Promising Efficiency

Working With HEVC

Ken McCann, Chair, TM-AVC

Ken McCann, ZetaCast

We are currently witnessing something that has become a once-in-a-decade event in the world of video compression: the emergence of a major new family of video compression standards.

The mid-1990s saw the introduction of MPEG-2, the first compression standard to be widely adopted in broadcasting applications. H.264/AVC appeared in the mid-2000s, offering the same subjective quality at approximately half the bitrate. Now, a new standard, High Efficiency Video Coding (HEVC), has been developed that promises a further factor of two improvement in compression efficiency for the mid-2010s.

The HEVC standard has been jointly developed by the same two standardization organizations whose previous collaboration resulted in both MPEG-2 and H.264/AVC: the ISO/IEC Moving Picture Experts Group (MPEG) and the ITU-T Video Coding Experts Group (VCEG).

The initial edition of the HEVC standard was completed in January 2013 and it is published by ISO/IEC as ISO/IEC 23008-2 (MPEG-H Part 2) and by ITU-T as Recommendation H.265. This first version supports applications that require single-layer 4:2:0 video with 8 or 10 bit sampling. Further work is planned to be completed in 2014 to extend the standard to support contribution applications, as well as adding tools for scalable video coding and more sophisticated 3D coding.

HEVC Overview

The basic architecture of HEVC is the same as that of both MPEG-2 and H.264/AVC: a block-based hybrid that combines motion-compensated prediction and transform coding with entropy coding.

A simplified block-diagram of an HEVC encoder is shown in Figure 1.

Within this traditional architecture, HEVC includes many innovations, particularly in the flexible quad-tree block partitioning structure that facilitates the use of large sizes of coding, prediction and transform blocks. Figure 2 highlights some of the key differences between HEVC and the H.264/AVC standard.

HEVC Profiles, Tiers and Levels

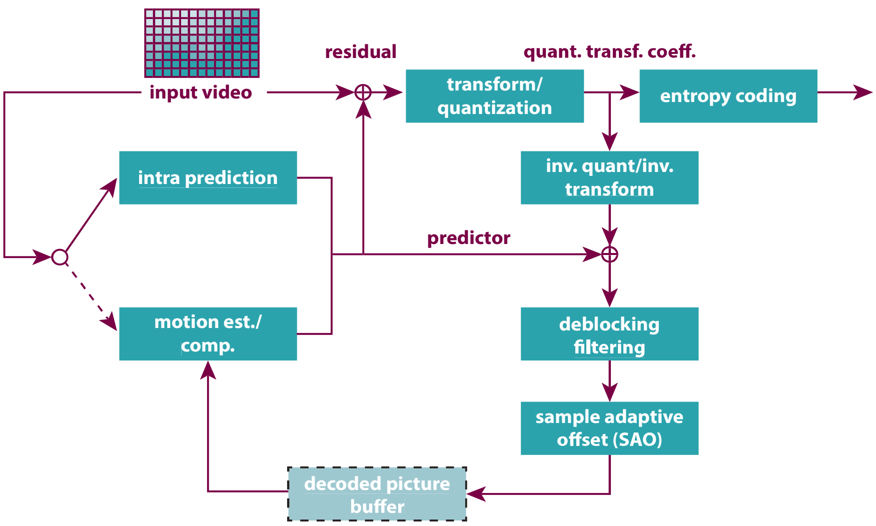
Conformance points for HEVC are defined by using a combination of three constructs: profiles, tiers and levels. Previous video coding standards used only profiles and levels.

Profiles define subsets of the syntax and semantics of the standard. The initial HEVC standard contains three profiles: the Main, Main 10, and Main Still Picture profiles. DVB applications are likely to focus on the Main and Main 10 profiles, which support 4:2:0 format video with 8 bit depth and up to 10 bit sampling depth, respectively.

Two tiers have been defined for HEVC, to specify classes of applications whose requirements differ only in terms of the maximum bit and coded picture buffer size. The Main Tier is relevant for most DVB use cases, although the High Tier may be applicable to contribution and other "professional" applications.

Levels define limits on the allowed values of key parameters, such as the maximum sample rate and the maximum picture size, which consequently specify which video formats are supported. 13 levels have been specified for the Main and Main 10 profiles, as shown in Figure 3. The supported video formats include UHDTV formats as large as 7680×4320 at 120 frames/s.

