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Enabling the Dolby® AC-4 Audio Coding Technology in European Broadcast Ecosystems

John Hope, Gael Lassure (Dolby); K. Mathew (Envivio); Nicolas Chesne, Ripinder Singh (STM)

Introduction

Since May 2014, the Conseil Supérieur de l'Audiovisuel (the French regulatory authority) authorized UHD broadcasting trials from the Eiffel Tower (UHF-C26) of two UHD TV programs in a DVB-T2 multiplex operated by TDF.

In May 2014 and 2015, in addition to its satellite and IP live services, France Televisions used one of these DTT channels during the French Open tennis tournament for UHD TV pilot trials with regular 4K/UHD receivers from the consumer market. In 2015, Dolby, along with TDF and Envivio, proposed a set of trials to demonstrate the first live broadcast of a UHD signal with the baseline profile of the new Dolby® AC-4 audio codec and with 4Kp50 video, in addition to a traditional stereo audio channel. These trials presented Dolby with an opportunity to demonstrate that Dolby AC-4 could coexist in a 4K-HEVC-T2 ecosystem without additional financial outlay by broadcasters. A number of European OEMs contributed Dolby AC-4 developmental products to the trials. For Dolby, the principal aim in these live sports event trials was to verify expected operation of the Dolby AC-4 codec in an end-to-end live broadcast chain.

The Dolby AC-4 Codec

Dolby AC-4, the new audio codec standardized in ETSI TS 103 190, improves upon today's use cases by increasing reach, simplifying operations, and improving accessibility. Furthermore, Dolby AC-4 also enables next-generation experiences such as personalized and immersive audio. At the heart of increased reach is a highly efficient audio compression codec, capable of rendering quality audio of 5.1 surround sound at 96 kbps or stereo at 48 kbps. This represents a 2:1 improvement in coding efficiency over Dolby Digital Plus™ (E-AC-3). This, combined with the capability to efficiently deliver multi-language content and optimized audio reproduction for every playback environment, extends the reach even further.

Dolby AC-4 simplifies operations by providing unique tools that address two common issues: simplified loudness management and the ability to maintain audio/video synchronization. The encoder provides real-time loudness management for non-loudness-corrected sources. It also enables improved dialogue intelligibility for today's pre-mixed content and tomorrow's object-based content. Among transmission codecs, Dolby AC-4 is the first in the world to have the capability to be used in a video-synchronous mode, where frames of Dolby AC-4 are coded and aligned with frames of corresponding video.

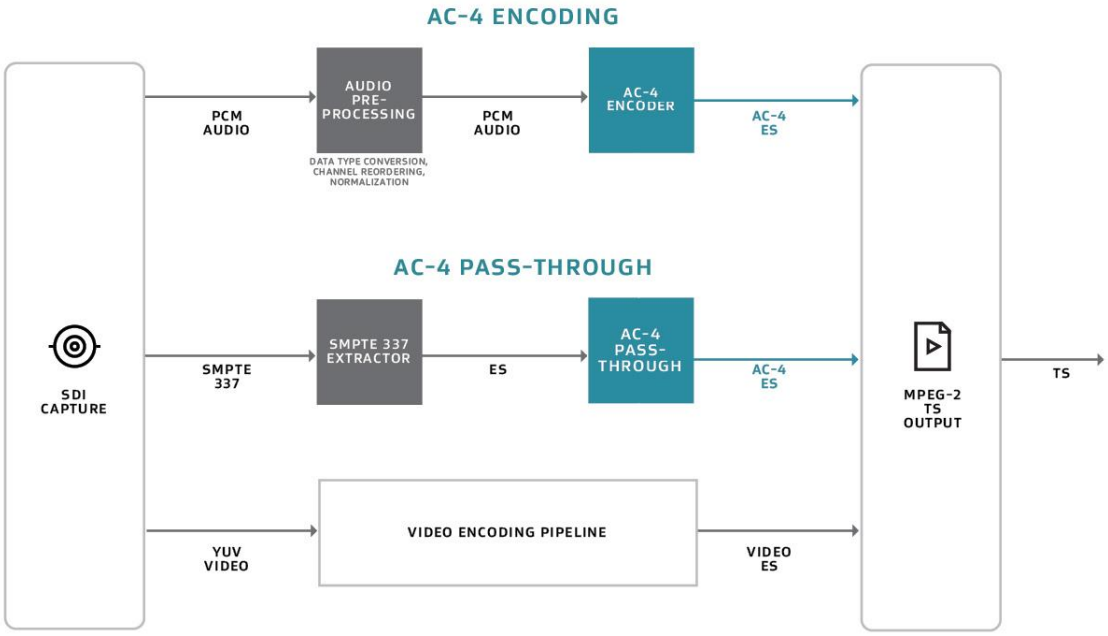
Dolby AC-4 was designed from the ground up to take advantage of object-based audio. This means that Dolby AC-4 supports deployment of Dolby Atmos® and other immersive and personalized sound experiences in next-generation broadcast systems.

