Guidelines for Implementation: DASH-AVC/264 Interoperability Points

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DASH Industry Forum

Version 2.0

Note: This document is no specification.

Scope

The scope of the interoperability points defined in this document is to provide basic support for high-quality video distribution over the top. Both live and on-demand services are supported. Extensions for improved audio-visual experience are defined.

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Contents

List of Figures

List of Tables

Acronyms, abbreviations and definitions

For acronyms, abbreviations and definitions refer to ISO/IEC 23009-1 [1].

In addition, the following abbreviations and acronyms are used in this document:

AAC	Advanced Audio Coding
AVC	Advanced Video Coding
DRM	Digital Rights Management
DTV	Digital Television
FCC	Federal Communications Commission
GOP	Group-of-Pictures
HD	High-Definition

1	HDMI	High-Definition Multimedia Interface
2	KID	common Key IDentifier
3	IDR	Instantaneous Decoder Refresh
4	PCM	Pulse Code Modulation
5	PPS	Picture Parameter Set
6	PS	Parametric Stereo
7	SBR	Spectral Band Replication
8	SD	Standard Definition
9	SMPTE	Society of Motion Picture and Television Engineers
10	SPS	Sequence Parameter Set
11	TT	Timed Text
12	TTML	Timed Text Markup Language

1. Introduction

The scope of the initial DASH-AVC/264 interoperability point is the basic support high-quality video distribution over the top. Both live and on-demand services are supported. It is expected that the client supports at least

- presentation of progressive high-definition video up to 720p (based on H.264/AVC [5][6] Progressive High Profile),
- presentation of stereo audio (based on HE-AAC v2 Profile [9]),
- support of basic subtitles (based on ISO/IEC 14496-30 [20]),
- basic support for encryption/DRM (based on ISO/IEC 23001-7 [21]).

In addition, it is recognized that certain clients may only be capable to operate with H.264/AVC Main Profile. Therefore content authors may provide and signal a specific subset of DASH-AVC/264 by providing a dedicated interoperability identifier referring to a standard definition presentation. This interoperability point is defined as DASH-AVC/264 SD.

In addition, one extension for HD video (up to 1080p) and several multichannel audio extensions are defined.

Test cases and test vectors for DASH-AVC/264 Interoperability Points are defined in [23]. The conformance and reference software for DASH-AVC/264 Interoperability Points is defined in [24] (based on the MPEG conformance software [2]).This version of the document defines the following Interoperability Points. The version in which each Interoperability Point was added is also provided in Table 1.

Table 1 Interoperability Points and Extensions defined in this document

Interoperability Point or Extension	Identifier	Version	Section
DASH-AVC/264	`http://dashif.org/guidelines/dash264`	1.0	6.3
DASH-AVC/264 SD	`http://dashif.org/guidelines/dash264#sd`	1.0	7.3
DASH-AVC/264 HD	`http://dashif.org/guidelines/dash264#hd`	2.0	8.3
DASH-IF multichannel audio extension with Enhanced AC-3	`http://dashif.org/guidelines/dashif#ec-3`	2.0	9.4.2.3
DASH-IF multichannel extension with Dolby TrueHD	`http://dashif.org/guidelines/dashif#mlpa`	2.0	9.4.2.3

DASH-IF multichannel audio extension with DTS Digital Surround	`http://dashif.org/guidelines/dashif#dtsc`	2.0	9.4.3.3
DASH-IF multichannel audio extension with DTS-HD High Resolution and DTS-HD Master Audio	`http://dashif.org/guidelines/dashif#dtsh`	2.0	9.4.3.3
DASH-IF multichannel audio extension with DTS Express	`http://dashif.org/guidelines/dashif#dtse`	2.0	9.4.3.3
DASH-IF multichannel extension with DTS-HD Lossless (no core)	`http://dashif.org/guidelines/dashif#dtsl`	2.0	9.4.3.3
DASH-IF multichannel audio extension with MPEG Surround	`http://dashif.org/guidelines/dashif#mps`	2.0	9.4.4.3
DASH-IF multichannel audio extension with HE-AACv2 level 4	`http://dashif.org/guidelines/dashif#heaac-mc51`	2.0	9.4.5.3
DASH-IF multichannel audio extension with HE-AACv2 level 6	`http://dashif.org/guidelines/dashif#heaac-mc71`	2.0	9.4.5.3

Beyond these initial IOPs and extensions, it is expected that additional IOPs and extensions will be defined in future versions of this document.

2. Definition and Usage of Interoperability Points

2.1. Profile Definition in ISO/IEC 23009-1

MPEG DASH defines formats for MPDs and segments. In addition MPEG provides the ability to further restrict the applied formats by the definition of *Profiles* as defined on section 8 of ISO/IEC 23009-1 [1]. Profiles of DASH are defined to enable interoperability and the signaling of the use of features.

Such a profile can also be understood as permission for DASH clients that implement the features required by the profile to process the Media Presentation (MPD document and Segments).

Furthermore, ISO/IEC 23009-1 permits external organizations or individuals to define restrictions, permissions and extensions by using this profile mechanism. It is recommended that such external definitions be not referred to as profiles, but as *Interoperability Points*. Such an interoperability point may be signalled in the `@profiles` parameter once a URI is defined. The owner of the

URI is responsible to provide sufficient semantics on the restrictions and permission of this interoperability point.

This document makes use of this feature and provides a set of Interoperability Points. Therefore, based on the interoperability point definition, this document may be understood in two ways:

- a collection of content conforming points, i.e. as long as the content conforms to the restrictions as specified by the IOP, clients implementing the features can consume the content.
- a client capability points that enable content and service providers for flexible service provisioning to clients conforming to these client capabilities.

2.2. Usage of Profiles

A Media Presentation may conform to one or multiple profiles/interoperability points and conforms to each of the profiles indicated in the **`MPD`**`@profiles` attribute is specified as follows:

When `ProfA` is included in the **`MPD`**`@profiles` attribute, the MPD is modified into a profile-specific MPD for profile conformance checking using the following ordered steps:

1. The **`MPD`**`@profiles` attribute of the profile-specific MPD contains only `ProfA`.
2. An **`AdaptationSet`** element for which `@profiles` does not or is not inferred to include `ProfA` is removed from the profile-specific MPD.
3. A Representation element for which `@profiles` does not or is not inferred to include `ProfA` is removed from the profile-specific MPD.
4. All elements or attributes that are either (i) in this Part of ISO/IEC 23009 and explicitly excluded by `ProfA`, or (ii) in an extension namespace and not explicitly included by `ProfA`, are removed from the profile-specific MPD.
5. All elements and attributes that "may be ignored" according to the specification of `ProfA` are removed from the profile-specific MPD.

An MPD is conforming to profile `ProfA` when it satisfies the following:

1. `ProfA` is included in the **`MPD`**`@profiles` attribute.
2. The profile-specific MPD for `ProfA` conforms to ISO/IEC 23009-1
3. The profile-specific MPD for `ProfA` conforms to the restrictions specified for `ProfA`.

A Media Presentation is conforming to profile `ProfA` when it satisfies the following:

1. The MPD of the Media Presentation is conforming to profile `ProfA` as specified above.
2. There is at least one Representation in each Period in the profile-specific MPD for `ProfA`.
3. The Segments of the Representations of the profile-specific MPD for `ProfA` conform to the restrictions specified for `ProfA`.

2.3. Interoperability Points and Extensions

This document defines Interoperability Points and Extensions. Both concepts make use of the profile functionality of ISO/IEC 23009-1.

Interoperability Points provide a basic collection of tools and features to ensure that content/service providers and client vendors can rely to support a sufficiently good audio-visual experience. Extensions enable content/service providers and client vendors to enhance the audio-visual experience provided by an Interoperability Point in a conforming manner.

The only difference between Interoperability Points and Extensions is that Interoperability Points define a full audio-visual experience and Extensions enhance the audio-visual experience in typically only one dimension.

Examples for the usage of the `@profiles` signaling are provided in Annex A of this document.

3. DASH-Related Aspects

3.1. Scope

DASH-AVC/264 is uses ISO base media file format based encapsulation and has significant commonality with a superset of the ISO BMFF On-Demand and the ISO BMFF Live profile as defined in ISO/IEC 23009-1 [1], sections 8.3 and 8.4, respectively. DASH-AVC/264 is intended to provide basic support for on-demand and live content. The primary constraints imposed by this profile are the requirement that each Representation is provided in one of the following two ways

- as a single Segment, where Subsegments are aligned across Representations within an Adaptation Set. This permits scalable and efficient use of HTTP servers and simplifies seamless switching. This is mainly for on-demand use cases.
- as a sequence of Segments where each Segment is addressable by a template-generated URL. Content generated in this way is mainly suitable for dynamic and live services.

In both cases (Sub)Segments must begin with Stream Access Points (SAPs) of type 1 or 2, i.e. regular IDR frames in case of video. In addition, (Sub)Segments are constrained so that for switching video Representations within one Adaptation Set the boundaries are aligned without gaps or overlaps in the media data. Furthermore, switching is possible by a DASH client that downloads, decodes and presents the media stream of the come-from Representation and then switches to the go-to Representation by downloading, decoding and presenting the new media stream. No overlap in downloading, decoding and presentation is required for seamless switching of Representations in one Adaptation Set.

3.2. DASH features

3.2.1. Introduction

This section introduces the detailed constraints of the MPD and the DASH segments in a descriptive way referring to ISO/IEC 23009-1 [1]. The DASH-based restrictions have significant commonality with the ISO BMFF Live and On-Demand profiles from the MPEG-DASH specification.

