SMPTE CONFERENCE 2016 ULTRAHD FORUM ITALIA Beyond Definition

Emerging Technology
SMPTE Seminar
8th edition
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PASSAGGI
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OLTRE LE FRONTIERE

High Efficency Compression Codecs

Bruce Devlin, SMPTE UK Governor, MrMXF

Vatican City ~ October 7, 2016

High Efficiency Compression Codecs

Bruce Devlin

Mr MXF Ltd.

UK Regional Governor

mrMXF

Overview

- UHD distribution - What's the problem?

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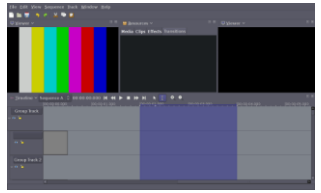
UHD Distribution – what's the problem?



Acquire

Produce

Master

Distribute

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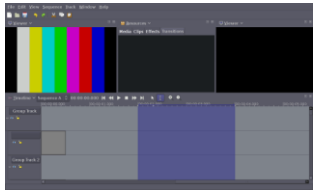
UHD Distribution – what's the problem?

1916-2016

Might be UHD1
Might be HDR HFR WCG
From compressed to Raw

- Might be:
  - One version
  - HD + SDR + HDR



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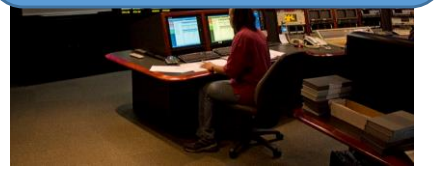

- Might be:
  - One version of UHD
  - HD + SDR + HDR as simulcast or side channels

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UHD Distribution – what's the problem?

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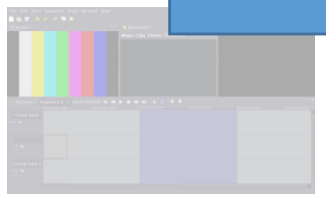

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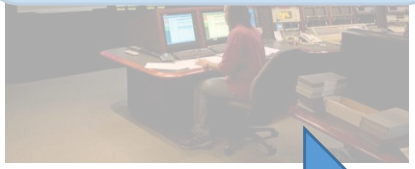

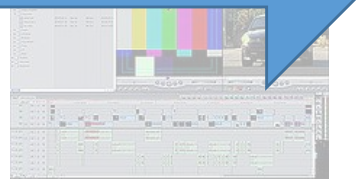

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You are here

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The Compression Landscape

1916-2016

- Today
  - HD (payTV, broadcast, cable, satellite)
    - MPEG2, AVC
  - Online
    - VP9, AVC (youtube & facebook, Subscription VoD)

- Tomorrow
  - UHD (payTV, broadcast, cable, satellite)
    - HEVC
      - HDR support, standardization for 4K, inclusion in next generation ATSC and DVB standards
  - Online
    - AV1, HEVC
      - AV1 – licensing model, internet company adoption

