Global 8K Live Streaming Showcase 2020: The technologies behind the scenes

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1. Introduction

In December 2020 a number of technology companies have come together to demonstrate 8K live streaming over the Internet. The demonstration consisted of an end-to-end 8K live video showcase from live production to encoding, streaming and playback on 8K TVs.

Intel, NHK Technologies, Poznan Supercomputing and Networking Center – PSNC, Spin Digital, and Globo were supported by Sony, Astrodesign, and Zixi in the event.

The demonstration presented a viable workflow for 8K live streaming over the Internet and included 4 main technology components:

- **8K live production** system with multiple cameras and live switching and mixing
- **HEVC real-time encoder** with low-latency and broadcast-grade quality 8K video at low bitrate
- **Low-latency** live streaming over the public Internet
- **8K HEVC software decoder** and media player for 8K TVs with HDMI 2.1 interface

The 8K live TV programme was produced at the PSNC's 8K studio in Poznan (Poland), with the video signal encoded using Spin Digital's HEVC encoder and streamed to multiple locations across the world where it was received live and played on 8K screens. Viewing locations included NHK Technologies in Tokyo, Globo in Rio de Janeiro, Intel in Portland Oregon, and Spin Digital in Berlin.

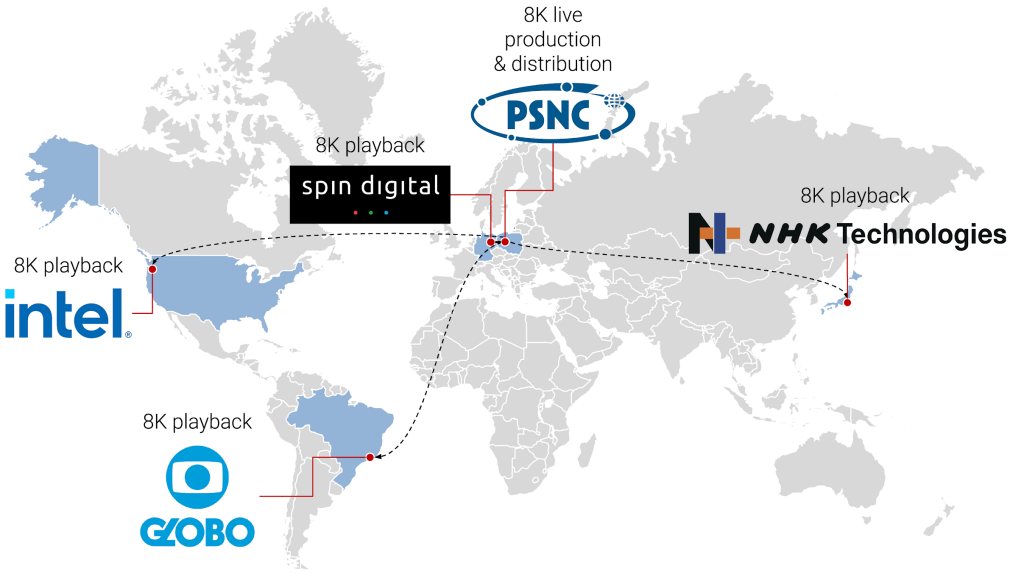

Figure 1: Global 8K live streaming over the Internet

The press release of the main original event can be found here:

- https://spin-digital.com/announcements/global-8k-live-2020/

A video summarizing the demonstration is available in Youtube:

- https://www.youtube.com/watch?v=pPDENsqsNcQ&t=54s

And an 8K HEVC encoded video with the complete program is available for download[1]:

[1] To play back the 8K video a 8K HEVC capable player is needed. It is recommended to use Spin Digital's software media player (Spin Player) installed on a Windows 10 PC with an Intel Core i9-9900X (10 cores) or equivalent processor. More information including complete system requirements and how to obtain an evaluation license of Spin Player is available here: https://spin-digital.com/products/spin_player/

- https://drive.google.com/drive/u/0/folders/1wrqiwt--nkimh94HzTaegRZ9ZgQZkGLX

This document presents further technical details on the different technologies used for the demonstration and how all the components were integrated together into a complete workflow for 8K live. It starts with a historical analysis on 8K live transmissions in order to give a perspective to the presented demonstration and to highlight the current technology readiness of 8K live solutions.

This demonstration is the result of partners' multi-year joint R&D efforts on different technologies for 8K. It is a significant milestone towards the adoption of 8K technologies for large scale live events.