Specifically:

- Segment formats are based on ISO BMFF with fragmented movie files, i.e. (Sub)Segments are encoded as movie fragments containing a track fragment as defined in ISO/IEC 14496-12 [4], plus the following constraints to make each movie fragment independently decodable:
  - Default parameters and flags are stored in movie fragments ('`tfhd`' or '`trun`' box) and not track headers ('`trex`' box)
  - The '`moof`' boxes shall use movie-fragment relative addressing for media data that does not use external data references, and the flag '`default-base-is-moof`' shall also be set and `data-offset` shall be used, i.e. `base-data-offset-present` shall not be used (follows ISO/IEC 23009-1 [1]).
- Alignment with ISO BMFF Live & On-Demand Profiles, i.e. within each Adaptation Set the following applies
  - Fragmented movie files are used for encapsulation of media data
  - (Sub)Segments are aligned to enable seamless switching

Beyond the constraints provided in the ISO BMFF profiles, the following additional restrictions are applied.

- IDR-like SAPs (i.e., SAPs type 2 or below) at the start of each (Sub)Segment for simple switching.
- Segments have almost equal duration. The maximum tolerance of segment duration is ±50% and the maximum accumulated deviation over multiple segments is ±50% of the signaled segment duration (i.e. the `@duration` attribute or the **`S`**`@d` in the **`SegmentTimeline`**). Such fluctuations in actual segment duration may be caused by for example ad replacement or specific IDR frame placement. Note that the last segment in a representation may be shorter according to ISO/IEC 23009-1 [1].

  Note: If accurate seeking to specific time is required and at the same time a fats response is required one may use On-Demand profile for VoD or the **`SegmentTimeline`** based addressing. Otherwise the offset in segment duration compared to the actual media segment duration may result in a less accurate seek position for the download request, resulting in some increased initial start-up. However, this problem is expected to be specific for only a small subset of applications.

- The **`SegmentTimeline`** adheres to similar constraints as above and is only used in order to signal occasional shorter Segments (possibly caused by encoder processes) or to signal gaps in the time line. It is not used for providing Segments with significantly varying duration. The timing in the segment timeline shall be accurate and no constraints on segment duration deviation are added except the maximum segment duration as specified in the MPD.
- only non-multiplexed Representations are supported, i.e. each Representation only contains a single media component.

- Addressing schemes are restricted to
    - templates with number-based addressing
    - templates with time-based addressing
    - subsegments with segment index. In this case either the `@indexRange` attribute is expected to be present.
- the '`lmsg`' brand for signaling the last segment is applied for any content with **`MPD`**`@minimumUpdatePeriod` present and the **`MPD`**`@type="dynamic"`.
- In case multiple Adaptation Sets with `@contentType='video'` are offered, exactly one video Adaptation Set is signaled as the main one unless different Adaptation Sets contain the same content with different quality or different codecs. In the latter case, all Adaptation Sets with the same content shall be signaled as the main content. Signalling as main content shall be done by using the Role descriptor with `@schemeIdUri="urn:mpeg:dash:role:2011"` and `@value="main"`.
- Restrictions on the presence of certain elements and attributes as defined section 3.2.4.

It is expected that a DASH-AVC/264 client is able to process content offered under these constraints. More details on expected client procedures are provided in section 3.3.

3.2.2. Media Presentation Description constraints

DISCLAIMER: This section serves for the definition of the interoperability point in a similar way, as done for the profile definitions in ISO/IEC 23009-1, but is not intended as a normative specification.

> NOTE: The term "ignored" in the following description means, that if an MPD is provided and a client that complies with DASH-AVC/264 removes the element that may be ignored, then the MPD is still complying with the constraints of the MPD as defined in ISO/IEC 23001-9, section 5.

The Media Presentation Description shall conform to the following constraints:

— The rules for the MPD and the segments as defined in ISO/IEC 23001-9, section 7.3, shall apply.

— Representations with value of the `@mimeType` attribute other than `xxx/mp4` with `xxx={video, audio, application, text, subtitle}` or `application/xml+ttml` may be ignored. Additional profile or codec specific parameters may be added to the value of the MIME type attribute. For details refer to specific parameters below.

— The **`Subset`** element may be ignored.

— The **`Period.SegmentList`** element shall not be present.

— If the **`AdaptationSet.SegmentList`** is present in an **`AdaptationSet`** element then this **`AdaptationSet`** element may be ignored.

- If the **Representation.SegmentList** is present in a **Representation** element then this **Representation** element may be ignored.

- Elements using the `@xlink:href` attribute may be ignored from the MPD. The Representations conforming to this profile are those not accessed through an Adaptation Set that uses an `@xlink:href`.

- An **AdaptationSet** containing **ContentComponent** element may be ignored, i.e. an Adaptation Set with multiplexed media streams may be ignored. Note that the information present in the **ContentComponent** element may be added to the **AdaptationSet** element.

- An **AdaptationSet** element not including the parameters as mandated in section 3.2.4 for an Adaptation Set may be ignored.

- A **Representation** element not including the parameters as mandated in section 3.2.4 may be ignored.

- If the **MPD**`@type` is equal to "`static`" and the **MPD**`@profiles` attribute includes "`urn:mpeg:dash:profile:isoff-on-demand:2011`" then

  - **AdaptationSet** elements with **AdaptationSet**`@subsegmentAlignment` not present, or set to '`false`' may be ignored.

  - **Representation** elements with a `@subsegmentStartsWithSAP` value absent, zero or greater than 2 may be ignored.

  - If the **Representation** element does not contain a **BaseURL** element then this **Representation** element may be ignored.

- If the **MPD**`@type` is equal to "`dynamic`", then

  - the **MPD**`@profiles` attribute shall include the signaling for the "`urn:mpeg:dash:profile:isoff-live:2011`"

- if the **MPD**`@profiles` attribute includes "`urn:mpeg:dash:profile:isoff-live:2011`", then

  - **AdaptationSet** elements with **AdaptationSet**`@segmentAlignment` not present, or set to '`false`' may be ignored.

  - **Representation** elements with a `@startWithSAP` value absent, zero or greater than 2 may be ignored.

  - The attribute **MPD**`@maxSegmentDuration` shall be present.

— If a Period contains multiple Adaptation Sets with `@contentType="video"` then at least one Adaptation Set shall contain a Role element `<Role schemeIdUri="urn:mpeg:dash:role:2011" value="main">` and each Adaptation Set containing such a **`Role`** element shall provide perceptually equivalent media streams.

3.2.3. Segment format constraints

Representations and Segments referred to by the Representations in the profile-specific MPD for this profile, the following constraints shall be met:

— Representations shall comply with the formats defined in ISO/IEC 23009-1, section 7.3.

— In Media Segments, all Segment Index ('`sidx`') and Subsegment Index ('`ssix`') boxes, if present, shall be placed before any Movie Fragment ('`moof`') boxes.

— If the **`MPD`**`@type` is equal to "`static`" and the **`MPD`**`@profiles` attribute includes "`urn:mpeg:dash:profile:isoff-on-demand:2011`", then

  — Each Representation shall have one Segment that complies with the Indexed Self-Initializing Media Segment as defined in section 6.3.5.2 in ISO/IEC 23009-1.

— If the **`MPD`**`@type` is equal to "`dynamic`" and **`MPD`**`@minimumUpdatePeriod` is present, then if the Media Segment is the last Media Segment in the Representation, this Media Segment shall carry the '`lmsg`' compatibility brand.

3.2.4. Presence of Attributes and Elements

Elements and attributes are expected to be present for certain Adaptation Sets and Representations to enable suitable initial selection and switching.

Specifically the following applies:

- For any Adaptation Sets with `@contentType="video"` the following attributes shall be present
  - `@maxWidth` (or `@width` if all Representations have the same width)
  - `@maxHeight` (or `@height` if all Representations have the same height)
  - `@maxFrameRate` (or `@frameRate` if all Representations have the same frame rate)
  - `@par`

  Note: The attributes `@maxWidth` and `@maxHeight` are expected to be used such that they describe the target display size. This means that they may exceed the actual largest size of any coded Representation in one Adaptation Set.

- For any Representation within an Adaptation Set with `@contentType="video"` the following attributes shall be present:
  - `@width`, if not present in **`AdaptationSet`** element
  - `@height`, if not present in **`AdaptationSet`** element
  - `@frameRate`, if not present in **`AdaptationSet`** element
  - `@sar`
- For Adaptation Set or for any Representation within an Adaptation Set with `@contentType="video"` the attribute `@scanType` shall either not be present or shall be set to "`progressive`".
- For any Adaptation Sets with value of the `@contentType="audio"` the following attributes shall be present
  - `@lang`
- For any Representation within an Adaptation Set with value of the `@contentType="audio"` the following elements and attributes shall be present:
  - `@audioSamplingRate`, if not present in **`AdaptationSet`** element
  - **`AudioChannelConfiguration`**, if not present in **`AdaptationSet`** element

3.2.5. Dimension Constraints

No constraints are defined on MPD size, or on the number of elements.

3.2.6. Generic Metadata

Generic metadata may be added to MPDs based on DASH. For this purpose, the Essential Property Descriptor and the Supplemental Property Descriptor as defined in ISO/IEC 23009-1 [1], clause 5.8.4.7 and 5.8.4.8, may be added.

Metadata identifiers for content properties are provided here: http://dashif.org/identifiers.

However, it is not expected that DASH-AVC/264 clients supports all metadata at `http://dashif.org/identifiers` unless explicitly required.

3.3. Client Implementation Guidelines

As mentioned, the DASH-related aspects of the interoperability point as defined in section 3.2 can also be understood as permission for DASH clients that only implement the features required by the description to process the Media Presentation (MPD document and Segments). However, the detailed DASH-AVC/264 DASH-related client operation is not specified. Therefore, it is also unspecified how a DASH client exactly conforms. This document however provides guidelines on what is expected for conformance to this interoperability point.