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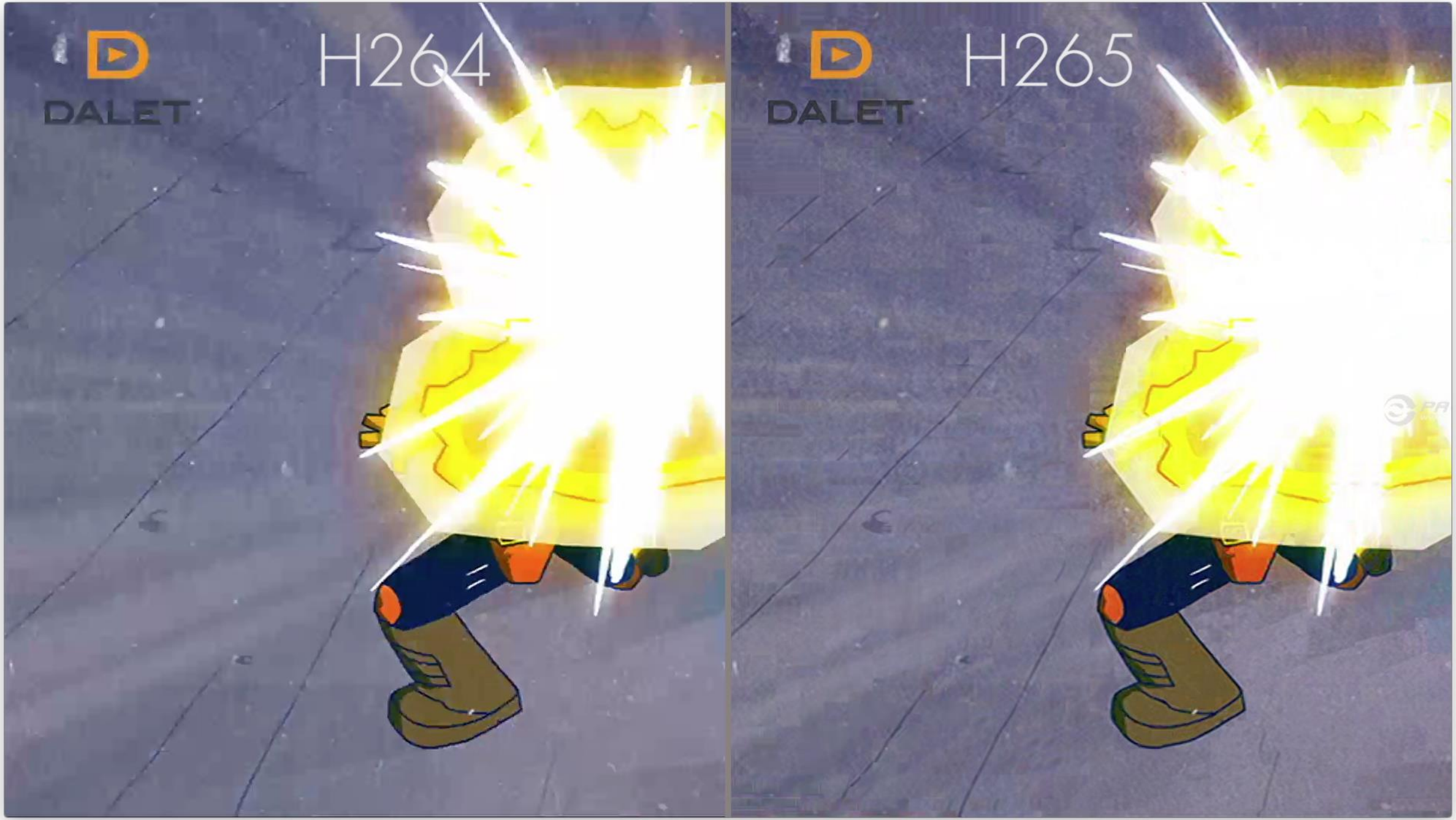
Thanks to

HEVC

- Goals
  - 50% of the bitrate of AVC for the same quality (Build on existing MPEG tools like Transport Stream)
  - Resolutions from QVGA (320 x 240) to 8K (7680 x 4320)
  - High Efficiency with a low delay configuration
  - Ubiquitous decoder support
- Ownership
  - MPEG consortium – hundreds of contributors representing national bodies
- File Structure
  - MP4 and coming soon MXF
- Licensing
  - MPEG-LA
    - Free (<100k products), $0.2/decoder up to $25M/yr
    - "*No assurance is or can be made that the License includes every essential patent*"


DALET
H264
DALET
H265

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AV1

- Goals
  - Simple ubiquitous decoder
  - Performance similar to HEVC
  - Predictable licensing
- Ownership
  - AOMedia consortium – tens of companies
- File Structure
  - Based on Matroska
- Licensing
  - W3C Royalty Free licensing approach – yet to be proven
  - Teams of lawyers patent checking tools included in the codec

HEVC encoding techniques (1)

- "*Decoding is a Science, encoding is an Art*"
  - Standard tools
    - Coding Trees of variable block sizes, not macroblocks
    - Parallel Processing via optional Tiles & Wavefront Parallel processing (WPP)
    - CABAC entropy encoding
    - Intra prediction (i.e. prediction within a frame)
    - Motion Compensation - Better sub-pixel performance than AVC (longer filters)
    - Motion vector prediction – many modes to predict the motion vectors to sub pixel accuracy
    - Loop filters – deblocking (like AVC), Sample Adaptive Offset (to reduce banding ringing)
  - Standard bitstream, proprietary encoding techniques
    - Content Adaptive encoding claimed to save 30% on bitrate
      (re-encode based on visual model)