2. 8K Format: An Historical Perspective

With a total resolution of 7680x4320 pixels, and four times the number of pixels per frame compared to 4K/UHD-1, the emerging 8K video format (also known as UHD-2) is designed to provide a stronger sensation of reality and a considerably greater immersive experience, with users being completely absorbed by the audiovisual content (Sugawara and Masaoka 2013). The 8K standard offers not only a higher pixel count but an improved image quality with High Dynamic Range (HDR), Wide Color Gamut (WGC), and optionally High Frame Rates (HFR) for an overall improved visual experience (Putman 2020).

Apart from technical improvements of the video quality, recent studies have shown that 8K brings in additional benefits to the subjective perceived quality such as increased perception of depth and 3-dimensionality, which results, in general, in an increased sensation of immersion and realness (Masaoka 2013), (Park, Kim, and Park 2019), (Ogura 2018).

When used for live applications, 8K aims at providing users with a highly immersive view of live events such as concerts, sports, and lectures, occurring at an event site. In addition to traditional broadcasting for home users, 8K live events can be experienced at large-screen immersive spaces with the aim of sharing a more realistic and emotional experience of the live event for group audiences.

The Japanese broadcaster NHK has pioneered the development of 8K having presented the first satellite and broadband transmissions already in 2008 (Shishikui, Fujita, and Kubota 2009), and having launched the first 8K broadcasting channel ten years later (Sujikai and Ichigaya 2021). In the meantime, from 2009 to 2017, NHK continued to carry out 8K transmission experiments over satellite, terrestrial, and IP networks (NHK 2019). 8K live pilots were showcased at some of the most important sporting events of the last decade, such as the 2012 Olympics in London (BBC 2012), the 2014 FIFA World Cup in Brazil (Stanton et al. 2015), and the 2016 Olympics in Rio (Kerschbaumer 2016).

Apart from NHK, other companies have been performing 8K live trials in the last few years. In 2017 PSNC organized an 8K live streaming demonstration for the TNC17 conference using Sony IP-Live production and a 100 Gbit/s network (Binczewski et al. 2017). In 2018 two demonstrations were performed: one via DVB-S2X satellite platform by SES, Spin Digital, and Sharp (SES 2018); and another one by TV Globo and Intelsat during the World Cup in Russia (Kurz 2018).

In 2019 three 8K live demos were performed within the context of the EU-funded Immersify project. One of these demonstrations was presented at InterBEE, in which an 8K live program was streamed from Poznan (Poland) to Tokyo (Japan) via open Internet using HLS (Immersify 2019). In the same year, SES and Spin Digital continued their efforts to validate 8K satellite transmission (SES 2019). France TV, Spin Digital, and Advantech conducted an 8K live streaming test of the Roland Garros tennis tournament via IP local network (France TV 2019). BT media also presented one of the world's first live sports broadcasts (Hernandez 2019).

Although the Tokyo Olympic Games - to be broadcasted in 8K - were postponed by one year due to the COVID-19 pandemic, a few 8K transmission pilots and demos were conducted in 2020. BT Sport and Samsung presented the UK's first public live 8K sports broadcast (Coy 2020). In the Immersify project, a demonstration of 8K live streaming over the Internet from Poznan to Linz (Austria) was realized once again in a different scenario (Immersify 2020). The Spanish broadcaster RTVE tested the 8K broadcasting workflow over the DVB-T2 terrestrial infrastructure (RTVE 2020). And, as presented in this paper, in December 2020, a group of technology companies, including Intel, PSNC, Spin Digital, NHK Technologies, and Globo, organized a global demonstration of 8K live streaming over the Internet (Spin Digital 2021).

The following table summarises the most important events related to 8K live transmission. The table shows the video coding standard and bitrate used for signal distribution as well.

Year	Organizer	Event	Transmission	Codec - Bitrate
2008	NHK	IBC 2008	Satellite and IP 8K live transmission	MPEG2 650 Mbit/s
2011	NTT, BBC, NHK	IBC 2011	Live transmission from London to Amsterdam and Tokyo via IP network	n.a. 300 Mbit/s
2012	NHK, BBC	London Olympic Games	8K live trial public viewings of the Olympic Games in the UK and Japan.	H.264 280 Mbit/s
2014	NHK	Transmission experiment	First 8K terrestrial transmission over a distance of 27 Km in Japan	H.264 91.8 Mbit/s
2014	NHK, RNP, NTT	FIFA World Cup in Brazil	Public viewing at World Cup transmitted to Japan	H.264 280 Mbit/s
2016	NHK	Olympic Games in Rio	Start of satellite broadcast tests from Rio (BR) to six public viewings in Japan	HEVC n.a
2017	PSNC	TNC17 conference	8K live streaming in 100 Gbit/s network over 1000 km (Poznan-Linz)	Sony LLVC 30 Gbit/s
2018	Spin Digital, SES, Sharp	SES Industry Days	8K transmission of pre-recorded content via satellite using DVB-S2X	HEVC (offline) 80 Mbit/s

