios shot in RAW Format:

- Pane color glass window
- Night campfires and flames
- Outdoor sunset
- Indoor scene with window and sunlight
- Birthday night shots
- Tiki torches
- Sparklers on birthday cakes or very bright candles
- Sunset with car and bright lights

VQEG – Development of Low-Impairment Subjective and Objective Analysis

The following tasks require development and the VQEG is well positioned to help:

1) Collection and Generation of Adv-DSC Test Content
   a) VQEG has the proper technical expertise to create or capture HDR and wide-color gamut test material using the VIME Flickr database structure
2) Subjective trials of Adv-DSC using ISO 29170-2
   a) Full subjective trials for challenging content described in the Adv-DSC call-for-technology
   b) Expansion of ISO 29170-2 to include diagonal motion to stress block based codec design
3) Development of new objective and subjective analysis techniques:
   a) Low-impairment high-dynamic range (HDR) content
   b) Low-impairment wide-color gamut content

VQEG members who are interested in collaboration on this topic should review the standards presented in this article and contact me at jgoel@qti.qualcomm.com.