Enabling the Products

TRANSMISSION ENCODER

For DTT, the live transmission encoder chosen for the France Televisions trials at the 2015 French Open tennis tournament was the Envivio Muse™ UHD 4K Any-Screen Live Encoder/Transcoder. The Muse UHD employs a proprietary multiprocessor software approach, distributing HEVC encoding across multiple server nodes to provide the power to perform high-quality UHD compression on industry-standard servers. This enables seamless migration to HEVC, with cost-effective, scalable deployment in the data center and the cloud. Figure 1 shows a high-level block diagram of the Muse UHD, focused on the support of Dolby AC-4.

Figure 1. High Level Block Diagram of Envivio Muse UHD



The primary developmental activity integrates a Dolby AC-4 encoder SDK that supports encoding of up to six channels of 48 kHz PCM audio carried on the 3G-SDI input. The encoding pipeline for Dolby AC-4 is similar to other Dolby audio codecs already supported by the Muse UHD, with control and status communicated through the application programmer interface (API) of the SDK.

The SDK is configured with the desired encoding parameters, and it returns the codec latency, which Muse uses to adjust the MPEG-2 audio time stamps for correct A/V synchronization.

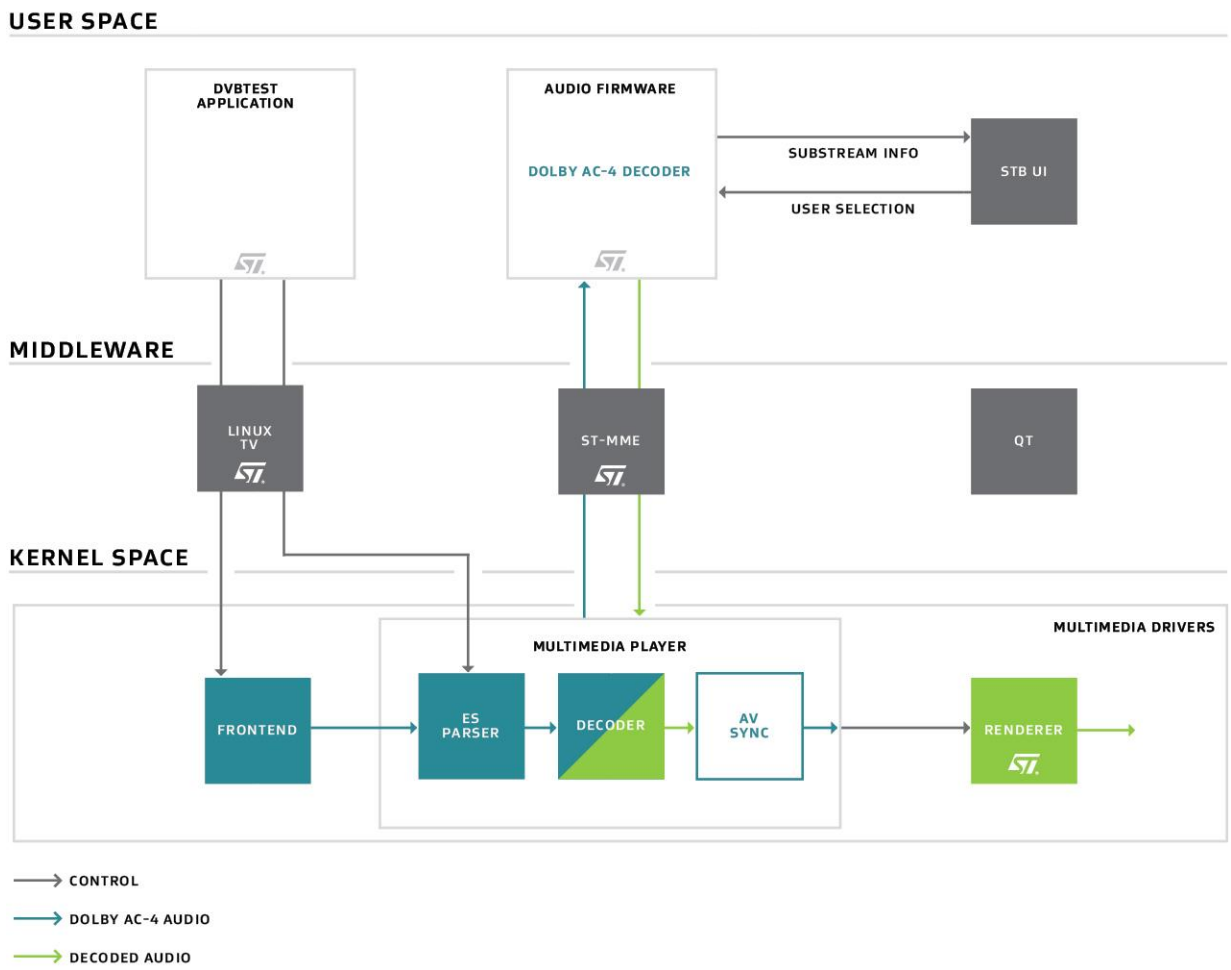
Another area of development is the support of pass-through multiplexing of pre-encoded Dolby AC-4, when input to Muse as coded audio embedded on SDI to SMPTE 337. The Muse pass-through module monitors the coded frames extracted by the SDI capture module and computes the bit rate of the Dolby AC-4 bitstream, using toc_parser and br_calc code libraries supplied by Dolby.

