Mapping SDI with a Light-Weight Compression for High Frame Rates and Ultra-HD 4K Transport over SMPTE 2022-5/6
Background

- **intoPIX**
  - Leading technology provider of image compression technology
  - Expert in JPEG 2000 IP-cores for FPGA
  - Founded in 2006, based in Belgium

- **Markets**
  - Digital Cinema
  - Broadcast
  - Pro-AV
  - Medical
  - Aerospace
  - Military
Transporting Video

- SDI-based transport: the legacy workflow for broadcast
  - Point-to-point video transmission
  - Familiar, operational practice and interoperability
  - Transport uncompressed video, multiple compression cycles
  - Need for expensive dedicated hardware

- SDTI-based transport: a nice addition
  - SDTI (SMPTE 305M) uses standard SDI interfaces
  - Enables compression, less degradation through multiple I/O systems

- Interfaces deployed in broadcast facilities
  - HD-SDI (SMPTE 292M) = 1.5Gbps
  - 3G-SDI (SMPTE 424M) = 3Gbps
  - (6G UHD-SDI (SMPTE 32NF-70) = 6Gbps)
Transporting Video

- IP-based transport: a strong market trend in broadcast
  - Packetized video transmission
  - Use of COTS, standard IT technologies
  - Reduction of cost, size, number of cables
  - Agile, flexible, and scalable workflow
  - Dealing agnostically with a multiplicity of formats
  - Reconfiguring systems without changing physical configurations
  - Ubiquitous accessibility

- Readily available interfaces
  - $1\text{GB Ethernet} = 1\text{Gbps}$
  - $10\text{GB Ethernet} = 10\text{Gbps}$
Question #1

How to upgrade legacy SDI infrastructure in studios by taking advantage of an IP-based network while maintaining the operational practices of a SDI-based workflow?
Growing Bandwidth

<table>
<thead>
<tr>
<th></th>
<th>HD 1080i60</th>
<th>HD 1080p60</th>
<th>HFR HD 1080p120</th>
<th>Ultra-HD 4K 60fps</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bandwidth</td>
<td>1.5Gbps</td>
<td>3Gbps</td>
<td>6Gbps</td>
<td>+12Gbps</td>
</tr>
<tr>
<td>Multiplier</td>
<td>1</td>
<td>x2</td>
<td>x4</td>
<td>x8</td>
</tr>
<tr>
<td>Interface</td>
<td>HD-SDI</td>
<td>3G-SDI</td>
<td>10GB Ethernet</td>
<td>?</td>
</tr>
</tbody>
</table>

- Bandwidth requirements are growing fast
  - Higher video resolutions, frame rates to transport
  - Growing number of parallel streams to manage

- Uncompressed video distribution is a real challenge
  - HFR HD on a single 3G-SDI link
  - Ultra-HD 4K on a single 10GB Ethernet link
How to transport higher resolutions, frame rates and number of streams, basically more pixels, without compromising latency and visual quality?
Rising to the Challenge

● Reality facts
  • Existing infrastructures (3G-SDI, 10GB Ethernet) limit the transport of higher quality video
  • 10Gbps is practically the upper limit to transport video over a single link
  • Broadcast industry has just upgraded from SDI to 3G-SDI and will face heavy investments to enable the transport of 4K video

● 3 keys to a smart solution
  • SMPTE 2022-5/6
  • SDI mapping
  • Light-weight compression
SDI Mapping

• SMPTE 2022-5/6 standard
  • Enables the mapping of raw SD/HD/3G-SDI video on Ethernet.
  • Supports the transfer of compressed video if:
    • Less than one frame latency
    • Sufficient compression ratio to fit
    • Visually lossless picture quality

• Light-weight visually lossless guaranteeing compression at very low compression ratio with no impact on latency seems optimal to perfectly map SDI links over Ethernet
Light compression at visually lossless ratios enables the transport of multiple video streams over a single 10GB Ethernet link

- 3 Ultra-HD 4K streams
- 6 HFR HD streams
- 6 HD streams (half bandwidth)

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<table>
<thead>
<tr>
<th>Content</th>
<th>Bitrate</th>
<th>Target</th>
<th>Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faster pixels</td>
<td>HFR HD 1080p120</td>
<td>6Gbps</td>
<td>HD-SDI</td>
</tr>
<tr>
<td>More pixels</td>
<td>Ultra-HD 4K 60fps</td>
<td>12Gbps</td>
<td>3G-SDI</td>
</tr>
<tr>
<td>More streams</td>
<td>6 x HD 1080p60</td>
<td>18Gbps</td>
<td>10G-Eth</td>
</tr>
</tbody>
</table>
Today 4:2:0 allows Ultra-HD 4K over 10GB Ethernet / HDMI 2.0

Because the human eye has lower acuity for color differences than for luminance, chroma subsampling achieves low compression ratios by simply dropping some color information.

<table>
<thead>
<tr>
<th>Subsampling</th>
<th>Description</th>
<th>Compression</th>
</tr>
</thead>
<tbody>
<tr>
<td>4:4:4</td>
<td>Full color resolution</td>
<td>1:1</td>
</tr>
<tr>
<td>4:2:2</td>
<td>Half horizontal color resolution</td>
<td>3:2</td>
</tr>
<tr>
<td>4:2:0</td>
<td>Half horizontal, vertical color resolution</td>
<td>2:1</td>
</tr>
</tbody>
</table>
Chroma Subsampling Limitations

- Chroma subsampling requires little processing, but
  - 4:1 compression ratio is out of reach
  - 4:4:4 (digital cinema) and 4:2:2 (broadcast) are mandatory for industrial compliance

- Image compression can achieve better results visually

- Hence the need for a codec specifically designed to operate at low levels of compression, without compromising visual quality and latency
Introducing TICO

- Light-weight video compression
- Visually lossless compression
  - up to 4:1 ratio
- Fixed latency
  - 1 to 8 pixel lines
- Very low hardware requirements
  - No external memory
  - Low power consumption
- Wide range of formats
  - From mobile to 8K Ultra-HD
- Designed to be a standard for industry-wide support
Mezzanine Solution

- Robustness against multiple generations
  - Wavelet-based, sub-intra frame compression
  - Constant quality through multiple encoding/decoding passes
  - No interference with the final compression format used for delivery
Using a light-weight video compression, such as TICO, over SMPTE 2022-5/6 through SDI mapping is a smart upgrade path to manage higher resolutions, frame rates and number of streams while assuring visual quality and very low hardware complexity and cost.
Future Demonstrations

- Xilinx SMPTE 2022-5/6
  - video over IP reference design
  - TICO 3G-HD and Ultra-HD 4K transport over 10GB Ethernet

- Macnica SMPTE 2022-5/6
  - video over IP reference design
  - TICO 3G-HD and Ultra-HD 4K transport over 10GB Ethernet
Thank you for your attention