The DASH-related aspects in DASH-AVC/264 as well as for the ISO BMFF based On-Demand and Live profiles of ISO/IEC 23009-1 are designed such that a client implementation can rely on relatively easy processes to provide an adaptive streaming service, namely:

- selection of the appropriate Adaptation Sets based on descriptors and other attributes
- initial selection of one Representation within each adaptation set
- download of (Sub)Segments at the appropriate time
- synchronization of different media components from different Adaptation Sets
- seamless switching of representations within one Adaptation Set

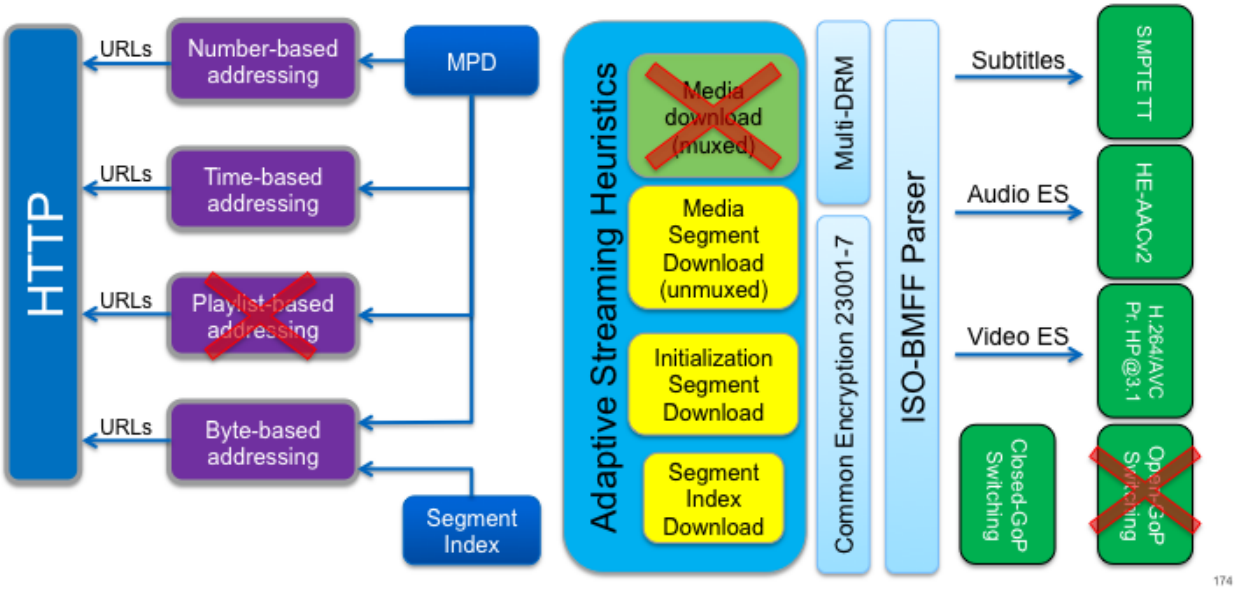


Figure 1 DASH aspects of a DASH-AVC/264 v1 client compared to a client supporting the union of DASH ISO BMFF live and on-demand profile.

Figure 1 shows the DASH aspects of a DASH-AVC/264 client compared to a client supporting all features of the DASH ISO BMFF Live and On-Demand profile. The main supported features are:

- support of HTTP GET and partial GET requests to download Segments and Subsegments
- three different addressing schemes: number and time-based templating as well as byte range based requests.
- support of metadata as provided in the MPD and Segment Index
- download of Media Segments, Initialization Segments and Segment Index
- ISO BMFF parsing
- synchronized presentation of media components from different Adaptation Sets
- switching of video streams at closed GOP boundaries

The features of the client are expected to be tested in an interoperability effort to ensure full support. Based on test cases, more detailed client requirements may be added.

3.4. Transport-Related Issues

3.4.1. General

It is expected that servers and clients operating in DASH-AVC/264 environments support the normative parts of HTTP/1.1 as defined in RFC2616 [18]. Specifically

- Clients are expected to support byte range requests, i.e. issue partial GETs to subsegments. Range requests may also be issued by using Annex E of 23009-1 using the syntax of the second example in Annex E.3,

  BaseURL@byteRange="$base$?$query$&range=$first$-$last$"

- HTTP Servers serving segments are expected to support suitable responses to byte range requests (partial GETs). HTTP Servers may also support the syntax using Annex E of 23009-1 using the syntax of the second example in Annex E.3,

  BaseURL@byteRange="$base$?$query$&range=$first$-$last$"

- Clients are expected to follow the reaction to HTTP status and error codes as defined in section A.7 of ISO/IEC 23009-1.

3.4.2. Synchronization Considerations

In order to properly access MPDs and Segments that are available on DASH servers, DASH servers and clients are expected to synchronize their clocks to a globally accurate time standard. Specifically it is expected that the Segment Availability Times as computed from the MPD according to ISO/IEC 23009-1 [1], section 5.3.9.5 and additional details in ISO/IEC 23009-3 [3], section 6.4 are accurately announced in the MPD.

Options to obtain timing for a DASH client are for example:

- Usage of NTP or SNTP as defined in RFC5905 [33].
- The Date general-header field in the HTTP header (see RFC2616 [18], section 14.18) represents the date and time at which the message was originated, and may be used as an indication of the actual time.

Anticipated inaccuracy of the timing source is expected to be taken into account when requesting segments close to their segment availability time boundaries.

3.5. Considerations for Live Services

Live services are supported in DASH. MPEG defines two types of Media Presentations: static and dynamic. For static Media Presentations all segments are available at the value of **MPD**@availabilityStartTime. For dynamic Media Presentations, Segments get available over time. If **MPD**@type="dynamic" then this provides an indication to the client at startup to join at the live edge, i.e. download the latest available segment and start playing from there on. To determining the latest available segment, please refer to the details in ISO/IEC 23009-3 [3], section 6.4.

In addition, to communicate unforeseen events such as the addition of a new period in a live service or the end of the Media Presentation, MPEG-DASH supports an MPD update procedure as defined in section 5.4 of ISO/IEC 23009-1 [1]. If the attribute **MPD**@minimumUpdatePeriod is present

updates to the MPD are expected and restricted in a sense that at the location where the MPD is available at a certain time, the MPD is also valid for the duration of the value of the **MPD**@minimumUpdatePeriod attribute.

If the attribute **MPD**@minimumUpdatePeriod is set to 0 then all Segments with availability start time less than the request time of the MPD are available at the location advertised in the MPD.

DASH clients operating based on such an MPD and consuming the service at the live edge typically need to request a new MPD prior to downloading a new segment. However, in order to minimise MPD requests and resulting traffic load, the client may use one or more of the following optimisations:

- If the client fetches the MPD using HTTP, the client should use conditional GET methods as specified in RFC 2616 [18], clause 9.3 to reduce unnecessary network usage in the downlink.
- Clients may also rely on the 'lmsg' message and request a new MPD only in case a segment is received with an 'lmsg' brand. Otherwise the client may use template constructions to continue determining the URL and the segment availability start time of segments. If the server implements other means to provide indication of MPD updates, e.g. in band events, and the client is aware of this, the client may also use this signal to trigger the request of an updated MPD.

If the attribute **MPD**@minimumUpdatePeriod is set to a value greater than 0 then all Segments with availability start time less than the sum of the request time and the value of the **MPD**@minimumUpdatePeriod will eventually get available at the advertised position at their computed segment availability start time. Note that by providing a **MPD**@minimumUpdatePeriod is set to a value greater than 0, DASH servers reduce the polling frequency of clients, but at the same time cannot expect that clients will request an updated MPD to be informed on changes in the segment URL constructions, e.g. at the start of a new Period.

4. Media Coding Technologies

4.1. Introduction

In addition to DASH-specific constraints, DASH-AVC/264 also adds restrictions on media codecs and other technologies. This section provides an overview on technologies for different media components and how they fit into the DASH-related aspects of DASH-AVC/264.

4.2. Video

4.2.1. General

The codec considered for basic video support up to 1280 x 720p at 30 fps is H.264 (AVC) Progressive High Profile Level 3.1 decoder [6]. This choice is based on the tradeoff between content availability, support in existing devices and compression efficiency.

Further, it is recognized that certain clients may only be capable to operate with H.264/AVC "Progressive" Main Profile Level 3.0 and therefore content authors may provide and signal a specific subset of DASH-AVC/264.

Notes

- H.264 (AVC) Progressive High Profile Level 3.1 decoder [6] can also decode any content that conforms to
    - H.264 (AVC) Constrained Baseline Profile up to Level 3.1
    - H.264 (AVC) "Progressive" Main Profile up to Level 3.1.
- H.264 (AVC) H.264/AVC "Progressive" Main Profile Level 3.0 decoder [6] can also decode any content that conforms to H.264 (AVC) Constrained Baseline Profile up to Level 3.0.

Further, the choice for HD extensions up to 1920 x 1080p and 30 fps is H.264 (AVC) Progressive High Profile Level 4.0 decoder [6].

Other video-related enhancements are expected to be addressed in extensions.

4.2.2. DASH-specific aspects for H.264/AVC video

For the integration of the above-referred codecs in the context of DASH, the following applies for H.264 (AVC):

- The encapsulation of H.264/MPEG-4 AVC video data is based on the ISO BMFF as defined in ISO/IEC 14496-15 [7].
- Clients are expected to support Inband Storage for SPS/PPS based ISO/IEC 14496-15, Amendment 2 [22], i.e. sample entry '`avc3`' and '`avc4`'.
- SAP types 1 and 2 correspond to IDR-frames in [6].
- The signaling of the different video codec profile and levels for the codecs parameters according to RFC6381 [8] is documented in Table 2. Note that any of the codecs present in Table 2conforms to the profile level combination that is supported in DASH-AVC/264.

