JPEG-XS and ST 2110

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intoPIX
ST 2110 is taking off
It is designed to become the infrastructure of choice
What is the « real » economics of going IP?

• Reducing complexity
  – less cables, bi-directional

• Becoming more agile
  – re-routing, easy configuration, less space, smaller building & OB, simplified workflows

• Reducing Cost?
We have more pixels to manage, store and transport

... but the roads are jammed already

« Can we put more cars on a road without creating traffic jam & delaying the arrival time of each passengers? »
HD: Needs 10GbE infrastructures

Uncompressed: **2.4 Gbps** for HD 60fps

**IP INFRASTRUCTURE 10GbE**

- **IP CAMERAS**
- **IP REPLAY & STORAGE**
  Intra-frame compression is needed for the storage to ease read & write access to the disks & to reduce storage cost of all incoming streams
- **IP PRODUCTION SWITCHER**
- **IP MONITORING**
  Many solutions exist for downscaling great amounts of streams in low resolution
- **COTS IP SWITCH**
  COTS in this case means at least **10GbE ports** for all devices & switches
  (At least Cat 6 cables)
4K: Needs at least 25GbE infrastructures

Uncompressed: **9.6Gbps** for 4K 60fps

**IP INFRASTRUCTURE 25GbE?**

- **IP CAMERAS**
- **IP REPLAY & STORAGE**
  - Intra-frame compression is needed for the storage to ease read & write access to the disks & to reduce storage cost of all incoming streams
- **IP PRODUCTION SWITCHER**
- **IP MONITORING**
  - New scaling capabilities needed for monitoring
- **COTS IP SWITCH**
  - COTS in this case means at least **25GbE ports** for all devices & switches
8K: Needs at least 100/400GbE infrastructures $$$

Uncompressed: **38.4Gbps** for 8K 60fps and **76.8Gbps** for 8K 120fps

**IP INFRASTRUCTURE 100/400GbE?**

- **IP CAMERAS**
- **IP REPLAY & STORAGE**
  - Intra-frame compression is needed for the storage to ease read & write access to the disks & to reduce storage cost of all incoming streams
- **IP PRODUCTION SWITCHER**
- **IP MONITORING**
  - New scaling capabilities needed for monitoring (even more steps down)
- **COTS IP SWITCH**
  - COTS in this case means at least **100/400GbE ports** for all devices & switches
What if a technology could help

...managing easily more pixels over a limited bandwidth, safeguarding low latency and a pixel perfect quality?
Call for a new standard

Manage more pixels!

Save cost & power!

Preserve quality with no latency!

Simplify ST 2110 connectivity!
Call for a new standard

- **2016**
  - Call for proposal
  - A new low-latency lightweight image coding system
  - Liaison with AIMS, SMPTE and VSF

- **2017**
  - TICO selected as baseline amongst 6 international proposals.

- **2018**
  - Collaborative work. The standard moves to voting and publication phases

- **2019**
  - JPEG-XS goes Life!
  - First implementations shown at NAB 2019

XS = Xtra Small Xtra Speed
Where can JPEG XS be implemented?
Where can JPEG XS be implemented?

In any applications for which **pixel perfect quality, minimal latency, low complexity and efficient video bandwidth** are crucial!
JPEG-XS, Coming to ST2110

• The new Part -22 - Compressed video essence
# JPEG-XS, Coming to ST 2110

ongoing standardisation

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Description</th>
<th>Target Date</th>
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<tbody>
<tr>
<td>ISO/IEC 21122-1</td>
<td>Part 1 : Core coding system</td>
<td>Q2 2019: PROOF – to be soon published + AMD for extended cap. Q2 2020</td>
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<tr>
<td>ISO/IEC 21122-2</td>
<td>Part 2 : Profiles and buffer models</td>
<td>Q2 2019: submitted to ISO for publication + AMD for extended cap Q2 2020</td>
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<td>ISO/IEC 21122-3</td>
<td>Part 3 : Transport and container formats</td>
<td>Q3 2019: under last ballot – Final DIS</td>
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<td>ISO/IEC 21122-4</td>
<td>Part 4: Conformance testing</td>
<td>Q3 2019: under last ballot - DIS</td>
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<td>ISO/IEC 21122-5</td>
<td>Part 5 Reference software</td>
<td>Q4 2019: first ballot - CD</td>
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<tr>
<td>SMPTE 2110-22</td>
<td>Compressed essence in ST 2110</td>
<td>Final Stage.</td>
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</table>
JPEG-XS, Benefits to ST 2110

