Versatile Video Coding (VVC) – The New Standard and its Capabilities

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mhv online /2020

1

Versatile Video Coding (VVC)

Joint ITU-T (VCEG) and ISO/IEC (MPEG) project, completed July 2020

Rec. **ITU-T H.266** & **ISO/IEC 23090-3**

Coding Efficiency

~50% saving over H.265/HEVC

emph. HD / UHD / 8K resolutions
emph. HDR / WCG
emph. 10 bit

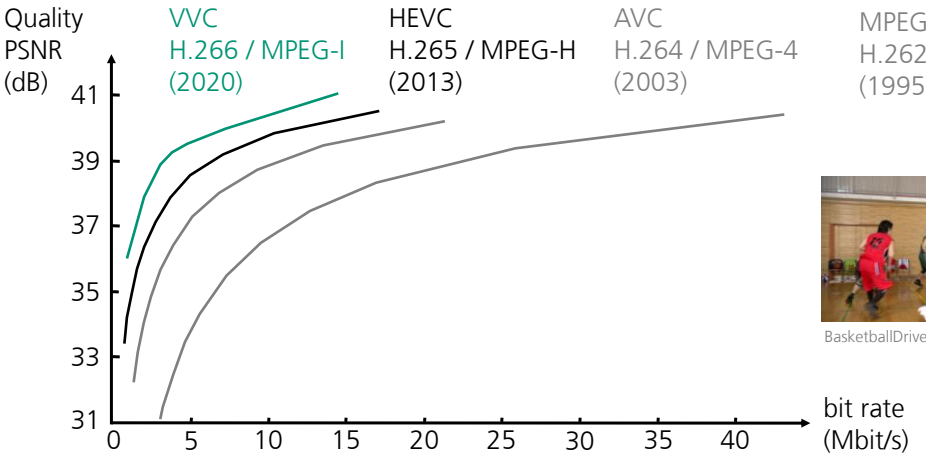
Versatility

Rendered "screen" content coding
Adaptive resolution changes
Independent sub-pictures
Tiles, slices and wavefronts
Layered multistream & scalability
Bitstream extraction and merging
360° video projection handling
Random access & splicing features
Gradual decoder refresh

2

2

History of Video Coding Standards



BasketballDrive (1920 x 1080, 50Hz)

3

3

VVC – Coding Efficiency

Jevons Paradox

"The efficiency with which a resource is used tends to increase (rather than decrease) the rate of consumption of that resource."

Video is >80% of internet traffic (and rising)

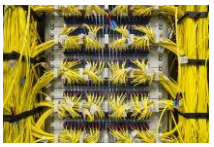
4

4

Video Coding Consumption 2018–2020

82%

of all Internet traffic is now video



12X

increase in AR/VR traffic

7X

increase in video monitoring traffic

* Cisco Visual Networking Index: Forecast and Trends, 2018–2022

5

5

VVC – Timeline

2015 Oct. – Exploration Phase

- Joint Video Exploration Team (JVET) of ITU-T VCEG and ISO/IEC MPEG established October '15 in Geneva
- Joint Video Exploration Model (JEM) as software playground to explore new coding tools
- 34% bitrate savings for JEM relative to HEVC provided evidence to start a new joint standardization activity with a…

2017 Oct. – Joint Call for Proposals (CfP)

- Submit bitstreams and decoded video for proposed video coding technology
- Compare submission with HEVC anchor for given sequences, bitrates and coding conditions

2018 Apr. – Development Phase

- Subjective evaluation results of submitted CfP responses and HEVC anchor
- Initial starting point of standard development

2020 Jul. – Final Standard

6

6

VVC – Call for Proposals

Results

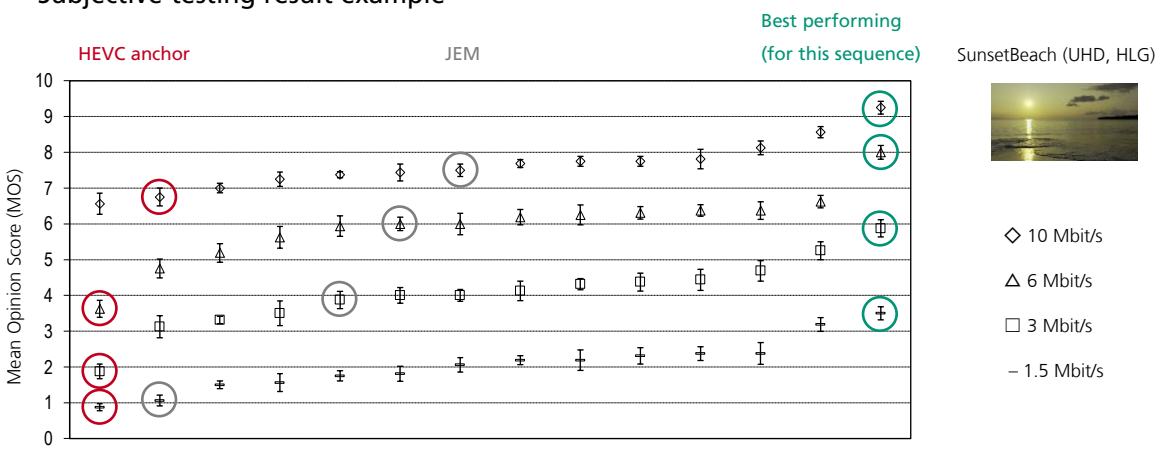
- JVET received submissions from 32 organizations.
- 40% or more bitrate savings in terms of PSNR over HEVC were shown.
- All submissions were superior in terms of subjective quality than…
  - HEVC (in most test cases).
  - JEM (in a relevant number of test cases).