2018	Globo, Intelsat, NTT	FIFA World Cup in Russia	8K live transmission from Moscow (RU) to Rio's science museum (BR), through Tokyo (JP) and Atlanta (US)	HEVC 90 Mbit/s
2018	NHK	NHK BS8K channel	World' first 8K satellite channel in Japan	HEVC 100 Mbit/s
2019	France TV, Spin Digital, Advantech	Roland Garros	8K live streaming over IP local network	HEVC 100 Mbit/s
2019	BT Media	IBC 2019	8K live sports broadcasts from Northampton (UK) to Amsterdam (NL)	HEVC n.a
2019	PSNC, NHK Tech., Spin Digital	InterBEE 2019	8K live production and HLS streaming from Poznan (PL) to Tokyo (JP)	HEVC 80 Mbit/s
2020	BT Sport, Samsung	Champions League	UK's first public 8K live sports broadcast	HEVC n.a
2020	RTVE	Broadcast pilot	First terrestrial transmission of 8K HDR pre-recorded signal using DVB-T2	HEVC (offline) 33 Mbit/s
2020	Spin Digital, Intel, PSNC, NHK Tech., Globo	Global IP streaming	Low-latency 8K live streaming over the Internet	HEVC 120 Mbit/s - 48 Mbit/s

Table 1. Summary of key 8K live transmission events

3. End-to-End 8K Live Streaming Workflow

The demonstration presented in December 2020 consisted of an end-to-end 8K live video streaming workflow from live production to playback on 8K screens. This live workflow consists of 4 main components:

1) **8K Live production**: An 8K live program was produced at the PSNC's 8K studio in Poznan using multiple 8K cameras, live switching system, and 5.1 audio.
2) **8K live encoding**: The resulting live 8K program was encoded using a real-time software HEVC encoder developed by Spin Digital. The encoder is able to provide broadcast-grade quality in a low-latency configuration at 120 Mbit/s, and the same level of quality was possible with a bit rate of 48 Mbit/s in a high-efficiency encoding configuration.
3) **8K low-latency streaming**: The 8K content was distributed to multiple viewing points across the globe using the open Internet. The streaming module of the encoder produced a low-latency stream that was transported over the public Internet using the Zixi protocol.
4) **8K playback**: The 8K live stream was played back using a software HEVC decoder and 8K media player developed by Spin Digital. This software media player has been optimized for 8K resolutions and live streaming with low latency.

Figure 2 shows a high level architecture of the 8K live streaming workflow used for the demonstration highlighting the mentioned components: production, encoding, streaming and playback. In the next sections there is more detailed information of each one of these components of the 8K live workflow.