Table 2 H.264 (AVC) Codecs parameter according to RFC6381 [8]

Profile	Level	Codec Parameter
H.264 (AVC) Constrained Baseline Profile X=?1????00	1.1	`avc[1..4].42X00B`
	1.2	`avc[1..4].42X00C`
	1.3	`avc[1..4].42X00D`
	2.0	`avc[1..4].42X014`
	2.1	`avc[1..4].42X015`

	2.2	avc[1..4].42X016
	3.0	avc[1..4].42X01E
H.264 (AVC) "Progressive" Main Profile Y=??????00	1.1	avc[1..4].4DY00B
	1.2	avc[1..4].4DY00C
	1.3	avc[1..4].4DY00D
	2.0	avc[1..4].4DY014
	2.1	avc[1..4].4DY015
	2.2	avc[1..4].4DY016
	3.0	avc[1..4].4DY01E
H.264 (AVC) Progressive High Profile Y=??????00	1.1	avc[1..4].64Y00B
	1.2	avc[1..4].64Y00C
	1.3	avc[1..4].64Y00D
	2.0	avc[1..4].64Y014
	2.1	avc[1..4].64Y015
	2.2	avc[1..4].64Y016
	3.0	avc[1..4].64Y01E
	3.1	avc[1..4].64Y01F
	4.0	avc[1..4].64Y028

4.2.3. Video Metadata

The provisioning of video metadata in the MPD is discussed in section 3.2.4.

4.3. Audio

4.3.1. General

Content offered according to DASH-AVC/264 IOP is expected to contain an audio component in most cases. Therefore, clients consuming DASH-AVC/264-based content are expected to support

stereo audio. Multichannel audio support and support for additional codecs is defined in extensions in section 9 of this document.

The codec for basic stereo audio support is MPEG-4 High Efficiency AAC v2 Profile, level 2 [9].

Notes

- HE-AACv2 is also standardized as Enhanced aacPlus in 3GPP TS 26.401 [11].
- HE-AACv2 Profile decoder [6] can also decode any content that conforms to
    - MPEG-4 AAC Profile [9]
    - MPEG-4 HE-AAC Profile [9]

Therefore, Broadcasters and service providers encoding DASH-AVC/264 content are free to use any AAC version. It is expected that clients supporting the DASH-AVC/264 interoperability point will be able to play AAC-LC, HE-AAC and HE-AACv2 encoded content.

For all HE-AAC and HE-AACv2 bitstreams, explicit backwards compatible signaling shall be used to indicate the use of the SBR and PS coding tools.

4.3.2. DASH-specific aspects for HE-AACv2 audio

In the context of DASH, the following applies for the High Efficiency AAC v2 Profile

- The content is expected to be prepared according to the MPEG-DASH Implementation Guidelines [3] to make sure each (Sub)Segment starts with a SAP of type 1.
- The signaling of MPEG-4 High Efficiency AAC v2 for the codecs parameters is according to IETF RFC6381 [8] and is documented in Table 3. Table 3 also provides information on the ISO BMFF encapsulation.

Table 3 HE-AACv2 Codecs parameter according to RFC6381 [8]

Codec	Codec Parameter	ISO BMFF Encapsulation	SAP type
MPEG-4 AAC Profile [9]	`mp4a.40.2`	ISO/IEC 14496-14 [10]	1
MPEG-4 HE-AAC Profile [9]	`mp4a.40.5`	ISO/IEC 14496-14 [10]	1
MPEG-4 HE-AAC v2 Profile [9]	`mp4a.40.29`	ISO/IEC 14496-14 [10]	1

Note: Since both, HE-AAC and HE-AACv2 are based on AAC-LC, for the above-mentioned "Codec Parameter" the following is implied:

- `mp4a.40.5` = `mp4a.40.2` + `mp4a.40.5`
- `mp4a.40.29` = `mp4a.40.2` + `mp4a.40.5` + `mp4a.40.29`

4.3.3. Audio Metadata

4.3.3.1. General

Metadata for audio services is defined in ISO/IEC 23009-1.

4.3.3.2. ISO/IEC 23009-1 audio data

With respect to the audio metadata, the following elements and attributes from ISO/IEC 23009-1 are relevant:

- the `@audioSamplingRate` attribute for signaling the sampling rate of the audio media component type in section 5.3.7 of ISO/IEC 23009-1
- the **`AudioChannelConfiguration`** element for signaling audio channel configuration of the audio media component type.in section 5.3.7 of ISO/IEC 23009-1.

4.4. Auxiliary Components

4.4.1. Introduction

Beyond regular audio and video support, TV programs typically also require support for auxiliary components such as subtitles and closed captioning. For example, a Federal Communications Commission (FCC) Advisory Committee has recommended that a standard for the closed-captioning of online video content developed by the Society of Motion Picture and Television Engineers (SMPTE). DASH-AVC/264 addresses these requirements.

4.4.2. Basic Subtitles and Closed Captioning

The chosen technology for basic subtitles and closed captioning is W3C TTML [14] and the SMPTE profile on SMPTE Timed Text [15]. Graphics-based subtitles and closed captioning are also supported by SMPTE Timed Text [15].

Support for other technologies such as

- CEA-708 Digital Television (DTV) Closed Captioning [12]
- 3GPP Timed Text [13]
- Web VTT [16]

are not expected in DASH-AVC/264, but may be required in certain environments. Conversion of CEA-608 and CEA-708 into SMPTE TT may be done according to SPMTE 2052-10 [19].

Note that by the choice of SMPTE TT as the supported format at the client, other formats such as EBU TT [17] are also supported as long as only the subset that is also supported by SMPTE TT is used in the content authoring.

4.4.3. DASH-specific aspects of Auxiliary components

In the context of DASH, the following applies for text/subtitling:

- All graphics type samples are SAP type 1.

- The signalling of the different text/subtitling codecs for the codecs parameters is according to RFC6381 [8] is documented in Table 4. Table 4 also provides information on ISO BMFF encapsulation.
- For live services, encapsulation in ISO BMFF is definitely necessary. However, for On-Demand cases, the full file of subtitles may be provided as XML data only.

Table 4 Subtitle Codecs parameter according to RFC6381 [8]

Codec	MIME type	Codec Parameter @codecs	ISO BMFF Encapsulation
SMPTE Timed Text [15] without encapsulation	`application/ttml+xml`	`not present`	n/a
SMPTE Timed Text [15] with ISO BMFF encapsulation	`application/mp4`	`stpp`	ISO/IEC 14496-12 [34] ISO/IEC 14496-30 [20]

5. DRM-Related Aspects

5.1. Introduction

DASH-AVC/264 does not intend to specify a full end-to-end DRM system. However DASH-AVC/264 provides a framework for multiple DRMs to protect DASH content by adding instructions or *Protection System Specific*, proprietary information in predetermined locations to DASH content that is encrypted with Common Encryption as defined in ISO/IEC 23001-7 [21].

The Common Encryption (‘`cenc`’) protection scheme specifies encryption parameters that can be applied by a scrambling system and key mapping methods using a common key identifier (KID) to be used by different DRM systems such that the same encrypted version of a file can be combined with different DRM systems that can store proprietary secure information for licensing and key retrieval in the Protection System Specific Header box (‘`pssh`’). The DRM scheme for each `pssh` box is identified by the `SystemID` field in that box.

The recommendations in this document reduce the encryption parameters and use of the encryption metadata to specific use cases for VOD and live content with key rotation.

5.2. Base Technologies

The base standards to support common encryption in combination with ISO BMFF is ISO/IEC 23001-7. In particular

- Common Encryption with CTR mode as defined in ISO/IEC 23001-7:2011 [21].
- Key rotation as defined in ISO/IEC 23001-7 [21]. Note: the latter was added as AMD1 to the 1st edition of ISO/IEC 23001-7:2011
- XML syntax for expressing default KIDs, as defined in ISO/IEC 23001-7:2013

