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Backwards-compatible object audio carriage using Enhanced AC-3

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Introduction

Motivation

In traditional channel-based audio mixing, sound elements are mixed to the fixed speaker channels, i.e. left, right, centre, left surround and right surround. This paradigm is well known and works when the channel configuration at the decoding end can be predetermined, or assumed with reasonable certainty to be 2.0, 5.X or 7.X.

However, with the popularity of new speaker setups, no assumption can be made about the speaker setup used for playback. Therefore, channel-based audio does not offer a sufficient method for adapting a representation where the source speaker layout does not match the speaker layout at the decoding end. This presents a challenge when trying to author content that plays back well independently to the speaker configuration.

In object-based audio, individual sound elements are delivered to the playback device, where they are rendered based on the used speaker layout. Because individual sound elements can be associated with a much richer set of metadata, giving meaning to the elements, the method of adaptation to the speaker configuration reproducing the audio can provide better information regarding how to render to fewer speakers.

Enhanced AC-3 (E-AC-3), defined in ETSI TS 102 366 [1], is a widely used format for transmission of channel-based audio content. When the goal is to transport object-based audio in an environment where compatibility with pre-existing devices is paramount, joint object coding (JOC), as specified in the present document, can be used in conjunction with E-AC-3.

Document structure

The present document is structured as follows:

- Clause 4 explains the concept of object-based audio (OBA) and specifies the decoder interface.
- Clause 5 specifies object audio metadata (OAMD), the OBA metadata format.
- Annex B specifies how OAMD can be converted to an audio definition model (ADM), providing an interconnection to the professional metadata generation and monitoring.
- Clause 6 specifies the JOC tool that converts the output of an E-AC-3 decoder to objects, as specified in ETSI TS 102 366 [1].
- Clause 7 specifies the quadrature mirror filter bank tool that is used by the JOC tool.
- Annex C lists requirements on packaging a bitstream as defined in the present document into an ISO based media file format.
- Annex D lists requirements on an MPEG DASH media presentation description signaling a bitstream as defined in the present document.
- Annex E provides requirements on a MPEG CMAF compliant media format containing a bitstream as defined in the present document.

1 Scope

The present document specifies an extension to the E-AC-3 codec.

The extension adds an object-based three-dimensional spatial representation of coded audio information and metadata. It is backward compatible with the one- and two-dimensional channel-based spatial representation of coded audio information as defined in ETSI TS 102 366 [1].

NOTE: In this context, backward compatibility is defined as follows: The three-dimensional spatial representation specified in the present document can be decoded on a device compliant with the syntax and semantics specified in ETSI TS 102 366 [1]. In this case, such a device will output one- or two-dimensional channel-based audio as per the coding algorithm defined in ETSI TS 102 366 [1] alone. Thus, support for decoders specified in ETSI TS 102 366 [1] and associated user experiences are fully maintained with the extension defined herein.

The present document specifies the following:

- 1) Syntax and semantics of the OBA metadata, carried via the extensible metadata delivery format (EMDF), specified in ETSI TS 102 366 [1]
- 2) Syntax and semantics of metadata to control a tool for conversion of one- or two-dimensional channel-based audio to a higher number of audio signals, part of the three-dimensional spatial representation (JOC)
- 3) Additional requirements on the E-AC-3 decoder as specified in ETSI TS 102 366 [1]
- 4) Requirements on the OBA, the JOC tool, the quadrature mirror filter bank tool, packaging the bitstream into ISO based media file format, the signalling in an MPEG DASH media presentation description, and requirements on a MPEG CMAF compliant media file, containing a bitstream as defined in the present document.
- 5) Informative guidance for conversion from 1) to the ADM as defined in Recommendation ITU-R BS.2076 [i.1]

2 References

2.1 Normative References

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The following referenced documents are necessary for the application of the present document.

- [1] ETSI TS 102 366: "Digital Audio Compression (AC-3, Enhanced AC-3) Standard".
- [2] ISO/IEC 23000-19: "Common Media Application Format for Segmented Media".
- [3] ISO/IEC 23009-1: 'Dynamic adaptive streaming over HTTP (DASH) -- Part 1: Media presentation description and segment formats'.
- [4] ISO/IEC 14496-12: "Information technology -- Coding of audio-visual objects -- Part 12: ISO base media file format".

2.2 Informative References

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The following referenced documents are not necessary for the application of the present document, but they assist the user with regard to a particular subject area.

[i.1] Recommendation ITU-R BS.2076: "Audio Definition Model".