The Dolby AC-4 elementary stream produced by the encoder module or the pass-through module is input to the MPEG-2 multiplexer, which calculates the optimal number of Dolby AC-4 frames per PES packet. The bitstream is then packetized and multiplexed with HEVC video to create an MPEG-2 transport stream on UDP for transmission.

SET-TOP BOX

As a partner of the Dolby initiative to deploy Dolby AC-4 throughout the broadcast ecosystem, ST Microelectronics (STM) has integrated the codec into its receiver system. This is accomplished by enabling the playback of 4K video paired with Dolby AC-4 audio on the STiH418-based set-top box (STB) reference platform, associated with a DVB-T2 tuner. The goal was to demonstrate an STB that fully integrates the new decoder through its generic middleware and multimedia drivers. The final platform can then seamlessly switch between the legacy TV channels and enhanced media channels. The required additions are shown in the block diagram in Figure 2.

Figure 2. Block Diagram of Set-Top Box Architecture



Neither the front end (the demodulation and transport-stream demultiplexing stages) nor the back end (the rendering stage) requires modification to cope with the new audio format. Only the decoding stage must be enhanced to be Dolby AC-4 capable. In the STM software architecture, the decoding stage is split into three blocks: frame parsing, decoding, and A/V synchronization logic. While the frame parsing is part of the multimedia drivers, the decoding is off-loaded using a multimedia engine interface (ST-MME). On this platform, STM has integrated the Dolby AC-4 decoder as an ST-MME component that runs on the host processor (ARM® Cortex™ A9) and uses Dolby AC-4 decoder libraries that the Dolby implementation team optimized for ARM NEON™ technology.

Lastly, the A/V synchronization logic does not require any change, as the Dolby AC-4 decoder precisely reports its internal decoding delay. The synchronization logic directly uses this information to adjust the presentation time of each decoded frame.

Some minor changes were also required on the standard interfaces to expose the Dolby AC-4 decoder through the Linux® DVB API so that the application could select the correct decoding chain, depending on the content being broadcast.

Monitoring and Quality Control

The MPEG-2 transport stream output of the Envivio Muse UHD is formatted into UDP protocol and carried on an IP link, known as the "TS over IP" format. The advantage is that PC-based transport-stream analyzer tools are available from OEMs such as DekTec, which also contributed to the trials by adding Dolby AC-4 bitstream parsing and analysis to its existing StreamXpert® analyzer software. UDP streams containing Dolby AC-4 can also be generated by the DekTec PC-based StreamXpress® tool, enabling convenient testing of STB and TV sets in isolation.