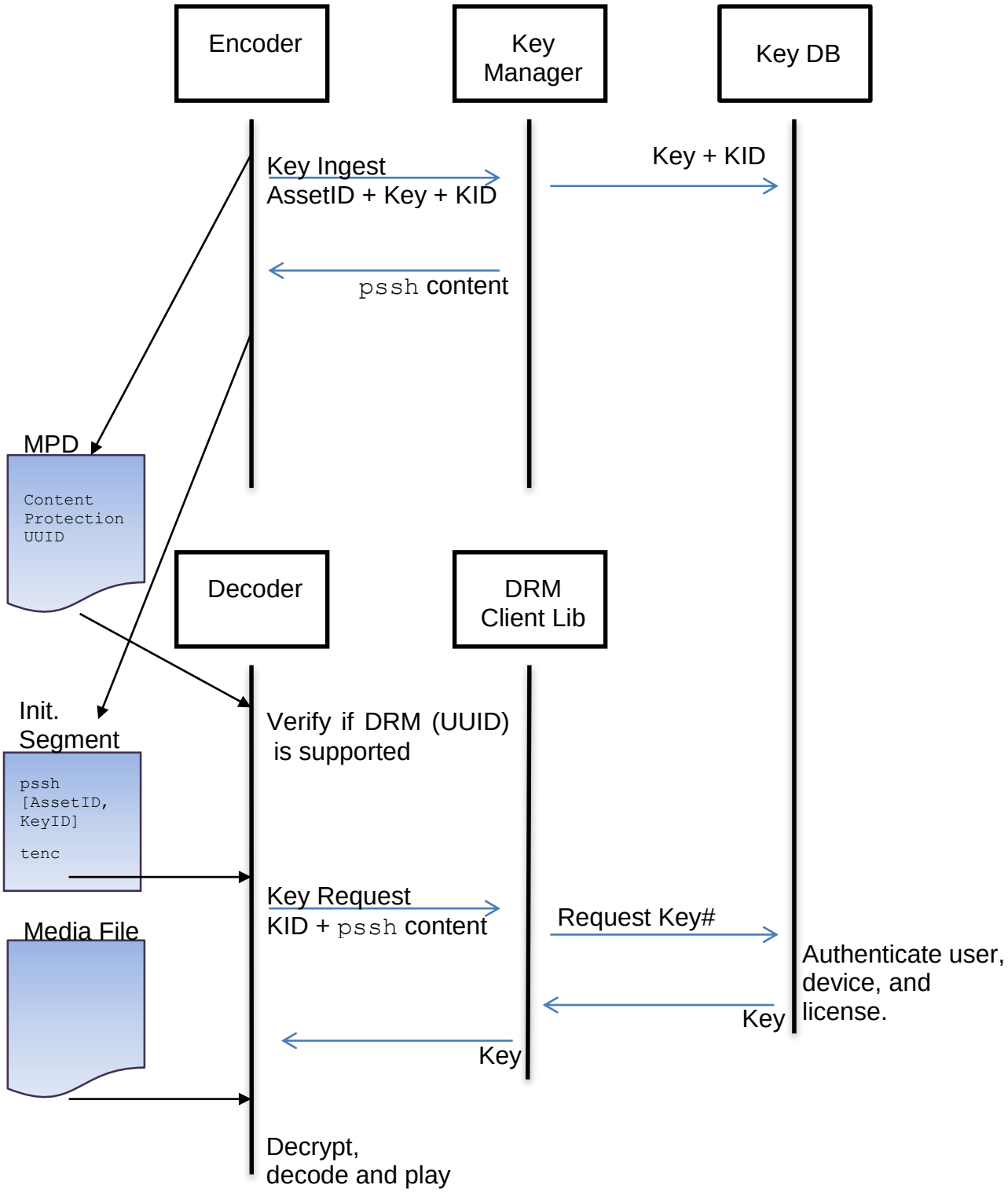
The main DRM elements are:

1. The **`ContentProtection`** descriptor (see [1] 5.3.7.2-Table 9, 5.8.5.2 and [1] 5.8.4.1) that contains the URI for signaling of the use of Common Encryption as well as the specific DRM being used.
2. '`tenc`' parameters that specify encryption parameters and KID (see [21] 8.2.1). The '`tenc`' information is in the Initialization Segment (see [21] 8.2.1). The default KID information may also appear in the MPD (see [21] 11.1).
3. '`pssh`' parameters that are "Protection System Specific" (see [21] 8.1). The `pssh` information is in Initialization or Media Segments (See [21] 8.1 and 8.2). It may also be present in the MPD (see [1] 5.8.4.1, [21] 11.2.1) in a scheme-specific way. Information in the MPD increases the MPD size but may allow faster parsing, earlier access and addition of DRMs without content modification.

5.3. Workflow Overview

Figure 2 below shows a simple workflow with `pssh` information in the Initialization Segment for informational purpose.

Figure 2 Workflow with `pssh` information in the Initialization Segment.



5.4. Integration and Mapping to DASH

5.4.1. MP4 Structure Overview

Table 5 provides pointers to relevant information in the specifications to understand the standard DRM components and where the relevant information is located. The table is for informational purpose only.

Table 5 Boxes relevant for DRM systems

Box	Full Name / *Usage*	Info at
`moof`	movie fragment header *One 'moof' box for each fragment in each stream*	ISO BMFF [4], 8.32 + [1]
`moov`	movie header, container for all the metadata *One 'moov' box per elementary stream. 1 x for each video stream, + 1 x for the audio stream*	ISO BMFF [4] , 8.1
`pssh`	protection system specific header box	[21], 8.1.1
`saio`	SampleAuxiliaryInformationOffsetsBox *Contains the offset of the IVs & encryption data.*	[21], 5
`saiz`	SampleAuxiliaryInformationSizesBox *Contains the size of the IVs & encryption data.*	[21], 5
`schi`	scheme information box	[21], 4
`seig`	CencSampleEncryptionInformation GroupEntry *Contains tenc information in sample in segments for key rotation.*	[21], 6
`sinf`	protection scheme information box	[21], 4
`stsd`	sample descriptions (codec types, initialization etc.)	ISO BMFF [4], 8.16
`tenc`	track encryption box *contains tenc parameters*	[21], 8.2.1

5.4.2. Box Hierarchy

The following shows the box hierarchy and composition:

- In the 'moov' box:
  - one or more 'pssh' boxes
  - in 'trak::mdia::minf::stbl::stsd':
    - the 'sinf' box that contains:
      - the 'frma' box
      - the 'schm' box
      - the 'schi' box that contains:
        - the 'tenc' box

- In the ‘moof’ box:
  - in the ‘traf’ box:
    - the ‘saiz’ box
    - the ‘saio’ box
    - if using key rotation, the ‘sbgp’ box
    - if using key rotation, the ‘sgpd’ box that contains:
      - the ‘seig’ box

5.5. DRM Aspects for DASH-AVC/264

5.5.1. General

To enable signaling of a specific DRM scheme in DASH using the Base Technologies as presented in section 5.2 one of the following options as provided in section 5.5.2 can be applied.

5.5.2. `pssh` and `tenc` Parameters in Movie or Movie Fragment Box

The `pssh` and `tenc` parameters are exclusively provided in the movie or movie fragment box, i.e. in the Initialization Segment (and possibly in the movie fragment box for key rotation) for the live profile or in the movie box for the On-Demand profile:

- ‘`tenc`’ parameters are provided by '`tenc`' box in the content file that specify encryption parameters and KID as specified in [21], section 8.2.1.
- ‘`pssh`’ parameters are provided by `pssh` box in the content file as specified in [21], section 8.1.

5.5.3. Use of Content Protection Descriptor

5.5.3.1. General

`ContentProtection` descriptor shall always appear on the **`AdaptationSet`** level.

5.5.3.2. Generic ContentProtection Descriptor

`ContentProtection` descriptor with `@schemeIdUri` value of `"urn:mpeg:dash:mp4protection:2011"` must be present.

Default KID value, as specified by the '`tenc`' box, should be carried in the MPD, within the above **`ContentProtection`** descriptor above, using the `@cenc:default_KID` attribute defined in [21], section 11.1. The value of the attribute is the KID value in a UUID notation.

```
<ContentProtection schemeIdUri="urn:mpeg:dash:mp4protection:2011"
       value="cenc" cenc:default_KID="34e5db32-8625-47cd-ba06-68fca0655a72"/>
```

DASH allows the `@cenc:default_KID` attribute in every DRM-specific **`ContentProtection`** descriptor, but for DASH-AVC/264, the latter should only be included in **`ContentProtection`** descriptor with the `urn:mpeg:dash:mp4protection:2011` `@schemeIdUri` value, so that it is specified only once and is available in one place for all applications. The ‘`tenc`’

box that specifies encryption parameters and KID is also present in the movie box, as specified in [21], section 8.2.1.

5.5.3.3. DRM-specific ContentProtection Descriptor

A **`ContentProtection`** descriptor in MPD specifies a specific DRM scheme. An example is provided below:

```
<ContentProtection
    schemeIdUri="urn:uuid:xxxxxxxx-xxxx-xxxx-xxxx-xxxxxxxxxxxx"
    value="DRMNAME version"/>
```

The URI (marked by x) is generated and provided by single DRM provider and uniquely identifies this DRM system.

The `@value` attribute describes the DRM system and version in a human readable form

5.5.3.4. pssh Parameter in MPD

Carrying `tenc` and `pssh` parameters in the MPD are useful to allow license evaluation, key identification and retrieval before availability of the initialization segment, which may distribute client requests and is relevant to allow an early decision by the client if this key is already available and to otherwise retrieve it before or during download of the Initialization Segment.

Carriage of `tenc.default_KID` parameter is described in 5.5.3.2 above.

`pssh` parameters can be carried in the MPD within a DRM-specific **`ContentProtection`** descriptor and in the DRM-specific syntax and namespace. Examples are provided in 5.9.3 and in [21] sec. 11.2.

5.6. Key Rotation

5.6.1. Introduction

Key rotation is mainly used to allow changes in entitlement for continuous live content. It is used as defined in [21] with the following requirements:

- In the initialization segment, the movie box '`moov`' contains '`tenc`' box and may contain a '`pssh`' box for each DRM to store root license information for authentication and authorization.
- In addition, each Movie Fragment may contain at most one '`pssh`' in each '`moof`' box per SystemID that contains sufficient information to acquire keys for this movie fragment, when combined with:
    - information from '`pssh`' in '`moov`'
    - KID from '`seig`' box

  (This will likely result in some redundant `pssh` boxes but will facilitate processing and trick play, of linear content that is later made available as VOD assets)

- Any KIDs in Movie Fragments override the 'tenc' parameter of the 'default_KID', as well as the 'not encrypted' parameter.

5.6.2. Encryption of Different Representations

Generally, different Representations of one Adaptation Set are protected by the same license, i.e. encrypted with the same key. That means all Representations have the same value of 'default_KID' in their 'tenc' boxes in their Initialization Segments.

In the case of key rotation, that applies to the root license (one per DRM) and the same value of KID in each leaf license contained in each Media Segment.

In cases where HD and SD content are contained in one asset, different license rights may be required for each quality level. It then is often advisable to create individual Adaptation Sets for each quality level, each with a different **ContentProtection** descriptor in the Adaptation Set. While there may be some Representations that are equivalent in both Adaptation Set and therefore increase the content size, their size typically relatively small and switching between an HD and SD Adaptation Set is difficult to be applied seamlessly because these quality levels typically vary in DRM output controls, use different decryption licenses and keys and use different decoding parameters for e.g. subsampling, entropy coding, aspect ratios and color spaces.