3 Definitions of terms, symbols, abbreviations and conventions

3.1 Terms

For the purposes of the present document, the following terms apply:

audio channel: data representing an audio signal designated to a dedicated speaker position

audio definition model: metadata model describing format and content of audio files, specified in Recommendation ITU-R BS.2076 [i.1]

audio object: data representing an object essence plus corresponding object properties

bed: group of multiple bed objects

bed object: static object whose spatial position is fixed by an assignment to a speaker

block: portion of a frame

channel-based audio: audio content that is presented by one or more audio signals and a corresponding channel configuration

channel configuration: targeted speaker layout

codec frame: series of PCM samples or encoded audio data representing the same time interval for all channels in the configuration

NOTE: Decoders usually operate in a codec-frame-by-codec-frame mode.

common media application format: MPEG media file format optimized for delivery of a single adaptive multimedia presentation to a large number and variety of devices; compatible with a variety of adaptive streaming, broadcast, download, and storage delivery methods

DASH descriptor: DASH element used for property signalling

NOTE: DASH descriptors share a common structure.

DASH supplemental property descriptor: DASH descriptor that specifies supplemental information about the containing DASH element that may be used by the DASH client for optimizing the processing

decoder interface: interoperability point of a decoder, accepting input data, providing output data, or both

elementary stream: bitstream that consists of a single type of encoded data (audio, video, or other data)

Enhanced AC-3: audio coding system developed by Dolby and specified in ETSI TS 102 366 [1]

extensible metadata delivery format: set of rules and data structures that enables robust signaling of metadata in an end-to-end process, involving a container, metadata payloads, and authentication protocols

NOTE: Specified in ETSI TS 102 366 [1].

intermediate spatial format: format that defines spatial position by distributing the signal to speakers located in a stacked-ring configuration

ISO based media file format: media file format as specified in ISO/IEC 14496-12 [4]

joint object coding: algorithms for delivering immersive audio at low bitrates, achieved by conveying a multi-channel downmix of the immersive content using perceptual audio coding algorithms together with parametric side information that enables the reconstruction of the audio objects from the downmix in the decoder

low-frequency effects: optional single channel of limited bandwidth (typically less than 120 Hz)

media presentation description: formalized XML-based description for a DASH media presentation for the purpose of providing a streaming service

object audio essence: part of the object that is PCM coded

object audio metadata: metadata used for rendering an audio object. The rendering information may dynamically change (e.g. gain and position)

object-based audio: audio comprised of one or more audio objects

object property: metadata associated with an object essence, which indicates the author's intention for the rendering process

pulse code modulation: digital representation of an analog signal where the amplitude of the signal is sampled at uniform intervals

QMF subband: frequency range represented by one row in a QMF matrix, carrying a subsampled signal

quadrature mirror filter bank: process in which a time-domain signal is transformed into the frequency domain and split into a filter bank comprising a number of frequency bands

rendering: processing of audio content to adapt it to a specific loudspeaker layout

room-anchored coordinates: coordinates specifying a position relative to a coordinate system which is fixed with respect to a room

screen-anchored coordinates: coordinates specifying a position relative to a coordinate system that is fixed with respect to the display surface in a room

speaker-anchored coordinates: coordinates specifying a position by choosing one speaker in a specific speaker layout

substream: part of an AC-4 bitstream, contains audio data and corresponding metadata

zone: sub-volume of the listening room

3.2 Symbols

For the purposes of the present document, the following symbols apply:

$\lceil x \rceil$	round x towards plus infinity
$\lfloor x \rfloor$	round x towards minus infinity
i	the imaginary unit

3.3 Abbreviations

For the purposes of the present document, the following abbreviations apply:

ADM	Audio Definition Model
CMAF	Common Media Application Format
DASH	Dynamic Adaptive Streaming over HTTP
E-AC-3	Enhanced AC-3
EMDF	Extensible Metadata Delivery Format
HH	Hours
HTTP	HyperText Transfer Protocol
IDX	Index
ISF	Intermediate Spatial Format
JOC	Joint Object Coding
LFE	Low-Frequency Effects
MM	Minutes
MPD	Media Presentation Description
MPEG	Moving Pictures Expert Group
MSB	Most Significant Bit
MTX	Matrix
MULZ	Mid-Upper-Lower-Zenith
OAMD	Object Audio MetaData
OBA	Object-Based Audio
PCM	Pulse Code Modulation
QMF	Quadrature Mirror Filter
SR	Stacked Ring
SS	Seconds
VEC	Vector
ZB	Bottom zone
ZU	Top zone

3.4 Conventions

Unless otherwise stated, the following conventions are used in the present document.

Typographic conventions:

- Italic font denotes variables (*n* is a variable)
- Monospace font denotes bitstream elements (`bits` is a bitstream element)

Function prototypes can take scalars, vectors, or matrices as argument and operate element-wise. The return type is either scalar or of the same form as the argument:

min(x)	The minimum value of the elements of <i>x</i>
max(x)	The maximum value of the elements of <i>x</i>
floor(x)	The largest integer(s) less than or equal to the elements of <i>x</i>
mod(a,b)	denotes the remainder of <i>a</i> after division by <i>b</i>
cos(x)	The cosine of the elements of <i>x</i>
sin(x)	The sine of the elements of <i>x</i>
exp(x)	The exponential value of the elements of <i>x</i>

NOTE 1: The return value of `exp()` can be complex valued.

NOTE 2: The return value of `mod()` can have a fractional part.