HEVC encoding techniques (2)

- "*Decoding is a Science, encoding is an Art*"
  - Range Extensions - Going beyond more pixels …2014
    - Beyond 10 bpp (bits per pixel)
    - 4:0:0 (greyscale), 4:2:2, 4:4:4
    - Cross component prediction (e.g. predict Red pixels from Green channel)
    - Extended precision processing
    - Color remapping metadata in SEI messages (Supplemental Enhancement Info)
    - Knee Function metadata is SEI messages for HDR
    - Mastering Display Color volume in SEI messages
  - Screen Content Coding Extensions … 2015
    - Adaptive Color Transform
    - Adaptive Motion Vector Resolution
    - Intra Block Copying
    - Palette Mode
    - Hybrid Log Gamma support

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UHDTV HEVC experiment

- From the SMPTE Journal: Vol 124 #3, April 2015
  Matthew S. Goldman, Lukas Litwic, Olie Baumann
- Experiment 1 – HEVC 4:2:0 10b (Main 10 Profile)
  - UHD1 → HEVC → Decode → Display (UHD)
  - UHD1 → HD → HEVC → Decode → UHD1 → Display (UHD)
- Experiment 2 – HEVC 4:2:2 10b (Main 422 10 Profile)
  - UHD1 → HEVC (Rext) → Decode → Display (UHD)
  - UHD1 → AVC (Frext) → Decode → Display (UHD)
- Experiment 3 – HEVC 4:2:0 10b (Main 422 10 Profile)
  - UHD1 @120fps → HEVC (Rext) → Decode → Display (UHD)
  - UHD1 @60fps → HEVC (Rext) → Decode → Display (UHD)
  - UHD1 @30fps → HEVC (Rext) → Decode → Display (UHD)

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UHDTV HEVC experiment

- From the SMPTE Journal: Vol 124 #3, April 2015
  Matthew S. Goldman, Lukas Litwic, Olie Baumann
- Experiment 1 – HEVC 4:2:0 10b (Main 10 Profile)
  - Conclusion – transmission in HD (not UHD) does not give significant bitrate savings
  - Tests up to 30Mbps performed
- Experiment 2 – HEVC 4:2:2 10b (Main 422 10 Profile)
  - Conclusion – HEVC Rext gives around 25% to 50% bitrate saving compared to FRExt
  - Tests 20Mbps to 100Mpbs performed
- Experiment 3 – HEVC 4:2:2 10b (Main 422 10 Profile)
  - Conclusion – 100% increase in frame rate requires 40% to 70% bitrate increase
  - Tests –up to 100Mbps performed

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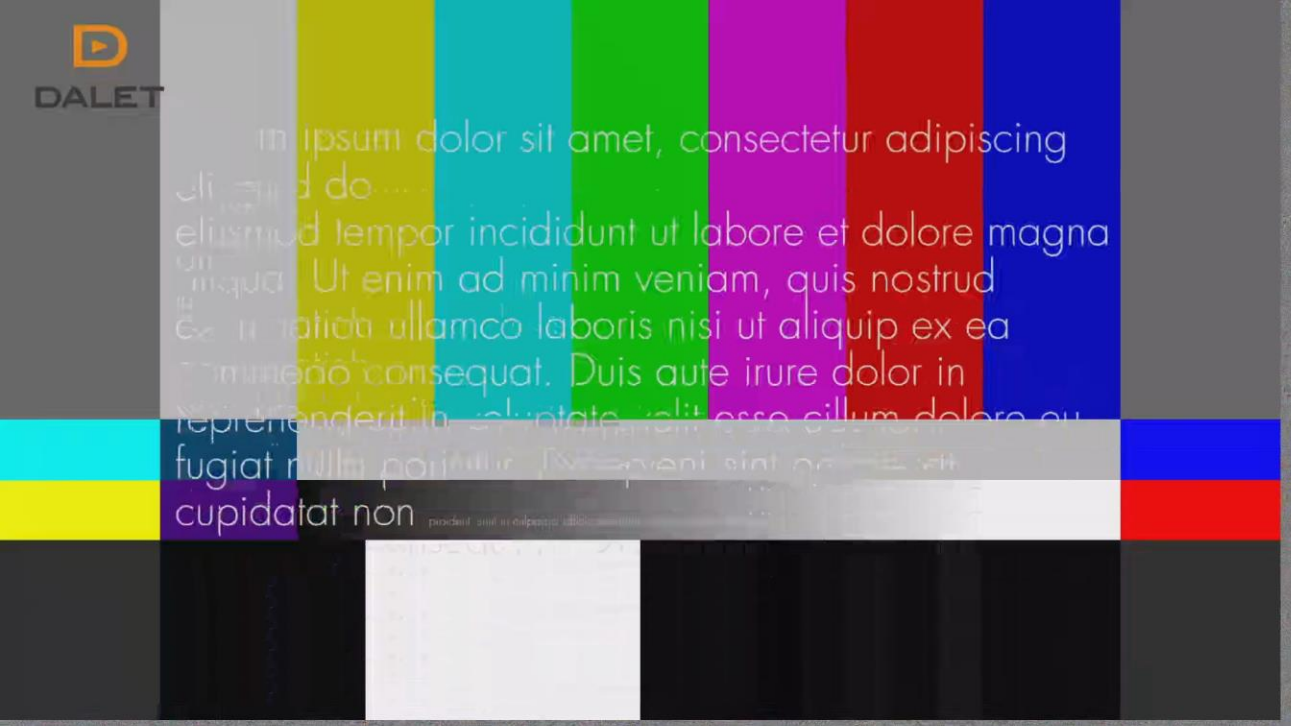
HEVC Noise experiment