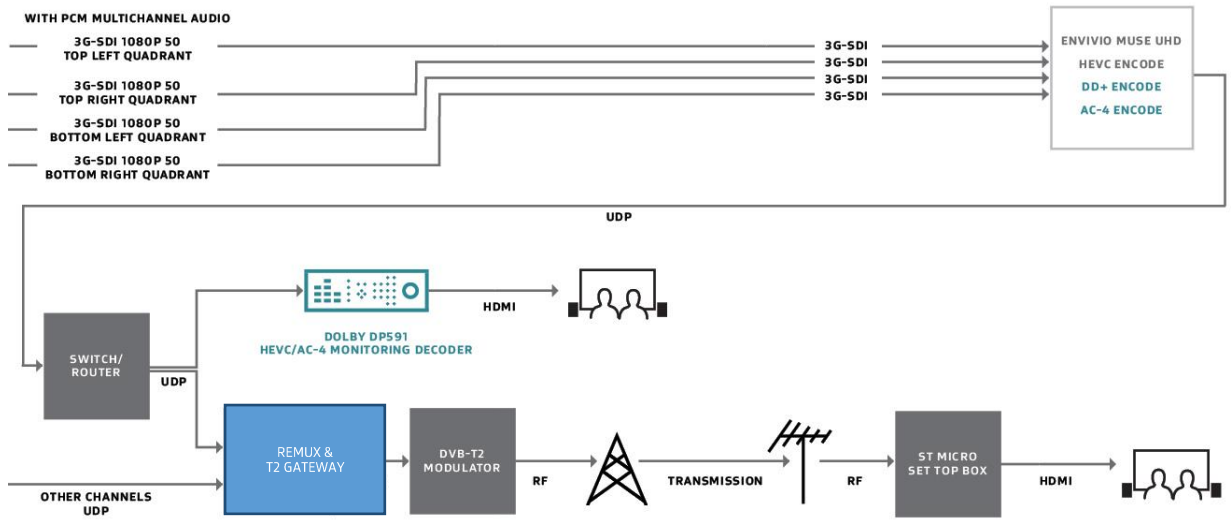
Workflow

At the live international sports event trials, Dolby AC-4 encoding in stereo and 5.1 surround sound was used in conjunction with 4K 10-bit HEVC video to produce a 22 Mbps MPEG-2 transport stream, transmitted via IP link to the Eiffel Tower and remultiplexed with a second UHD program before DVB-T2 broadcasting to a set-top box at a remote location on the demo booth.

A four-wire 3G-SDI-based workflow was adopted for these trials, as hardware and equipment for this mode of 4K carriage are more readily available than for the alternative two-wire 6G-SDI and single-wire 12G-SDI systems. Two system architectures were initially considered: pass-through and integrated encoding/multiplexing.

In the pass-through workflow, the Dolby AC-4 encoding takes place in a side chain that contains a Dolby AC-4 encoder, and the encoded Dolby AC-4 is re-embedded onto an embedded pair of the Top Left 3G-SDI. The four 3G-SDI signals of the main chain are delayed prior to the re-embedding to compensate for the latency of the Dolby AC-4 encoder. However, as Envivio succeeded in integrating the Dolby AC-4 encoder SDK into the Muse, the decision was made to use the significantly simpler integrated encoding/multiplexing workflow (Figure 3) for the trials.

Figure 3. Integrated Encoding/Multiplexing Workflow



The workflow shown in Figure 3 leads to simple interconnection and synchronization, because all encoding and multiplexing into MPEG-2 transport stream packets is performed by one piece of equipment—the Envivio Muse UHD. This design also supports simulcast operation by encoding incoming PCM audio into Dolby Digital Plus for transmission on legacy services. A Dolby AC-4 monitoring decoder serves as a confidence decoder of the Dolby AC-4 bitstream at the transmission site. The RF signal is received and decoded by the STB.

The use of UHDTV1-Phase1 (50p) and HEVC encoding exacerbated the normal challenge of performing live trials with a new audio codec, particularly in regard to the availability of test tools, 4K players, and general broadcast equipment. By pursuing cooperative development with several OEM partner companies, Dolby was able to address the needs of the entire broadcast ecosystem and meet these challenges.

Conclusion

The successful live-broadcast trials at this international sports event were the first live deployment of the Dolby AC-4 audio codec in an end-to-end workflow of 4Kp50 video and HEVC, transmitted over DVB-T2 terrestrial television. Further trials in France and in other countries are scheduled for later this year. Dolby's ecosystem-wide development approach, coupled with the dedication and willingness of our early adopter OEM partners, directly led to the success of the project. The Dolby AC-4 codec has been demonstrated to be a simple-to-integrate, bit-rate–efficient audio codec that well complements emerging video and transmission technologies.