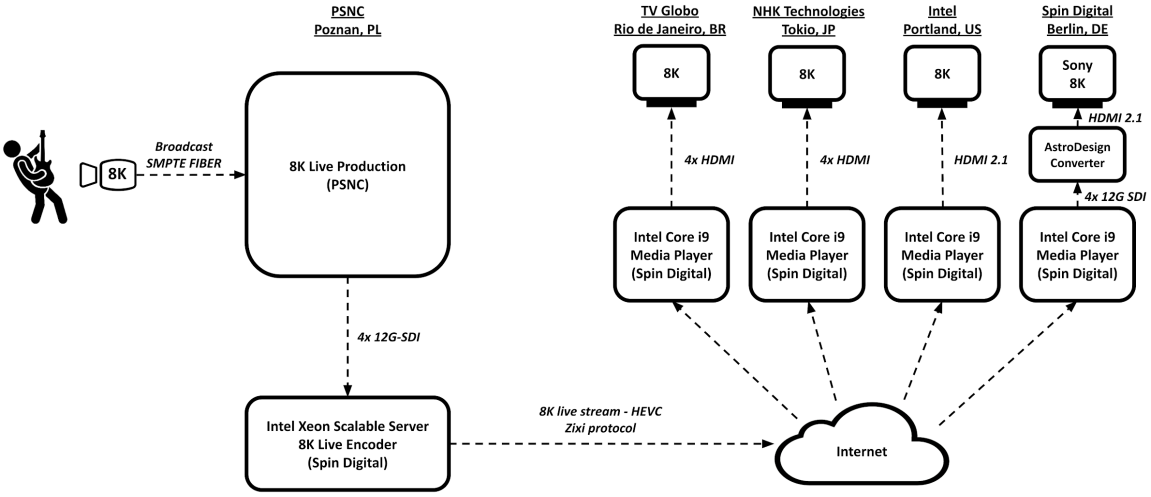

Figure 2: End-to-end 8K live streaming workflow

3.1. 8K Live Production

One of the main goals of the demonstration was to create a prototype scenario for real live 8K television production. The basic idea was to use three 8K cameras as well as additional sources of 8K video, graphics and animations that could be overlaid onto the 8K image. The demonstration took place in the space of the New Media Laboratory of the Poznan Supercomputing and Networking Center in Poznan, Poland. The lab and recording studio are both equipped with 8K video equipment, video processors, an 8K display wall (also available in 8K 3D scenario), sound system and - what is important for streaming - is connected to the Internet via a 100G broadband network.

In the demonstration, we used three Sony F65 CineAlta cameras connected via SMPTE fiber to three Baseband Processor Units BPU-8000 (Ichikawa et al. 2014). Each of them produced video at a resolution of 7680x4320 at 59.94 fps with 10-bit which was sent via 16x 3G-SDI links to the heart of the system, which were two live Barco "E2" units stacked together and working as a unified video processing system. The "E2" video processors were used to switch and mix all video streams. In addition to 8K camera inputs, they also received graphics from an overlay-graphics server, an 8K playout system, and a computer handling video-conference interface with remote demonstration participants.

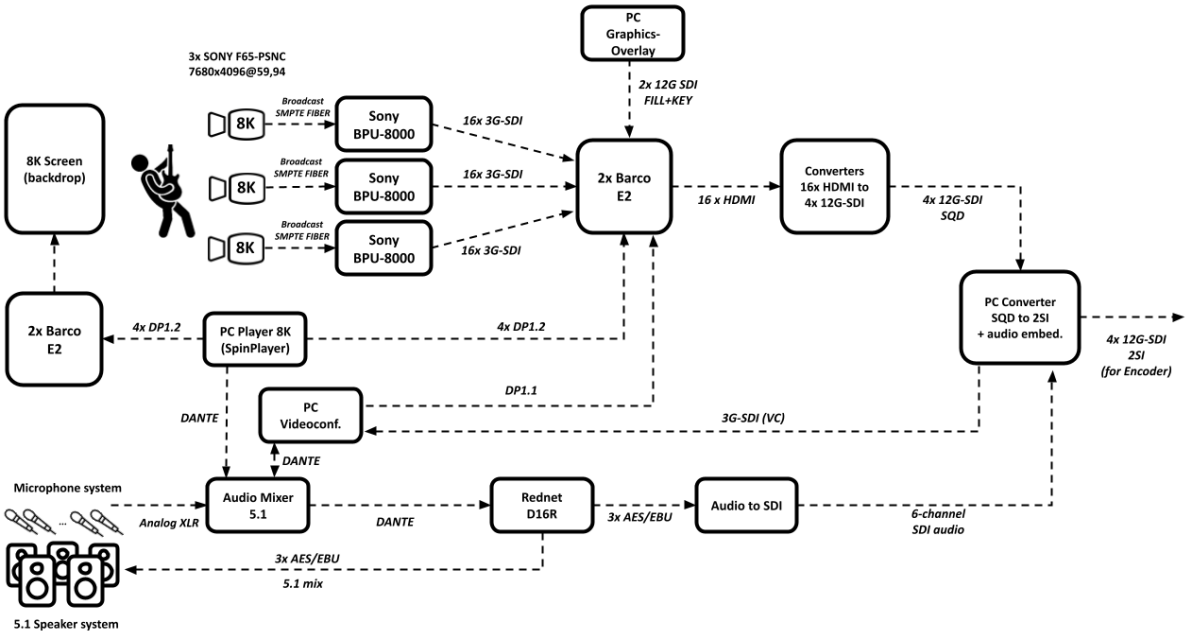

Figure 3: The 8K live production system including 5.1 live audio

The overlay-graphics server was running vMix software and produced two synchronised signals: *fill* (the actual color graphics) and *key* (premultiplied alpha channel). These two signals were processed and composed in "E2" processors, allowing any animated graphics such as artist signatures, lower thirds or animated logos of partners and clocks to be overlaid on the final 8K resolution program output. There were also two additional signal sources: one from PC-based media server running Spin Digital's 8K media player (Spin Player), which provided additional 8K video content, and the other one feeding the view of video-conference with project partners at the receiving locations. With these additional sources it was possible to both playback pre-recorded videos in 8K as well as include the view of the remote partners.