- Take some real source and “hurt” the HEVC encoder
- Make sure that HD and upconverted HD with noise look OK


DALET
ipsum dolor sit amet, consectetur adipiscing
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Ut enim ad minim veniam, quis nostrud
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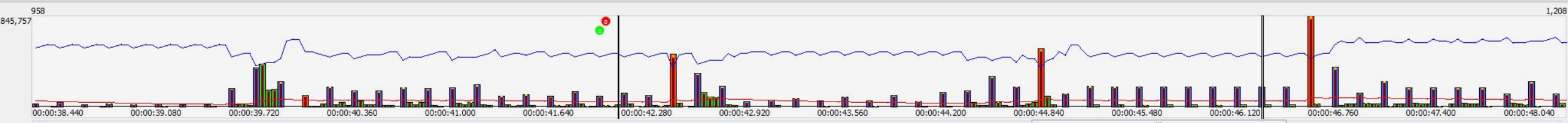
Nullam quis ante. Etiam sit amet orci eget eros faucibus tincidunt. Duis leo. Sed fringilla

StreamEye 4 E:/Video/Example_video/HEVC/HEVC_Clips2_June15/[redacted]_1080p/Gradients_and_Noise_1080P25_12MBPS.hevc

FILE REFERENCE VIEW OVERLAYS NAVIGATION HELP

50 % Display

bar chart



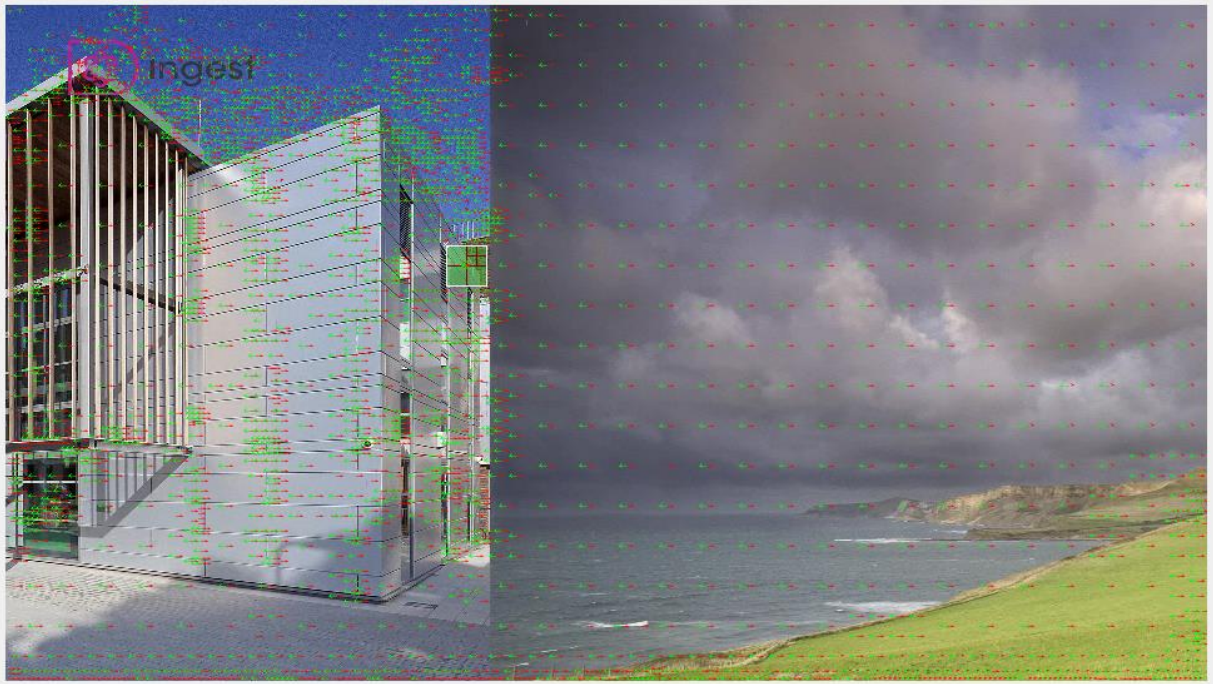
bar chart | thumbnails | area chart

picture

name	value	%
resolution	1920 x 1080	
size (bytes)		
cu	15 821	
prediction	1 046	
transform	14 460	
qp		
min / max	30 / 30	
pixels		
count	2 073 600	
intra	50 112 (2.42%)	
inter	531 392 (25.63%)	
skip	1 492 096 (71.96%)	
mv		
mv[0].x (max/min)	49 / -7	
mv[0].y (max/min)	28 / -17	
mv[1].x (max/min)	14 / -49	
mv[1].y (max/min)	14 / -24	
distribution (bits)		
total	128 424 (100.00%)	
split_cu_flag	1 611 (1.25%)	
cu_skip_flag	2 331 (1.82%)	