• transport of compressed essence *instead of uncompressed*.  
  – better in bandwidth to manage multiple streams in HD, 4K and 8K

• keep all existing advantages of moving to IP  
  – flexibility, scalability, unlimited accessibility

• better impact on operating and infrastructure costs  
  – upgrade capability, lower investments, lighter infrastructures & systems  
    smaller interfaces, ease the remote production and cloud migration.
JPEG-XS, Replacing Uncompressed

Combining the best speed, complexity and quality in one codec.
Test with objective and subjective methods

New ISO/IEC 29170-2 method for near-lossless quality assessment on both natural & synthetic images

- Full transparency to uncompressed down to 3bpp (10:1)
- Visually lossless down to 1.5bpp (20:1) on film/TV content
- Smooth degradation down to 0.5bpp (ringing artefacts/ no blocking artefacts!)

“FLICKER TEST“

Uncompressed

Interleave original and compressed every 1/8 sec (after 7th encode/decode)

Test on 360 scores (= persons) in total (from 4 universities/research centers)
JPEG XS, Best quality in single- and multi-generation

**SINGLE GENERATION EXPERIMENT**

ORIGINAL FRAME → ENCODER → DECODER → DECODED FRAME

PSNR

**MULTI GENERATION EXPERIMENT**

Performed for 10 generations

ORIGINAL FRAME → ENCODER → DECODER → DECODED FRAME 1

PSNR 1

ORIGINAL FRAME → ENCODER → DECODER → DECODED FRAME 2

PSNR 2
JPEG XS, Best quality in multi-generation

Notes:
- JPEG is 8bit only
- J2K is 3 to 5x more complex and needs external memory
JPEG-XS, High Quality in microseconds

Test: Natural image with equally distributed details vertically on JPEG-XS
JPEG-XS, High Quality in microseconds

Test: Natural image with equally distributed details vertically on JPEG-XS

Above 40dB typically visual lossless

Content: Alexa Drums 444 / 8 Bit

Down/Upsampling to 422 with minor effect - In this image

PSNR (dB) vs. bpp compression ratio for different codecs:
- ProRes 4444
- ProRes 422 HQ
- ProRes 422 LT
- ProRes 422 Proxy
- VC2
- JPEG2000

JPEG XS (WD)
JPEG-XS, High Quality in microseconds

Test: Mixed desktop content with natural images, CGI content, and text on JPEG-XS
JPEG-XS, High Quality in microseconds

Test: Mixed desktop content with natural images, CGI content, and text on JPEG-XS

PSNR (dB) vs bpp compression ratio

- Richter ScreenContent 444 / 8Bit

- 422 Downsampling reduces quality

- 444 recommended for text and mixed content
JPEG-XS, Minimal latency

- Down to a few **microseconds** (down to 1/10 of a millisecond): only a few video lines.
- Maximum responsiveness (few µs) – lines - perfect for any latency critical applications
- CBR (constant bitrate) for reliable video over IP transport.

*Humans are able to detect a latency only above 13 milliseconds.*

Massachusetts Institute of Technology (MIT)
JPEG XS, All platforms

Minimal complexity...leading to maximum efficiency

• Multiple profiles for Low power, Low logic
  – no external memory in hardware (FPGA, ASIC)
  – The smallest codec for FPGA at this efficiency

• Optimal syntax for software and speed optimizations (CPU, GPU)
  – up to 5x faster or more than JPEG2000 ISO standard in CPU, GPU

• Best ratio cost/infrastructure trade-off & Best ratio power trade-off
JPEG XS, Maximum Flexibility

• **Multiple resolutions**: HD, 4K, 8K... up to at least 16Kx16K

• **Multiple chroma formats**: 4:4:4, 4:2:2, 4:2:0, grayscale

• **Multiple color formats**: RGB, YUV, ...