Each video signal was controlled and mixed from the management console, where the TV switching engineer decided which signals and graphics to show in the final 8K program stream. Regarding the fact that the output of "E2" video processors was 16x HDMI connections, and the encoder and streaming server operated on 4x 12G-SDI 2-Sample Interleave (2SI) source signals, there was a need of using a chain of additional converters. Since there was no single device in the Lab that could perform all the necessary conversions, several separate converters had to be used. First, all 16x HDMI signals were converted to 16x 3G-SDI and then to 4x 12G-SDI Square-Division (SQD). The conversion between SQD and 2SI was performed on a PC workstation equipped with two BlackMagic DeckLink 8K Pro video cards. Another task of the PC converter machine was embedding SDI audio into the first of four 2SI output links.

The sound was recorded using a Sennheiser EW 500 G3 wireless microphone system and sent to Yamaha QL5 Digital Mixing Console. Then the 6-channel audio (5.1) was transmitted using the DANTE network protocol to AES3 converter and finally was embedded in SDI link and delivered to the converter PC.

Figure 4: Artist on stage and 8K camera in action at PSNC 8K TV production lab

Figure 5: PSNC controlling room. Audio and 8K video production

3.2. 8K Live Encoding

One of the key components in an 8K live workflow is the distribution encoder. Its main task is to compress the 8K signal at a relatively low bitrate, so that the resulting bitstream can be transmitted over current distribution networks (Internet, satellite, cable, etc.), and do it at a very high quality in order to ensure a high quality of experience expected from an 8K service. Moreover, the encoder has to compress the 8K signal in real-time and in low-latency in order to ensure a maximum end-to-end latency for the target live applications.

Among the available distribution video coding standards such as H.264/AVC, HEVC/H.265, AV1, VVC/H.266, currently HEVC represents the state-of-the-art in UHD (4K and 8K) compression for live workflows. Recent codecs such as AV1 or VVC can provide lower bitrates for 8K video compared to HEVC but at the cost of a very high computational complexity. Currently, there are no solutions available for 4K or 8K live encoding with AV1 or VVC.

As a result, HEVC is the best choice for 8K live workflows: it offers very high compression efficiency and implementations have achieved very high performance, both for 8K decoding and encoding for live applications. The licensing issues affecting HEVC, which have prevented the initial deployment of the codec, have been addressed by the licensors and are now well understood, at least in the broadcast industry.

Spin Digital has developed a high-quality high-performance HEVC live encoder, known as Spin Enc Live (Spin Digital 2020), which is tailored to high-end video applications, such as 4K and 8K broadcasting and live streaming using a software CPU-based solution.

The new encoder is based on Spin Digital's advanced decision algorithms for fast and high-quality encoding, which are combined with a highly optimized software implementation for Intel Xeon Scalable processors in order to achieve a very high level of quality and performance. The encoder includes SIMD processing using Intel's AVX-512 instructions and Intel DL Boost technologies, and scalable multithreading for systems that can include hundreds of CPU cores. As a result, Spin Enc live is able to produce quality and compression levels similar to best-in-class offline encoders (typically used for VoD) while, at the same time, providing the performance required for processing 8K signals at 60 frames per second in real-time.