The test vectors are limited to a single license (per DRM) per Adaptation Set but this does not explicitly exclude the viability of different licenses within one Adaptation Set.

5.7. Additional Content Protection Requirements

In addition, content authored claiming conformance to any DASH-264/AVC IOP the following holds:

- In the case where 'pssh' boxes are present in Initialization Segments, each Initialization Segment within one Adaptation Set shall contain an equivalent pssh box for each SystemID, i.e. license acquisition for one Representation is sufficient to ensure switching within Adaptation Set.
- In the case where license acquisition information is present in ContentProtection Descriptors, they shall only be present on the AdaptationSet element(s).
- in case of inband key delivery, the pssh box version 2 (as defined in 5.5.3) shall be equivalent for all Representations within one Adaptation Set, i.e. license acquisition for one Representation is sufficient to ensure switching within Adaptation Set.

5.8. Signaling

The DRM system is signaled with a URI as described in ISO/IEC 23009-1 [1] 5.8.5.2. The list of enabled DRMs can be found in the DASH identifier repository available here: http://www.dashif.org/identifiers/content-protection.

5.9. Common Encryption Test DRM

5.9.1. Introduction

In order to test common encryption without the necessity to do tests for a specific DRM, or all supported DRMs, a common encryption *Test-DRM* is defined.

Specifically the following aspects are defined for the *Test-DRM*:

- To test the encryption with common encryption scheme parameters, the key is provided in a separate file.
- To test the parsing of DRM relevant fields, two different test scenarios are defined to communicate the encryption parameters in the MPD and in the movie box (see section 5.5.2). The latter case also includes key rotation.

In the interest of testing independently of a specific DRM system, the keys are provided directly in lieu of the DRM information that is otherwise used to obtain the keys.

The use of an external file allows flexible referencing of the same key from different locations, to e.g. use the same key for audio, video or different Representations.

5.9.2. Test of Common Encryption

The key file location is the MPD directory or configurable in the player to avoid OS dependent path references. Its file name is the KID in 32 Hex lower case digits with .txt extension. The content is the decryption key in lower case Hex digits e.g.

`bdff1a347bd8e9f523f5ee6b16273d6e.txt` contains:
`050526bf6d3c386ffe5fc17c93506eca`

The key file name can be stored in the `pssh` to verify the creation and parsing of `pssh` information. If the `pssh` information is not present, the file name can also be derived directly with the knowledge of the KID.

In the test vectors 3 different test values for `@schemeIdUri` are defined to represent multi DRMs:

`00000000-0000-0000-0000-000000000000`
`00000000-0000-0000-0000-000000000001`
`00000000-0000-0000-0000-000000000002`

The test of common decryption is included in the successful decryption in the above cases.

5.9.3. ContentProtection descriptor

An extension namespace is defined in order to enable inclusion of `pssh` parameters in the **`ContentProtection`** element for the test DRMs above.

```
<?xml version="1.0" encoding="UTF-8"?>
<xs:schema targetNamespace="urn:dashif:iop:drm:2013"
    attributeFormDefault="unqualified"
```

```
    elementFormDefault="qualified"
    xmlns:xs="http://www.w3.org/2001/XMLSchema"
    xmlns="urn:dashif:iop:drm:2012" >


    <!-- KID is a 128-bit integer written in canonical UUID notation -->
    <xs:simpleType name="KeyIdType">
        <xs:restriction base="xs:string">
            <xs:pattern value=
                "[A-Fa-f0-9]{8}-[A-Fa-f0-9]{4}-[A-Fa-f0-9]{4}-[A-Fa-f0-9]{4}-[A-Fa-f0-9]{12}"/>
        </xs:restriction>

    </xs:simpleType>

    <xs:simpleType name="KeyIdListType">
        <xs:list itemType="KeyIdType" />
    </xs:simpleType>


    <xs:complexType name="Pssh">
        <xs:sequence>
            <xs:any namespace="##other" processContents="lax" minOccurs="0"
maxOccurs="unbounded"/>
        </xs:sequence>

        <!-- base64-encoded content of the `pssh` box -->
        <xs:attribute name="data" type="xs:base64Binary" use="required"/>
        <xs:attribute name="keyIdList" type="KeyIdListType"/>

        <xs:anyAttribute namespace="##other" processContents="lax"/>
    </xs:complexType>

</xs:schema>
```

An example is provided below:

```
<ContentProtection schemeIdUri="urn:uuid:00000000-0000-0000-0000-000000000000"
        value="DASH264DRM v2.0">
        <dash264drm:Pssh data="cG9zc2libGUgcm9vdCBwc3NoIGxpY2Vuc2UgaW5mbw==”/>
</ContentProtection>

<ContentProtection schemeIdUri="urn:mpeg:dash:mp4protection:2011"
        value="cenc" cenc:default KID="34e5db32-8625-47cd-ba06-68fca0655a72"/>
```

5.9.4. Test Scenarios

5.9.4.1. Introduction

Different test scenarios are defined which are then mapped to specific test cases in [23]. The first test scenario uses a single key with

1. `pssh` and `tenc` parameters in the movie box
2. `pssh` and `tenc.default_KID` parameters in the MPD.

Another test scenario implements key rotation with `tenc` and `pssh` information in the MPD. Finally, a use case for interleaving of unencrypted content is added.

5.9.4.2. Test Scenario 1: pssh and tenc Parameters in Movie Box

The simulation verifies the signaling of the DRM in the MPD, specifically the `pssh` and `tenc` information as it must be exercised to access the keys.

The signaling of encryption scheme(s) in MPD:

```
<ContentProtection schemeIdUri="urn:uuid:00000000-0000-0000-0000-000000000000">
<ContentProtection schemeIdUri="urn:uuid:00000000-0000-0000-0000-000000000001">
<ContentProtection schemeIdUri="urn:uuid:00000000-0000-0000-0000-000000000002">
```

The `pssh` box, if present, contains the base64 encoded filename of the key file.

5.9.4.3. Test Scenario 2: pssh and tenc Parameters in MPD

The simulation verifies the encoding of the parameters in the MPD as described in 5.5.3. The key file is indicated in the **`Pssh`**`@data` attribute as base64 encoded KID in lower case with .txt extension. For example, for a KID of `bdff1a347bd8e9f523f5ee6b16273d6`, the key will be in the file `bdff1a347bd8e9f523f5ee6b16273d6e.txt.`

Full **`Pssh`**`@data` with required base64 encoding in this case is:

```
<dash264iop:Pssh data=
”YmRmZjFhMzQ3YmQ4ZTlmNTIzZjVlZTZiMTYyNzNkNmUudHh0”/>
```

A separate key file is used for each key when key rotation is used.

5.9.4.4. Test Scenario 3: pssh and KID Parameters in MPD with Key Rotation

In this case, the `pssh` information may contain root license information. For the test scenario, the `pssh` information does not contain relevant key information but is present as a place holder. The static place holder is the base64 encoding of the string: `”possible root pssh license info”`, i.e.:

```
<dash264iop:Pssh data=”cG9zc2libGUgcm9vdCBwc3NoIGxpY2Vuc2UgaW5mbw==”/>
```

A separate key file with different `$KeyId$` value is used for each new key.

5.9.4.5. Test Scenario 4: pssh and tenc Parameters in MPD with Key Rotation and unencrypted elements

This extends the previous test scenario with segments that are signaled as unencrypted that are combined with encrypted segments.

6. Interoperability point DASH-AVC/264

6.1. Introduction

The scope of the DASH-AVC/264 interoperability point is the basic support of high-quality video distribution over the top. Both, live and on-demand services are supported. It is expected that the client supports at least the presentation of

- high-definition video up to 720p
- stereo audio
- basic subtitle support
- basic support for encryption/DRM

The compliance to DASH-AVC/264 may be signaled by an `@profiles` attribute with the value "`http://dashif.org/guidelines/dash264`"

6.2. Supporters

This interoperability point is supported by at least the following DASH-IF members: Akamai, bitmovin, CastLabs, Cisco, Dolby, Digital Primates, DTS, Elemental Technologies, Envivio, Ericsson, Fraunhofer, Harmonic, Imagine Communications, Intel, InterDigital, Media Excel, Microsoft, Netflix, Path1, Qualcomm Incorporated, RealNetworks, RGB Networks, Sony, Sorenson Media, Thomson Video Networks, Verimatrix.

6.3. Definition

Content may be authored claiming conformance to this IOP if a client can be properly play the content by supporting at least the following features:

- All DASH-related features as defined in section 3 of this document.
- H.264/MPEG AVC Progressive High Profile at level 3.1 as defined in section 4.2.
- MPEG-4 HE-AAC v2 level 2 profile audio codec as defined in section 4.3. Dynamic Range Control is not expected to be supported.
- subtitle and closed captioning support using SMPTE-TT as defined in section 4.4.2
    - For On-Demand single file download is sufficient.
    - For live services and/or if key rotation is to be supported, the encapsulation into ISO BMFF is necessary.
- content protection based on common encryption and key rotation as defined in section 5. And specifically, the client supports MPD-based parsing and movie box based parsing of DRM related parameters for common encryption.

If content is offered claiming conformance to this IOP, the content author is encouraged to use the HTTP-URL construction as defined in [3], section 5.1.4.

7. Interoperability Point DASH-AVC/264 SD

7.1. Introduction

It is recognized that certain clients may only be capable to operate with H.264/AVC Main Profile. Therefore content authors may provide and signal a specific subset of DASH-AVC/264 by providing a specific profile identifier referring to a standard definition presentation. This interoperability point is defined as DASH-AVC/264 SD.