7

7

VVC – Call for Proposals

Subjective testing result example



JVET-J0080: "Results of Subjective Testing of Responses to the Joint CfP on Video Compression Technology with Capability beyond HEVC", 10th JVET Meeting, San Diego, April 2018

8

VVC – Development

Draft 1 and First Test Model (VTM-1.0)

- Start off with a clean slate
- Add quadtree plus multi-type tree block partitioning (QT+MTT)
  - Fundamental impact on all coding tools to be added
  - Most common partitioning scheme among all CfP submissions
- VVC Test Model (VTM) as reference implementation of VVC specification draft
- Test promising coding tools from CfP on that lean basis (efficiency / complexity aspects)
- Agree on adding tested coding tools until sufficient bitrate reduction is achieved

9

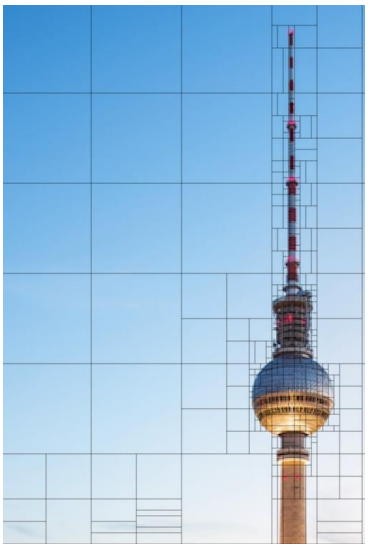
9

VVC – Development

Draft 10 and VTM-10 - New coding tools for coding efficiency

- Quadtree with Multi-type Tree (QT+MTT)
- Separate Tree for Luma and Chroma (CST)
- Dependent Quantization (DQ)
- Joint coding of chrominance residuals (JCCR)
- Multiple Transform Set (MTS)
- Low frequency non-separable transfor…
- Adaptive Loop Filter (ALF)
- Affine Motion C…
- S…idates
- …ution (AMVR)
- G…on mode (GPM)
- Bi-directional optical flow (BDOF)
- Merge with MVD (MMVD)
- Adaptive color transform (ACT)
- Bi-prediction with CU weights (BCW)
- Decoder-side motion vector …MVR)
- Symmetric motio…
- Sub…
- …(CIIP)
- …intra prediction (MRL)
- …lock copy (IBC)
- Intra sub-partitioning (ISP)
- Matrix based intra prediction (MIP)
- Cross-component Linear Model (CCLM)
- Luma mapping with chroma scaling (LMCS)
- Transform Skip Residual Coding (TSRC)
- Quantized residual DPCM …

Many incremental improvements of classic hybrid video coding design

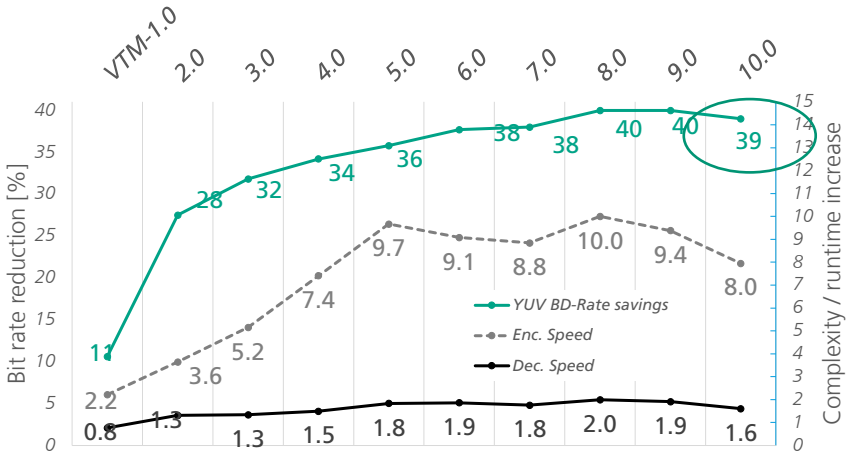


10

10

VVC – Coding Efficiency

VVC reference software (VTM) vs. HEVC reference software (HM)