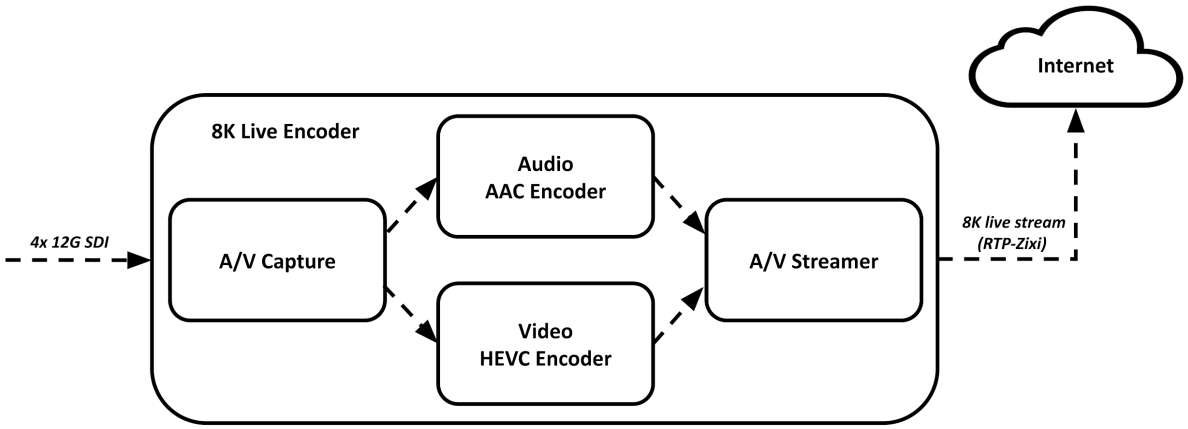

Figure 6: System diagram of the Spin Enc Live 8K real-time encoder

Spin Enc Live can be used in high-efficiency and low-latency environments. The high-efficiency configuration provides the highest quality and compression at the expense of higher latency, and it is typically addressed towards broadcast and Internet distribution applications. Subjective tests have shown that 8Kp60 broadcast quality can be achieved at a bitrate of 48 Mbit/s (Sanz and Nikrang 2020). The low-latency configuration guarantees a minimum end-to-end latency of 750 ms (assuming ideal transmission channel). In order to have a similar quality as with the high-efficiency configuration

the bitrate has to be increased to 120 Mbps. The low-latency configuration is addressed towards broadcast contribution and immersive live experience applications.

In addition to the HEVC encoder, Spin Enc Live provides the I/O modules needed for complete live applications such as 12G SDI video (and audio) capture, and TS over IP (TSoIP) and chunk-based live streaming (HLS).

Figure 6 shows a high level view of the encoder architecture used during the 8K live demonstration. The 8Kp60 production signal was sent via 12G SDI to the encoder, which was placed at PSNC's Media Lab. The low-latency configuration of the encoder was used to compress the video at 120 Mbit/s in broadcast-grade quality. The encoder was also tested using its high-efficiency configuration, achieving the same level of quality with a bitrate of 48 Mbit/s. The 5.1-channel audio signal was encoded in AAC-LC at a bitrate of 384 kbit/s. The encoded audiovisual signal was encapsulated using MPEG2-TS and RTP and streamed over the Internet using the Zixi protocol as described in the next section.

3.3. 8K Live Delivery over IP Networks

One of the objectives of the 8K live streaming demonstration was to deliver the 8K live signal over the public Internet without using expensive dedicated networks. This required the use of state-of-the-art live encoders capable of reducing the bitrate to acceptable levels for current Internet bandwidths, as shown in the previou section. In addition, it was required to provide the 8K live signal at the lowest possible latency in order to enable a sense of participation from the remote audiences in the live event. Combining low-bitrate Internet distribution and low-latency streaming required a carefully designed interaction between the live encoder, the streaming module, and the decoder at the receiving end.

Encoder streaming module: TS over IP

The encoder includes an streaming module that encapsulates the encoded audio and video signal using MPEG2-TS and produces an IP (UDP or RTP) stream for low-latency delivery over IP networks (TSoIP). In addition to encapsulation, MPEG2-TS provides information to enable synchronized decoding of multimedia information over a wide range of reception conditions. The method of synchronization in MPEG2-TS is based on the System Target Decoder (STD). The STD model is a buffer management model, which is used by encoders and decoders for interoperability. The STD specifies the decoder buffer sizes to hold coded media data and the time when a frame can be removed from the buffer and decoded as well as any reordering before display. The STD is very similar to the HEVC's hypothetical reference decoder (HRD) model and preserves the constraints given by the HRD model on picture timing, buffer size and buffer handling (Schierl et al. 2012).

Spin Enc Live streaming module produced an HEVC video (and AAC audio) stream compliant with the STD and HRD models given some buffer constraints. For the low latency application scenario used in this demonstration the HRD buffer was set to 200 ms (for high efficiency configuration the HRD buffer was set to 1000 ms).

Loss recovery and low-latency retransmision using Zixi

Delivering MPEG2-TS or RTP packets directly over the public Internet will result in significant quality degradations due to packet losses. Using TCP-based protocols such as RTMP or HTTP (DASH, HLS) would guarantee correct delivery but at the expense of very high latency. A third option is to use protocols that support Automatic Repeat reQuest (ARQ) such as Zixi, RIST or SRT (Wånggren and Thyresson 2019). For the 8K live streaming demonstration we selected the Zixi protocol. All of these protocols address two main requirements for low-latency streaming over the Internet:

- Loss recovery: using ARQ techniques for recovering packets lost due to Internet transmission.
- Low-Latency: perform the selective retransmission in a low-latency manner

The MPEG2-TS stream that was produced by the encoder was transmitted over the Internet using the Zixi protocol in a proxy configuration. A Zixi sender was connected to the encoder and a Zixi receiver to the decoder. The latency and buffering of the Zixi sender and receiver were configured in order to ensure reliable transmission at lowest latency possible (see section on latency analysis).