The compliance to DASH-AVC/264 SD may be signaled by an `@profiles` attribute with the value "`http://dashif.org/guidelines/dash264#sd`"

7.2. Supporters

This interoperability point is supported by the following DASH IF members: Akamai, bitmovin, CastLabs, Cisco, Dolby, Digital Primates, DTS, Elemental Technologies, Envivio, Ericsson, Fraunhofer, Harmonic, Imagine Communications, Intel, InterDigital, Media Excel, Microsoft, Netflix, Path1, Qualcomm Incorporated, RealNetworks, RGB Networks, Sony, Sorenson Media, Thomson Video Networks, Verimatrix.

7.3. Definition

A client that attempts to consume content generated conforming to this profile is expected to support the following features:

- All features as defined in section 6.3, except:
    - Instead of H.264/MPEG AVC Progressive High Profile at level 3.1, the highest video codec configuration is H.264/MPEG AVC Progressive Main Profile at level 3.0 as defined in section 4.2.

8. Interoperability Point DASH-AVC/264 HD

8.1. Introduction

For the support of high-quality video distribution up to 1080p, an additional interoperability point is defined.

Compliance to *DASH-AVC/264 HD* may be signaled by an `@profile` attribute with the value "`http://dashif.org/guidelines/dash264#hd`"

Note: To signal conformance to both interoperability points, DASH-AVC/264 and DASH-AVC/264 HD, the `@profile` attribute may contain both interoperability point indicators.

8.2. Supporters

This interoperability point is supported by the following DASH-IF members: Akamai, bitmovin, CastLabs, Cisco, Dolby, Digital Primates, DTS, Elemental Technologies, Envivio, Ericsson, Fraunhofer, Harmonic, Imagine Communications, Intel, InterDigital, Media Excel, Microsoft,

Netflix, Path1, Qualcomm, RealNetworks, RGB Networks, Sony, Sorenson Media, Thomson Video Networks, Verimatrix.

8.3. Definition

A client that attempts to consume content generated conforming to *DASH-AVC/264 HD* interoperability point is expected to support the following features:

- All features as defined in section 6.3.
- H.264/MPEG AVC Progressive High Profile at level 4.0 as defined in section 4.2.

9. Multi-Channel Audio Extension

9.1. Scope

The Scope of the Multichannel Audio Extension is the support of audio with additional channels and codecs beyond the basic audio support as specified in the DASH-AVC/264 base, which is limited to Stereo HE-AAC. Multichannel audio is widely supported in all distribution channels today, including broadcast, optical disc, and digital delivery of audio, including wide support in adaptive streaming delivery.

It is expected that clients may choose which formats (codecs) they support.

9.2. Technologies

9.2.1. Dolby Multichannel Technologies

9.2.1.1. Overview

The considered technologies from Dolby for advanced audio support are:

- Enhanced AC-3 (Dolby Digital Plus) [28]
- Dolby TrueHD [29]

9.2.1.2. DASH-specific issues

In the context of DASH, the following applies:

- The signaling of the different audio codecs for the codecs parameters is documented in [28] and [29], which also provides information on ISO BMFF encapsulation.
- For E-AC-3 the Audio Channel Configuration shall use the "`urn:dolby:dash:audio_channel_configuration:2011`" as defined at http://dashif.org/identifiers/audio-source-data/.

Table 6 Dolby Technologies: Codec Parameters and ISO BMFF encapsulation

Codec	Codec Parameter	ISO BMFF Encapsulation	SAP type
Enhanced AC-3 [28]	`ec-3`	ETSI TS 102 366 Annex F [28]	1
Dolby TrueHD	`mlpa`	Dolby [29]	1

9.2.2. DTS-HD

9.2.2.1. Overview

DTS-HD [30] comprises a number of profiles optimized for specific applications. More information about DTS-HD and the DTS-HD profiles can be found at www.dts.com.

9.2.2.2. DASH-specific issues

For all DTS formats SAP is always 1.

The signaling of the various DTS-HD profiles is documented in DTS 9302J81100 [27]. DTS 9302J81100 [27] also provides information on ISO BMFF encapsulation.

Additional information on constraints for seamless switching and signaling DTS audio tracks in the MPD is described in DTS specification 9302K62400 [32].

Table 7: DTS Codec Parameters and ISO BMFF encapsulation

Codec	Codec Parameter	ISO BMFF Encapsulation	SAP type
DT Digital Surround	`dtsc`	DTS 9302J81100 [27]	1
DTS-HD High Resolution and DTS-HD Master Audio	`dtsh`		
DTS Express	`dtse`		
DTS-HD Lossless (no core)	`dtsl`		

9.2.3. MPEG Surround

9.2.3.1. Overview

MPEG Surround, as defined in ISO/IEC 23003-1:2007 [31], is a scheme for coding multichannel signals based on a down-mixed signal of the original multichannel signal, and associated spatial parameters. The down-mix shall be coded with MPEG-4 High Efficiency AAC v2 according to section 5.3.3.

MPEG Surround shall comply with level 4 of the Baseline MPEG Surround profile.

9.2.3.2. DASH-specific issues

In the context of DASH, the following applies for audio codecs

- The signaling of the different audio codecs for the codecs parameters is according to RFC6381 [8] is documented in Table 8. Table 8 also provides information on ISO BMFF encapsulation.
- The content is expected to be prepared according to the MPEG-DASH Implementation Guidelines [3] to make sure each (sub-)segment starts with a SAP of type 1.

Table 8 Codecs parameter according to RFC6381 [8] and ISO BMFF encapsulation for MPEG Surround codec

Codec	Codec Parameter	ISO BMFF Encapsulation	SAP type
MPEG Surround [31]	`mp4a.40.30`	ISO/IEC 14496-14 [8]	1

Note: Since MPEG Surround is based on a down-mix coded with AAC-LC and HE-AAC, for the above mentioned "Codec Parameters" the following is implied:

mp4a.40.30 = AOT 2 + AOT 5 + AOT 30

9.2.4. MPEG-4 High Efficiency AAC Profile v2, level 6

9.2.4.1. Overview

Support for multichannel content is available in the HE-AACv2 Profile, starting with level 4 for 5.1 and level 6 for 7.1 [9]**Error! Reference source not found.**. All MPEG-4 HE-AAC multichannel profiles are fully compatible with the DASH-AVC/264 baseline interoperability point for stereo audio, i.e. all multichannel decoders can decode DASH-AVC/264 stereo content.

9.2.4.2. DASH-specific issues

In the context of DASH, the following applies for the High Efficiency AAC v2 Profile

- The content shall be prepared according to the MPEG-DASH Implementation Guidelines [3] to make sure each (sub-)segment starts with a SAP of type 1.
- Signaling of profile levels is not supported in RFC 6381 but the channel configuration shall be signaled by means of the **`ChannelConfiguration`** element in the MPD.
- The signaling of MPEG-4 High Efficiency AAC v2 for the codecs parameters is according to RFC6381 [8] and is documented in Table 9. Table 9 also provides information on the ISO BMFF encapsulation.
- For all HE-AAC bitstreams, explicit backward-compatible signaling of SBR shall be used.
- The content should be prepared incorporating loudness and dynamic range information into the bitstream also considering DRC Presentation Mode in ISO/IEC 14496-3 [9], Amd. 4.

- Decoders shall support decoding of loudness and dynamic range related information, i.e. dynamic_range_info() and MPEG4_ancillary_data() in the bitstream.

Table 9 Codecs parameter according to RFC6381 [8] and ISO BMFF encapsulation

Codec	Codec Parameter	ISO BMFF Encapsulation	SAP type
MPEG-4 AAC Profile [9]	`mp4a.40.2`	ISO/IEC 14496-14 [26]	1
MPEG-4 HE-AAC Profile [9]	`mp4a.40.5`	ISO/IEC 14496-14 [26]	1
MPEG-4 HE-AAC v2 Profile [9]	`mp4a.40.29`	ISO/IEC 14496-14 [26]	1

Note: Since both, HE-AAC and HE-AACv2 are based on AAC-LC, for the above mentioned "Codec Parameters" the following is implied:

mp4a.40.5 = AOT 2 + AOT 5

9.3. Client Implementation Guidelines

Independent of the codec, a client that supports one or more codecs of multichannel sound playback should exhibit the following characteristics:

- Playback multichannel sound correctly given the client operating environment. As an example, if the audio track delivers 5.1 multichannel sound, the client might perform one or more of the following: decode the multichannel signal on the device and output either 6ch PCM over HDMI, or pass that multichannel audio with no changes to external AVRs, or if the device is rendering to stereo outputs such as headphones, either correctly downmix that multi-channel audio to 2-channel sound, or select an alternate stereo adaptation set, or other appropriate choices.
- Adaptively and seamless switch between different bitrates as specified in the adaptation sets according to the playback clients logic. Seamless switching is defined as no perceptible interruption in the audio, and no loss of A/V sync. There is no expectation that a client can seamlessly switch between formats.

9.4. Extensions

9.4.1. General

9.4.1.1. Definitions

A *multichannel audio client* at least supports the following features:

- All DASH-related features as defined in section 3 of this document.

- content protection based on common encryption and key rotation as defined in section 5. And specifically, the client supports MPD-based parsing and movie box based parsing of DRM related parameters for common encryption.
- The client implementation guidelines in section 9.3.

9.4.1.2. Recommendations

If content is offered claiming conformance to any extension in this section, the content author is encouraged to use the HTTP-URL construction as defined in [3], section 5.1.4.

9.4.2. Dolby Extensions

9.4.2.1. Introduction

For the support of Dolby advanced audio support, two additional extensions are defined.

Compliance to *DASH-IF multichannel audio extension with Enhanced AC-3* (Dolby Digital Plus) [28] may be signaled by an `@profile` attribute with the value `"http://dashif.org/guidelines/dashif#ec-3"`.

Compliance to *DASH-IF multichannel extension with Dolby TrueHD* may be signaled by an `@profile` attribute with the value `"http://dashif.org/guidelines/dashif#mlpa"`.