• **Multiple bit depths**: From 8, 10, 12, 14 to 16bit

• **HDR support**: HDR support
JPEG XS, Maximum Flexibility

**Built-in 1- to 2-level downscaler**

- HD/4K/8K downscaler within workflows (i.e. for monitoring purpose)
- Lower CPU/GPU decoding requirements (less consumption to decode HD than 4K & 8K)
- Partial extraction for faster analytics and detection
JPEG XS, ST 2110 Bandwidth-efficient workflow

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<th>FORMATS</th>
<th>JPEG-XS</th>
<th>IP NETWORKS &amp; SDI MAPPING</th>
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<tr>
<td>HD 720p60 /1080i60</td>
<td>200 Mbps - 70 Mbps</td>
<td>1 to x streams over 1GbE (CAT 5e)</td>
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<tr>
<td>HD 1080p60</td>
<td>400 Mbps - 150 Mbps</td>
<td>1 to x streams over 1GbE (CAT 5e)</td>
</tr>
<tr>
<td>4K 2160p60</td>
<td>1,6 Gbps - 500 Mbps</td>
<td>1 stream over 1GbE (CAT 5e) 1 to x streams over 10GbE (CAT 6) Down to a single SDI cable (HD/3G-SDI)</td>
</tr>
<tr>
<td>8K 4320p60</td>
<td>6,4 Gbps - 2 Gbps</td>
<td>1 to 4 streams over 10 GbE (CAT 6) Down to a single SDI cable (3G/6G/12G-SDI)</td>
</tr>
<tr>
<td>8K 4320p120</td>
<td>12,8 Gbps - 4 Gbps</td>
<td>1 to 2 streams over 10 GbE (CAT 6) Down to a single SDI cable (6G/12G-SDI)</td>
</tr>
</tbody>
</table>
JPEG XS, ST 2110 Bandwidth-efficient workflow

IP INFRASTRUCTURE max. 10GbE

- IP CAMERAS
- IP REPLAY & STORAGE
- IP PRODUCTION SWITCHER
- IP MONITORING
- COTS IP SWITCH

Full access to 8K proxies directly from the coded streams
No scaling required, even from a simple laptop

HD, 4K, 8K uses no more than 10GbE or even just CAT5e

COTS in this case means max. 10GbE ports for all devices & switches
Conclusion

• JPEG-XS meets all the ST2110 quality requirements
  – CBR, latency, quality, complexity, ...

• JPEG-XS bandwidth-reduction enables to achieve more with ST2110
  – higher pixel rates, more streams, cheaper cables (CAT5e, 3G-SDI) and interfaces (<1Gbps, <10Gbps), reduced costs, reduced storage, reduced IP packets, ...

ST2110-22 & JPEG-XS are enabling to create cost-effective, bandwidth-efficient and high quality IP production workflows
Thank You

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About us, intoPIX

• Founded in 2006, HQ in Belgium.
• Technology provider of innovative compression technologies empowering visual communications.
• Member of AIMS, VSF, SMPTE and JPEG committees.
• Deliver unique FPGA/ASIC IP cores and fast SDKs to manage more pixels, preserve quality with no latency, save cost & power and simplify connectivity.
• Track record in terms of success stories, innovation achievements and effectiveness in enhancing Broadcast applications.
  – EMMY for technology & engineering on JPEG2000 VSF TR01, Invention & Standardization of TICO at SMPTE RDD35 and at JPEG as JPEG-XS, IABM Game Changer, IABM Peter Wayne Award for Innovation, EY Belgian Most promising growing company finalist, Delloite Fast50,...Serving 100+ customers worldwide
• More info on : www.intoPIX.com