Low-latency streaming player

On the receiver side the Zixi receiver provided the 8K decoder with an MPEG2-TS stream free of packet losses. The decoder then used the MPEG2-TS time samples to synchronize in the lowest latency possible with the encoder.

3.4. 8K Decoding and Playback

The 8K live stream was played back using Spin Digital's software media player called Spin Player. A new version of the media player specially designed for low-latency 8K live streaming was used. The media player consists of three main components:

- **Streaming reception**: The source module receives the TS encoded stream, demuxes the audio and video streams, and estimates the master clock based on the time samples present in the MPEG2-TS stream. This master clock is then used for the remaining player tasks such as decoding and rendering procedures
- **HEVC decoding**: Spin Digital optimized HEVC decoder was used for decoding. The decoder is a software solution optimized for recent CPUs. 8Kp60 at 120 Mbit/s can be decoded in real-time on a PC system with at least 10 X86 64-bit high-performance CPU cores.
- **Rendering**: The media player includes a flexible rendering and output module with support for GPUs or SDI devices. Depending on the 8K screen different interfaces can be used such as 4x HDMI 2.0 for legacy devices, HDMI 2.1 that supports 8Kp60 with a single cable, and 12G SDI for professional players requiring maximum quality.

The stream reception, decoder and renderer were configured for low-latency applications by minimizing the input buffering, number of frames in flight, and rendering buffers. The low-latency operation depends on the tight coupling between the encoder and decoder which was guaranteed by the low-latency streaming and selective retransmission implemented in the Zixi protocol.

The figure below shows the player configurations with different interfaces used during the demonstration.

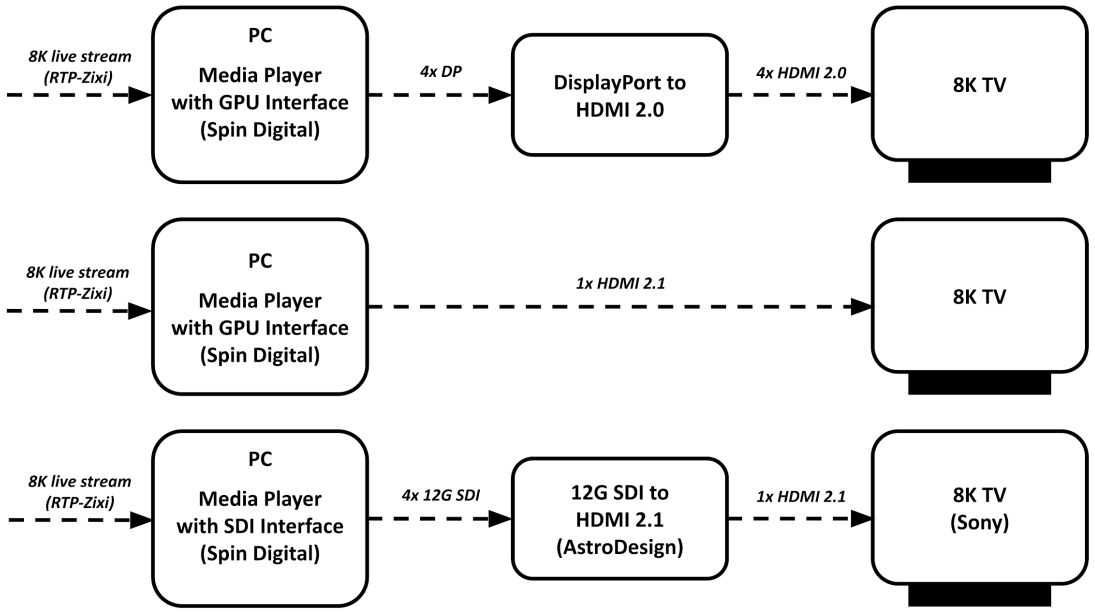

Figure 7: 8K media players with support for different 8K AV interfaces

4. Latency Analysis

Combining the low-latency configuration of the encoder and the low-latency settings in the transport protocol it was possible to transmit the 8K live video program with a glass-to-glass latency between 1 and 2 seconds depending on the location.

The end-to-end latency from Poznan to the different playback locations across the world was measured using synchronized clocks. The table below shows the end-to-end latency measurements and the contribution of the different components in the live workflow. Latency contributions are divided into three groups:

- **Live Production**: includes the 8K camera processing, live switching, and HDMI and SDI conversions.
- **Encoder + Playback**: includes SDI capture, HEVC encoding, MPEG2-TS muxing, demuxing, decoding and rendering.
- **Transmission (Zixi + network)**: includes the network delay as well as the selective retransmission performed by the Zixi protocol.
- **End-to-end Measured**: is the total latency measured using the synchronized clocks. It is approximately the same as the addition of the three previous components.