9.4.2.2. Supporters

These extensions are supported by the following DASH IF members: Dolby, DTS, Fraunhofer, BuyDRM, Sony.

9.4.2.3. Definition

Content may be authored claiming conformance to *DASH-IF multichannel audio extension with Enhanced AC-3*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - Enhanced AC-3 (Dolby Digital Plus) [28] and the DASH-specific features defined in section 9.2.1.2

Content may be authored claiming conformance to *DASH-IF multichannel extension with Dolby TrueHD*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - Dolby TrueHD and the DASH-specific features defined in section 9.2.1.2

9.4.3. DTS-HD Interoperability Points

9.4.3.1. Introduction

For the support of DTS advanced audio support, four additional extensions are defined.

Compliance to *DASH-IF multichannel audio extension with DTS Digital Surround* may be signaled by a `@profile` attribute with value "`http://dashif.org/guidelines/dashif#dtsc`".

Compliance to *DASH-IF multichannel audio extension with DTS-HD High Resolution and DTS-HD Master Audio* may be signaled by a `@profile` attribute with value "`http://dashif.org/guidelines/dashif#dtsh`"

Compliance to *DASH-IF multichannel audio extension with DTS Express* may be signaled by a `@profile` attribute with value "`http://dashif.org/guidelines/dashif#dtse`"

Compliance to *DASH-IF multichannel extension with DTS-HD Lossless (no core)* may be signaled by a `@profile` attribute with value "`http://dashif.org/guidelines/dashif#dtsl`"

9.4.3.2. Supporters

These extensions are supported by the following DASH IF members: Dolby, DTS, Fraunhofer, BuyDRM, Sony.

9.4.3.3. Definition

Content may be authored claiming conformance to *DASH-IF multichannel audio extension with DTS Digital Surround*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - DTS and the DASH-specific features defined in section 9.2.2.2

Content may be authored claiming conformance to *DASH-IF multichannel audio extension with DTS-HD High Resolution and DTS-HD Master Audio*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - DTS-HD High Resolution and DTS-HD Master Audio and the DASH-specific features defined in section 9.2.2.2

Content may be authored claiming conformance to *DASH-IF multichannel audio extension with DTS Express*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features

- all multichannel audio client features as defined in section 9.4.1
- DTS-HD Express and the DASH-specific features defined in section 9.2.2.2

Content may be authored claiming conformance to *DASH-IF multichannel extension with DTS-HD Lossless (no core)*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - DTS-HD Lossless (no core) and the DASH-specific features defined in section 9.2.2.2

9.4.4. MPEG Surround Interoperability Points

9.4.4.1. Introduction

For the support of MPEG Surround advanced audio support the following extension is defined.

Compliance to *DASH-IF multichannel audio extension with MPEG Surround* according to ISO/IEC 23003-1:2007 [31] may be signaled by an `@profile` attribute with the value "`http://dashif.org/guidelines/dashif#mps`".

9.4.4.2. Supporters

These extensions are supported by the following DASH IF members: Dolby, DTS, Fraunhofer, BuyDRM, Sony.

9.4.4.3. Definition

Content may be authored claiming conformance to *DASH-IF multichannel audio extension with MPEG Surround*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - ISO/IEC 23003-1:2007 and the DASH-specific features defined in section 9.2.3.2

9.4.5. MPEG HE-AAC Multichannel Interoperability Points

9.4.5.1. Introduction

Compliance to *DASH-IF multichannel audio extension with HE-AACv2 level 4* [9] may be signaled by an @profile attribute with the value "`http://dashif.org/guidelines/dashif#heaac-mc51`".

Compliance to *DASH-IF multichannel audio extension with HE-AACv2 level 6* [9] may be signaled by an @profile attribute with the value "`http://dashif.org/guidelines/dashif#heaac-mc71`".

9.4.5.2. Supporters

These extensions are supported by the following DASH IF members: Dolby, DTS, Fraunhofer, BuyDRM, Sony.

9.4.5.3. Definition

Content may be authored claiming conformance to *DASH-IF multichannel audio extension with HE-AACv2 level 4*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - HE-AACv2 level 4 [9] and the DASH-specific features defined in section 9.2.4.2

Content may be authored claiming conformance to *DASH-IF multichannel audio extension with HE-AACv2 level 6*

- if the content is multichannel audio content as defined in section 9.4.1, and
- if a client can be properly play the content by supporting at least the following features
  - all multichannel audio client features as defined in section 9.4.1
  - HE-AACv2 level 6 [9] and the DASH-specific features defined in section 9.2.4.2

10. References

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[2] ISO/IEC 23009-2:2012 Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 2: Conformance and Reference Software (2nd Study of DIS, available as w13512).

[3] ISO/IEC 23009-3:2012 Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 3: Implementation Guidelines (Study of ISO/IEC PDTR, available as w13514).

[4] ISO/IEC 14496-12:2012 Information technology -- Coding of audio-visual objects -- Part 12: ISO base media file format

[5] ISO/IEC 14496-10: Information technology -- Coding of audio-visual objects -- Part 10: Advanced Video Coding

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[8] IETF RFC 6381, The 'Codecs' and 'Profiles' Parameters for "Bucket" Media Types, August 2011.

[9] ISO/IEC 14496-3:2009 - Information technology -- Coding of audio-visual objects -- Part 3: Audio with Corrigendum 1:2009, Corrigendum 2:2011, Corrigendum 3:2012, Amendment 1:2009, Amendment 2:2010, Amendment 3:2012, and Amendment 4:2014.

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[26] ISO/IEC 14496-12:2012 Information technology -- Coding of audio-visual objects -- Part 14: The MP4 File Format

[27] DTS 9302J81100, “Implementation of DTS Audio in Media Files Based on ISO/IEC 14496”, http://www.dts.com/professionals/resources/resource-center.aspx

[28] ETSI TS 102 366 v1.2.1, Digital Audio Compression (AC-3, Enhanced AC-3) Standard (2008-08)

[29] MLP (Dolby TrueHD) streams within the ISO Base Media File Format, version 1.0, September 2009.

[30] ETSI TS 102 114 v1.3.1 (2011-08), “DTS Coherent Acoustics; Core and Extensions with Additional Profiles”

[31] ISO/IEC 23003-1:2007 - Information technology -- MPEG audio technologies -- Part 1: MPEG Surround

[32] DTS 9302K62400, “Implementation of DTS Audio in Dynamic Adaptive Streaming over HTTP (DASH)”, http://www.dts.com/professionals/resources/resource-center.aspx

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11. Annex A: Examples for Profile Signalling

11.1. Example 1

In this case DASH-AVC/264 content is offered, but in addition a non-conforming Adaptation Set is added.

Here is an example for an MPD:

- **MPD**@profiles="urn:mpeg:dash:profile:isoff-on-demand:2011, http://dashif.org/guidelines/dash264"
  - **AdaptationSet**@profiles="urn:mpeg:dash:profile:isoff-on-demand:2011, http://dashif.org/guidelines/dash264"
  - **AdaptationSet**@profiles ="http://dashif.org/guidelines/dash264"
  - **AdaptationSet**@profiles ="urn:mpeg:dash:profile:isoff-on-demand:2011"

Pruning process for IOP `http://dashif.org/guidelines/dash264` results in

- **MPD**@profiles ="http://dashif.org/guidelines/dash264"
  - **AdaptationSet**@profiles ="http://dashif.org/guidelines/dash264"
  - **AdaptationSet**@profiles ="http://dashif.org/guidelines/dash264"

It is now required that the pruned MPD conforms to DASH-AVC/264.

11.2. Example 2

In this case DASH-AVC/264 content is offered, but in addition a non-conforming Adaptation Set is added and one DASH-IF Example Extension Adaptation Set is added with the virtual IOP signal `http://dashif.org/guidelines/dashif#extension-example`.

Here is an example for an MPD:

- **MPD**@profiles ="urn:mpeg:dash:profile:isoff-on-demand:2011, http://dashif.org/guidelines/dash264, http://dashif.org/guidelines/dashif#extension-example"
    - @id = 1, **AdaptationSet**@profiles ="urn:mpeg:dash:profile:isoff-on-demand:2011, http://dashif.org/guidelines/dash264"
    - @id = 2, **AdaptationSet**@profiles ="http://dashif.org/guidelines/dash264"
    - @id = 3, **AdaptationSet**@profiles ="urn:mpeg:dash:profile:isoff-on-demand:2011, http://dashif.org/guidelines/dashif#extension-example"

Pruning process for profile http://dashif.org/guidelines/dash264 results in

- MPD@profiles="http://dashif.org/guidelines/dash264"
    - @id = 1, **AdaptationSet**@profiles="http://dashif.org/guidelines/dash264"
    - @id = 2, **AdaptationSet**@profiles="http://dashif.org/guidelines/dash264"

It is now required that the pruned MPD conforms to DASH-AVC/264.

Pruning process for profile http://dashif.org/guidelines/dashif#extension-example results in

- **MPD**@profiles="http://dashif.org/guidelines/dash264"
    - @id = 3, **AdaptationSet**@profiles="http://dashif.org/guidelines/dashif# extension-example"

It is now required that the pruned MPD conforms to DASH-IF Example Extension Adaptation Set.

12. Document History

Version 1.00: Initial publication of IOPs.

Version 1.01: Change http://dashif.org/metadata to http://dashif.org/identifiers.

Version 1.02: Correct application/xml+ttml to application/ttml+xml.

Version 1.03: Updated the disclaimer section.

Version 2.00: Addition of HD (8) and multichannel extensions (9), and clarifications on relatives 'moof' addressing (3.2.1), synchronization considerations (3.4.2), live services considerations (3.5) and audio loudness and dynamic range (9.2.4.2).