

Convey UHD 4K Video over 1 Gbit Ethernet with the intoPIX JPEG 2000 “Ultra Low Latency” compression profile

Jean-Baptiste Lorent, Director of Marketing & Sales at intoPIX

Introduction

Considering the uncompressed bandwidth of a UHD 4K video stream in 4:2:2 or 4:4:4 and the massive amount of deployed Gigabit Ethernet infrastructures, a codec that can offer the same benefits in terms of quality, latency and reliability as uncompressed transport, with a sufficient compression ratio to go under 1Gbit/second, is a key advantage.

intoPIX JPEG 2000 Ultra Low Latency FPGA IP-cores are perfectly answering this challenge. The implementation brings a visually lossless compression with the necessary compression ratio and a latency going below 1 frame from the encoder to the decoder. Deployed in the AV industry (Broadcast & Pro-AV) today for HD and UHD 4K, it enables users to reach a total of 10 milliseconds for a transmission.

Since 2007, intoPIX has been developing 4K JPEG 2000 FPGA Codecs in order to efficiently and invisibly tackle important cost and bandwidth challenges faced by the AV industry. intoPIX has pushed the boundaries of traditional JPEG 2000 compression technology used in Digital Cinema with a state-of-the-art, innovative Ultra Low Latency implementation, assuring visual quality and bandwidth under 1Gbit/s and compressing the 4K bandwidth to a manageable rate, with only 10 milliseconds of latency. The technology, called Ultra Low Latency (ULL) is now used in live production, contribution and many other latency-critical AV applications.

Catching the momentum

The industry is moving to 4K (UHDTV) and 1GbE ports and routers are affordable. Current VSF JPEG 2000 TR01: 2008 recommends the use of the Broadcast JPEG 2000 profile (ISO 15444-1 AMD3) with an MPEG2 transport stream encapsulation. JPEG 2000 is an Intra-Frame codec which makes it well adapted to low-latency applications in comparison with Inter-Frame codecs. The regular JPEG 2000 implementation typically has about 3 fields/frames or more of total latency.



Below 10 millisecond with intoPIX's Ultra Low Latency mode

intoPIX Ultra Low latency JPEG 2000 compression goes below 1 frame for the total compression latency. Using the same parameters of the JPEG 2000 Broadcast profile, the Ultra Low Latency mode includes a unique intoPIX Quality Optimizer (IPX-QO) mechanism for the JPEG 2000 horizontal striping: it preserves the quality at the boundaries of each stripe and reduces this latency below one frame in total.

Visually lossless quality

The comfort zone for visually lossless quality with JPEG 2000 compression is usually in a range going from 4:1 to 16:1. For Cinema projection applications, where the viewing distance is much more controlled than in other AV applications, it can go up to 30:1 while still retaining visually lossless quality.

JPEG 2000 Video	Min bitrate (Mbit/s)	Max bitrate (Mbit/s)
1080i60 422 (1,5Gbit/s)	75	200
1080P60 422 (3Gbit/s)	100	400
2160P60 422 (12Gbit/s)*	400	1000

**For reference and comparison, today 4K24p444-12bit Cinema movies are using 250Mbit/s JPEG 2000 encoding (JPEG 2000 DCI profile) and are moving to 500Mbit/s JPEG 2000 encoding for higher frame rates.*

In professional AV applications where compression is applied in lossless or visually-lossless modes, the horizontal striping provides a perfect quality. Moreover, intoPIX's Ultra Low Latency mode brings additional robustness at the stripe boundaries when a higher compression ratio is applied. The striping mechanism typically preserves the visually lossless quality within the VSF TR01 recommended compressed bitrates ranges.

Key benefits

- Enables users to carry 4K over 1GbEthernet IP network
- Goes below 10 milliseconds (encoder + decoder)
- Offers a visually lossless quality needed in production workflows & professional AV applications

Standardization evolution: SMPTE 2022 1/2 and new VSF TR01

Broadcast contribution and remote production uses JPEG 2000 for HD transmission. Today 1GE is the obvious affordable port. 4K JPEG 2000 can be carried easily, wrapped in MPEG2-TS and SMPTE 2022 1/2 standards.

Since 2016, the VSF J2K Interop Group (www.videoservicesforum.com) is working together with broadcasters, manufacturers and intoPIX on providing a new TR01 recommendation for carrying JPEG 2000 Ultra Low Latency over MPEG2-TS and SMPTE 2022 1/2. Several implementations have already been put in place by intoPIX's customers, particularly in Studio over IP and Pro-AV. The new VSF TR01

recommendation includes the support of 4K, 8K, HDR and HFR video formats with Ultra Low Latency mode.

FPGA implementation benefits:

An important benefit of the intoPIX JPEG 2000 implementation on FPGA is that it offers a competitive solution:

- The encoder and decoder consume approximately the same amount of FPGA resources. Enabling the implementation of either an encoder or a decoder on the same FPGA device.
- The cores are easy to implement as they are provided with a reference design running on FPGA development kits.
- The Ultra Low Latency can be activated within any intoPIX JPEG 2000 cores without consuming more FPGA resources.
- The JPEG 2000 Ultra Low Latency IP-cores are delivered with an optional MPEG2-TS encapsulation / de-encapsulation IP-core that complies with the VSF TRO1 recommendation and offers a large flexibility for custom implementation.

Conclusion

In live production workflows, bidirectional broadcasting, remote collaboration, KVM, Video over IP routing, or other time accurate broadcasting, the slightest delays are unacceptable. AV manufacturers strive to bring solutions guaranteeing extremely low latency combined with image quality and quality of service.

With an FPGA-based JPEG 2000 Ultra Low Latency video technology now available, it is possible to build AV equipment that offers an incredible and robust quality during the transfer of 4K content over 1GbE links with less than 10 milliseconds of delay.

Take the NEXT STEP using intoPIX JPEG 2000 ULL on FPGAs

For more details about intoPIX 4K over IP compression FPGA solutions including JPEG 2000:



www.intopix.com/JPEG2000



www.intopix.com/J2K_booklet



www.intopix.com/XilinxJPEG2000



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www.intopix.com/XilinxTransport

Corporate Headquarters:

intoPIX SA
Rue Emile Francqui 9
B-1435 Mont-Saint-Guibert - BELGIUM
Tel.: +32 10 23 84 70 Fax: +32 10 23 84 71
sales@intopix.com

China: sales.beijing@intopix.com
sales.shanghai@intopix.com
India: sales.india@intopix.com
Israel: sales.israel@intopix.com
Japan: sales.japan@intopix.com



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