prediction		
intra_prediction	947 (0.74%)	
pred_mode_flag	1 160 (0.90%)	
part_mode	1 044 (0.81%)	
inter_prediction	5 403 (4.21%)	
transform		
rqt_root_cbf	378 (0.29%)	
split_transform_flag	1 833 (1.43%)	
cbf_cb	106 (0.08%)	
cbf_cr	76 (0.06%)	
cbf_luma	3 195 (2.49%)	

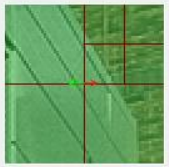
stream | picture | prediction | pixels | headers

decoded | predicted | unfiltered | residual | reference | difference | memory



block presenter

decoded



block info

name	value
location / idx	704x384 / 191
slice idx	0
tile idx	0
size	
ctu	738
prediction	1
transform	736
coded unit	
location	0x0 / 704x384
type	PART_2Nx2N
dimensions	64x64
depth	0
size	738
prediction	1
transform	736

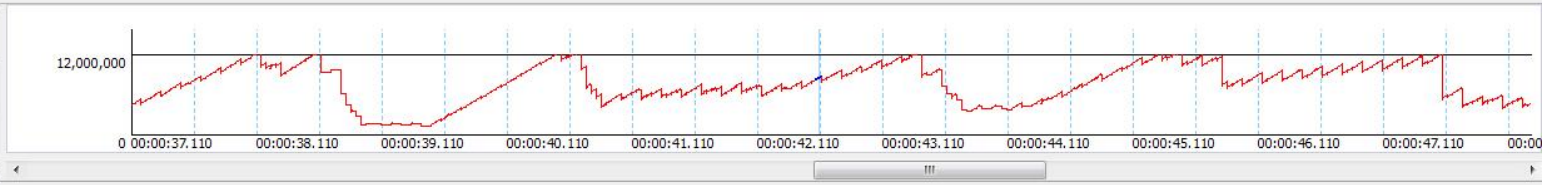
stream viewer

offset	name	value
0x025b860a	sei() (pic_timing)	
0x025b8618	slice_segment_layer_rbsp() { TRAIL_N }	
0x025b994e	sei() (pic_timing)	
0x025b995c	slice_segment_layer_rbsp() { TRAIL_R }	
0x025d155b	sei() (pic_timing)	
0x025d1569	slice_segment_layer_rbsp() { TRAIL_R }	
0x025d43f0	sei() (pic_timing)	
0x025d43fe	slice_segment_layer_rbsp() { TRAIL_N }	
0x025d56c5	sei() (pic_timing)	