Fig. 1: Simplified block diagram of an HEVC encoder



HEVC Performance

There are two types of measurements that can be carried out to evaluate the performance of a compression system: objective and subjective. Objective measurements perform some form of mathematical calculation, typically using the Peak Signal-to-Noise Ratio (PSNR), and are a convenient method of obtaining an approximate indication of video quality. However, the only way to really determine the quality perceived by viewers is still the time-consuming and expensive process of running formal subjective tests.

The goal of the HEVC work was to create a new standard that would require only about half the bitrate to give the same subjective quality as H.264/AVC. Verification testing to determine whether or not this performance goal has been achieved would ideally use a different set of test sequences from those used during the development of the standard, to avoid any accidental bias in favor of particular types of sequences.

Such an evaluation process is currently underway within the "Beyond HD" group of the EBU. The subjective testing has not yet been completed, but objective testing results for Main and Main 10 profile at level 5.1 were reported (at the DVB/EBU UHDTV Fact Finding Meeting in May) to give average bitrate savings of about 46% relative to the equivalent H.264/AVC profile and level combinations, for both 8 and 10 bit coding. These results were consistent with those of other studies, as were the observations that the greatest gains were achieved at the highest video resolutions. It appears that HEVC is particularly well suited to encoding UHDTV content, due to the larger coding and transform block sizes.

Inclusion of HEVC in DVB standards

Work is already underway on including HEVC in the DVB specification for the use of Video and Audio Coding in Broadcasting Applications based on the MPEG-2 Transport Stream (TS 101 154). Since the Commercial Requirements have not yet been completed, a "straw man" is being drafted to help facilitate the technical discussion. Main Tier will be used, but the exact choice of profile and level combinations has not yet been finalized. The general approach is to add DVB constraints to the generic HEVC profiles and levels only if application-specific requirements are identified, e.g., to enhance interoperability by constraining the combinations of video resolution, frame-rate and chromaticity that may be used in DVB applications.

The plan is to complete the work on the inclusion of HEVC in a revision of TS 101 154 in early 2014.

When will HEVC-based services be launched?

A specification is all very well, but when will there actually be HEVC services? The experience of MPEG-2 and H.264/AVC implies that consumers and industry are prepared to consider a change of video compression algorithm roughly once a decade, provided that it can be justified by about a factor of two improvement in coding efficiency and commercially attractive new services. If history repeats itself, then HEVC could support both a new generation of 1080p HDTV services and also the launch of the first UHDTV services in 2015.

Fig. 2: Comparison of HEVC and H.264/AVC

	HEVC	H.264/AVC
Coding Tree Unit	64x64, 32x32, 16x16 CTU	16 x 16 macroblock
Coding Unit	64x64, 32x32, 16x16, 8x8 CU	16 x 16 macroblock
Prediction Unit	square, symmetric rectangular, asymmetric rectangular PU	square, symmetric rectangular
Transform Unit	32x32, 16x16, 8x8, 4x4 TU	8x8, 4x4 transforms
Intra prediction	33 directional modes, planar, DC	9 directional modes
Motion prediction	advanced motion vector prediction	spatial median, temporal colocated
Luma interpolation	¼ pixel 7-tap, ½ pixel 8-tap	½ pixel 6-tap + ¼ pixel bilinear
Chroma interpolation	4-tap	bilinear
Entropy coding	CABAC	CABAC, CAVLC
Loop filtering	deblocking filter, sample adaptive offset (SAO)	deblocking filter

Fig. 3: Levels for Main and Main 10 profiles

Level	Maximum luma sample rate (samples/s)	Maximum luma picture size (samples)	Maximum bitrate (Mbits/s)		Example video formats
			Main Tier	High Tier	
1	552 960	36 864	0.35	-	
2	3 686 400	122 880	1.50	-	
2.1	7 372 800	245 760	3	-	
3	16 588 800	552 960	6	-	
3.1	33 177 600	983 040	10	-	
4	66 846 720	2 228 224	12	30	720p @ 50/60Hz
4.1	133 693 440	2 228 224	20	50	1080p @ 50/60Hz
5	267 386 880	8 912 896	25	100	
5.1	534 773 760	8 912 896	40	160	4Kx2K @ 50/60Hz
5.2	1 069 547 520	8 912 896	60	240	4Kx2K @ 100/120Hz
6	1 069 547 520	35 651 584	60	240	
6.1	2 139 095 040	35 651 584	120	480	8Kx4K @ 50/60Hz
6.2	4 278 190 080	35 651 584	240	800	8Kx4K @ 100/120Hz