11

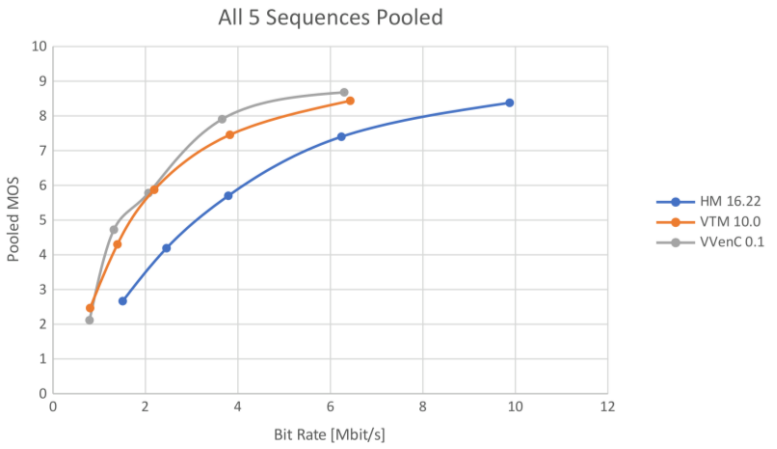
Even higher than HEVC vs. AVC

Subjective gains seem a bit higher than this

11

VVC – Coding Efficiency

VVC reference software (VTM) vs. HEVC reference software (HM)



12

UHD SDR subjective verification testing Oct 2020

Subjective gain

- ~43 % for VTM enc reference software
- ~49 % for VVenC (>100x faster, subjective opt.)

12

VVC – Versatility

Screen content coding (SCC)

Application

Gaming, screen sharing / remote desktop,…

Arena of Valor (1080p60)

Problem

- Video codecs typically optimized for camera captured video (different signal characteristics)
- Reduces coding efficiency for screen content

Solution

- Special screen content coding tools
- HEVC v4 SCC extensions -> not in main profile!
- VVC supports SCC already in v1 Main profile

13

13

VVC – Versatility

Adaptive resolution change

Application

Adaptive streaming with resolution switching

Problem

- Different resolution reference pictures cannot be used in inter-picture prediction
- Reduces coding efficiency at switching points

Solution

- Resample different resolution reference picture
- VVC supports reference picture resampling (RPR)
- RPR as enabler for spatial scalability in VVC v1

14

14

VVC – Versatility

Tile-based streaming

Application

Tiled streaming of 360-degree videos

Problem

- Managing a decoder sample budget dynamically post-encoding
- Throwing 24K video (tiles) at a 4K decoder

Solution

- More efficient coding of independent sub-pictures (in-picture padding)
- Flexible block addressing for easier extraction and merging of sub-pictures

15

15

VVC – Profiles

(Six, logically related)

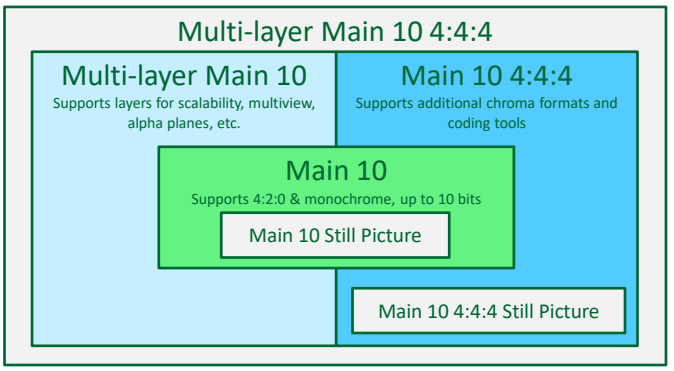


Figure originally by Virginie Drugeon of Panasonic

1) Main 10 profile: monochrome and 4:2:0, 8 to 10 bits, 1 layer
2) Main 10 Still Picture profile: based on the Main 10 profile, 1 picture only
3) Main 10 4:4:4 profile: based on Main 10 profile, also supports 4:2:2 and 4:4:4
4) Main 10 4:4:4 Still Picture profile: based on the Main 10 4:4:4 profile, 1 picture only
5) Multilayer Main 10 profile, based on the Main 10 profile, >= 1 layer
6) Multilayer Main 10 4:4:4 profile, based on the Main 10 4:4:4 profile, >= 1 layer

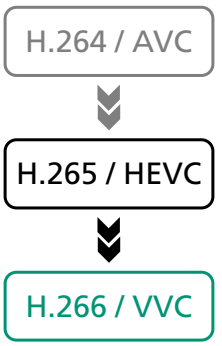
16

16

Versatile Video Coding (VVC)

Summary

- Coding Efficiency – VVC Test Model 6.1 over HEVC (HM)
  - ~50% lower bit rate for equal subjective quality HD and UHD (40% for PSNR)
  - ~9x encoder and 1.6x decoder runtime
- Versatility – enabled by:
  - Screen content coding tools (gaming, screen sharing,…)
  - Reference picture resampling (adaptive streaming)
  - Spatial scalability using RPR filters, also temporal, view, quality scalability
  - Independent sub-pictures (360 video, ROI)
  - Boundary handling for 360° video & gradual decoder refresh
  - Bitstream extraction & merging
  - Random access & splicing features
- Final Standard established July 2020



17

17

Thank you very much!

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18

18