From Poznan (PL) to	Live Production	Encoder + Playback	Transmission (Zixi + Network)	End-to-end Measured
Berlin (DE)	260 ms	700 ms	185 ms	1145 ms
Portland (US)	260 ms	750 ms	504 ms	1514 ms

Tokyo (JP)	260 ms	750 ms	972 ms	1982 ms
Rio de Janeiro (BR)	260 ms	750 ms	1251 ms	2261 ms

Table 2. End-to-end latency contributions and measurements

As shown in the table, the main contributors to the overall latency are the encoding and decoding processes. The playback system installed in Berlin was able to reduce the playback latency by 50 ms by using an SDI renderer instead of the GPU-based renderer used in the other players. The transmission delay, as expected, was very dependent on the physical distance between origin and destination with the lowest being from Poland to Germany (185 ms) and longest from Poland to Brazil (1251 ms).

The encoder was also configured in high efficiency mode at 48 Mbit/s. As mentioned before this mode allows for higher compression but requires higher encoding latencies. The obtained end-to-end latencies were: 3591 ms to Berlin, 4285 ms to Tokyo, and 3922 ms to Portland.

5. Technical Specifications

Below we summarize the main technical specifications of the signal and systems used in the demonstration:

8K live production	- 3 Sony F65 CineAlta cameras with BPU-8000 - 8k live switching system built using Barco “E2” - Graphics-overlay with vMix - 4x 12G SDI (2SI) output interface
8K output video format	- Resolution and frame rate: 7680x4320 - 59.94 Hz - Color sampling and characteristics: 4:2:0, 10-bit, SDR, BT.709

Encoder	- Codec: HEVC/H.265 - Main 10 Profile - level 6.1
	- Encoder: Spin Digital’s Spin Enc Live v1.0
	- Bitrate:
	  - 120 Mbit/s (low-latency configuration)
	  - 48 Mbit/s (high efficiency configuration)
	- Platform: 4x Intel Xeon Platinum 8280 CPUs (total of 112 cores)

Audio	- Format: 5.1 channels - Codec: AAC-LC - Bitrate: 384 kbit/s
Distribution	- HTTP streaming with HLS and AWS CloudFront CDN distribution - MPEG2-TS over IP with RTP - Point to multipoint transport using Zixi broadcaster
Media player	- Spin Digital Media Player (Spin Player) v2.2.2 - Platform 1: Intel Core i9-9940X with GPU and HDMI 2.1 - Platform 2: Intel Xeon W-3265 with 12G SDI

8K TVs and interfaces	- TV: Sony KD-75ZH8 8K HDR Full Array LED TV - 12G SDI to HDMI 2.1 converter: Astrodesign 7076

6. Conclusion

In this paper we presented the technical details of the workflow used for an end-to-end 8K live video streaming showcase. It includes a detailed description of the live production, real-time 8K encoding, low-latency Internet streaming and playback on 8K TVs.

8K live streaming was first demonstrated by NHK in 2008 using a dedicated network and an MPEG-2 codec at 600 Mbit/s. 12 years later 8K live streaming was performed over the public Internet and using a state-of-the-art HEVC encoder at 120 Mbit/s.

We presented all the components needed for a real 8K live production. It starts from an 8K live production in a TV studio with multiple 8K cameras, graphics overlays, live switching, and live audio production. The live feed was compressed using a state-of-the-art HEVC software encoder for reducing the bitrate needed for 8K live applications making possible the delivery of broadcast-grade quality video at low-latency. An optimized streaming module based on TS over IP (TSoIP) and Automatic Repeat reQuest (ARQ) protocols such as Zixi was carefully integrated with the encoder and decoder in order. This allowed us to recover from packet losses due to Internet transmission and provide low-latency streaming over the public Internet. A software decoder and media player optimized for live and low-latency streaming was used for 8K video playback connecting to 8K screens using multiple interfaces.

Low-latency high-quality 8K live streaming over the public Internet opens possibilities for new immersive live experiences where events at venue locations can be experienced with audiences around the world in a way that gives the viewers at the remote locations a higher sense of a shared experience and connection with the performers.

We will continue the development of the production, encoding, streaming, and playback systems as well as performing pilots, tests and validations with the objective of making 8K live streaming a practical reality in applications such as live sports, concerts, lectures, and other areas where this new format can offer a new and more immersive experience to end users.

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