buffer

mode: Defined scale: 500(ms)

name	value
bitrate	12,000,000
cbr_flag	0
current	
init time	42.58(00:00:00...
time offset	0.04
cpb fullness	8,612,495



message | hex viewer | dpb | buffer

stop

Strm 1053 | Disp 1052 | Type B | Size 16053 | Offset 0x025d56c5 | Ready


Ingest


Ingest

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(Semi) Proprietary Solutions

1916-2016

- High Efficiency Encoding
  - Deliver UHD bitstream at HD bitrates
  - Deliver HD bitstream at SD Bitrates
  - Deliver SD bitstream at audio bitrates
- Standard bitstream, modified encoder
  - Solutions exist e.g. Beamr that modify the rate control yet produce standard bitstreams
- Modified bitstream, modified decoder
  - Solutions exist e.g. V-Nova's persius that meet the above goals and open up new markets

What causes platforms to change codec?

- Ultimately it will be need (“I can’t do this in any other way”)
- Competition (“I have to do this not to be left behind”)
- New (4K), exciting functionality (HDR)
- Cost saving (bandwidth/storage reduction)
- VR or holographic video adoption
- HDR and its wow factor

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What is preventing change of a codec?

1916-2016

- Users don’t see the potential in doing things differently
- Perception of a large (financial) risk
- Decoders for HEVC are not ubiquitous
- Supporting dual delivery paths is expensive
- Licensing confusion
- 4K hard to distinguish from HD. 8K cannot be seen at typical distances
- The economics of STB and screen replacement
- The economics of re-transcoding the back catalogue (more CPU)

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Is the codec the most important element of the chain?

- It is the heart of the issue. It holds the value & the challenge
  - for new services
  - for reducing the bandwidth of their existing services
- The tool chain is extremely long (camera to) TV so there are other issues
- Yes, however, some containers (TS and MP4) long outlive the codecs
- Media technology evolves slowly. It rarely 100% replaces its predecessors
- The video codecs consume the most processing and bandwidth!
- Each new codec is specialised towards a specific application

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What are the most important wrappers / containers for deploying those codecs?

- There really isn't much change for deploying HEVC
  - MPEG-DASH, MPEG2-TS, etc…

Is there more demand for encoders or decoders?

- The decoder numbers are huge, but the margins are slim
- Replacing encoders to get more value from existing decoders is key
- The enterprise market is growing fast.
  - Encode & Decode numbers are more symmetrical
  - Surveillance demands need very high compression, low price, high volume
- Hardware decoders over time will be integrated into consumer devices
- Encoders need more attention – these will dominate vendor effort

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Are you seeing technical and / or business demand for UHD?

1916-2016

- Absolutely. UHD is a better user experience (and needed for VR).
- Capture content at the highest quality you can afford
- It is becoming natural for movies and documentaries & sport
- Yes. Many UHD deals deployed
- Public consumption announced BT, KT, SK Broadband
- UHD emerging in room conferencing systems
- UHD for theatrical content distribution in emerging markets
- UHD displays is driving demand for UHD BluRays
- HDR is confusing the consumer (and possibly the vendor)

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What's next?

- We expect to bring new technology to market in 2017 that will revolutionize the economics and quality of delivered video.
- Release of AV1 would not be needed if HEVC licensing were free or clear

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Summary

- High Efficiency Compression is not a single technology
- High Efficiency Compression is not for a single market
- There will be different technologies that will:
  - Evolve for the PayTV, Broadcast, Cable, Satellite markets
  - Evolve for the online markets
  - Evolve for the Business & Industrial TV markets
  - Evolve alongside the High Dynamic Range Eco-System(s)
  - Evolve alongside the High Frame Rate ecosystem(s)
- They will all need standards for packaging, transport and usage.
- SMPTE is going to be busy

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Thanks to