CHANGE REQUEST

DASH-IF IOP CR rev - Current version: 4.3

Status:		Draft	X	Internal Review		Community Review		Agreed

Title:	Advanced Ad Insertion in DASH
Source:	Ad Insertion TF
Supporting Companies:	Hulu, Qualcomm, Tencent, Unified Streaming, <others to be added>
Category:	**A** ***Date:*** 2019-08-12 *Use one of the following categories:* ***C*** *(correction)* ***A*** *(addition of feature)* ***B*** *(editorial modification)*

Reason for change:	Ad Insertion is considered as one of the most important aspects in online video distribution. Also with the development of CMAF, some additional aspects are relevant, such as consistent development of Ad content, content insertion into CMAF live content, etc. This document addresses latest development in the context of Ad Insertion and maps this to DASH.
Summary of change:	1) Description of most relevant use cases 2) Ad Insertion architecture 3) Definition of main content requirements and recommendations 4) Definition of ad content requirements and recommendations 5) Definition of combined main and ad content 6) Ad specific metadata 7) Ad tracking
Consequences if not approved:	Insufficient Ad Insertion capabilities in DASH

Sections affected:	References, The whole clause 8 on DASH Ad Insertion in DASH-IF IOP is replaced
Other comments:	

Disclaimer:	This document is not yet final. It is provided for public review until the deadline mentioned below. If you have comments on the document, please submit comments by one of the following means: - at the github repository https://github.com/Dash-Industry-Forum/AdInsertion/issues, or - dashif+iop@groupspaces.com with a subject tag [AdInsertion] Please add a detailed description of the problem and the comment. Based on the received comments a final document will be published latest by the expected publication date below, integrated in a new version of DASH-IF IOP if the following additional criteria are fulfilled: - All comments from community review are addressed - The relevant aspects for the Conformance Software are provided - Verified IOP test vectors are provided
Commenting Deadline:	September 30th, 2019
Expected Publication:	December 15th, 2019
Contributors:	Zachary Cava (Hulu) Thomas Stockhammer (Qualcomm) Iraj Sodagar (Tencent) Rufael Mekuria (Unified Streaming)

	Andy Rosen (DSR) Gary Hughes (independent) Nicol So (Arris) Will Law (Akamai) Alex Giladi (Comcast) Cooper Pope (Turner) And others

Add References in yellow

Notes:
1) If appropriate, the references refer to specific versions of the specifications. However, implementers are encouraged to check later versions of the same specification, if available. Such versions may provide further clarifications and corrections. However, new features added in new versions of specifications are not added automatically.
2) Specifications not yet officially available are marked in *italics*.
3) Specifications considered informative only are marked in Arial

[1] DASH-IF DASH-264/AVC Interoperability Points, version 1.0, available at http://dashif.org/w/2013/06/DASH-AVC-264-base-v1.03.pdf

[2] DASH-IF DASH-264/AVC Interoperability Points, version 2.0, available at http://dashif.org/w/2013/08/DASH-AVC-264-v2.00-hd-mca.pdf

[3] ISO/IEC 23009-1:2012/Cor.1:2013 Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 1: Media presentation description and segment formats.

Note: this document is superseded by reference [4], but maintained as the initial version of this document is provided in the above reference.

[4] ISO/IEC 23009-1:2014 Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 1: Media presentation description and segment formats. Including:

- ISO/IEC 23009-1:2014/Cor 1:2015
- ISO/IEC 23009-1:2014/Cor 2:2017
- ISO/IEC 23009-1:2014/Amd 1:2015 High Profile and Availability Time Synchronization
- ISO/IEC 23009-1:2014/Amd 2:2015 Spatial relationship description, generalized URL parameters and other extensions
- ISO/IEC 23009-1:2014/Amd 3:2016 Authentication, MPD linking, Callback Event, Period Continuity and other Extensions.
- ISO/IEC 23009-1:2014/DAmd 4:2016 Segment Independent SAP Signalling (SISSI), MPD chaining, MPD reset and other extensions.

All the above is expected to be rolled into a third edition of ISO/IEC 23009-1 as:

- ISO/IEC 23009-1:2018 Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 1: Media presentation description and segment formats. [Note: Expected to be published by end of 2018. The draft third edition is available in the MPEG document m44441.]

In addition, the following documents are under preparation in MPEG:

- ISO/IEC 23009-1:2014/DCor 3:2018 [Note: Expected to be published by mid of 2019. The study of the COR is available as an output document w17951.]

- ISO/IEC 23009-1:2014/DAmd 5:2018 Device Information and other extensions. 2018 [Note: Expected to be published by mid of 2019. The DAM is available as an output document w18057.]

[5] ISO/IEC 23009-2:2014: Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 2: Conformance and Reference.

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[7] ISO/IEC 14496-12:2015 Information technology -- Coding of audio-visual objects -- Part 12: ISO base media file format. This also includes amendments and corrigendas, for details see here: https://www.iso.org/standard/68960.html

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Replace Clause 8 with the following

1. Ad Insertion in DASH

1.1. Introduction

1.1.1. Use Cases and Scenarios

1.1.1.1 Overview

This clause provides an overview of guiding use cases considered in the context of ad insertion for DASH. The initial focus is on use cases addressed in clause 1.1.1.3 together with the transition issues in clause 1.1.1.7.

In future version of this document, the remaining use cases will be addressed. However, the tools documented in this clause may very well be used for ad insertion for all documented use cases.

1.1.1.2 VoD

In this case content is statically defined and made available on demand to clients. Ad insertion takes place at pre-defined placement opportunities within the content. Opportunities are located at conventional pre-, mid-, and post-roll positions within the content.

No restriction is placed on the duration of the inserted ads. Service providers may choose to fill the opportunities when the client first requests content and/or when the client playout approaches the opportunity location. Service providers may also choose to skip an opportunity, in which case content will seamlessly continue.

If possible, content should be preconditioned such that segment boundaries are created at placement opportunities.

1.1.1.3 Live

In this case content is being made periodically available to clients as part of a live event. Placement opportunities are signalled by the content author via in-band cues such as SCTE-35. Service providers may have the right to replace a subset or all of the placement opportunities that occur.

Opportunities will have an explicit expected duration announced with them and may come with little to no pre-warning. Inserted advertisements will replace in stream content and should exactly match the expected opportunity duration to avoid delaying the main content.

While opportunities are generally expected to match the announced duration, in practice opportunities may be terminated early by the content author in response to the occurring event. In this case, the main content will take priority and the inserted advertisement will be cut short at the point of in-stream opportunity termination.

In addition to early termination, opportunities may be extended by the content author in response to the occurring event. In this case, the service provider may elect to return to the main stream and use the original in stream content for the remainder of the break or treat the extension as a new opportunity and fill the announced extended duration.

Service providers may choose to skip a replacement opportunity entirely, in which case the original in stream content will be played instead.

If in-band cues are used to signal opportunities, the content encoding should produce exact segment boundaries at the cue points.

1.1.1.4 Recorded Live

In this case content is a capture of a live stream that is made available on demand to clients. Placement opportunities are the same that occurred during the original live event. Service providers may have the right to replace a subset or all of the placement opportunities that occur.

Opportunities have an explicit duration and default content associated with them. Inserted advertisements will replace the default content and may vary in duration from the original content.

Service providers may choose to skip a replacement opportunity, in which case the default content will be played instead. Service providers may also choose to remove a placement opportunity, in which case the content before the opportunity will seamlessly transition to the content after the opportunity.

1.1.1.5 Pre-Roll into Live

In this case a service provider desires to present an advertisement prior to entering a live stream. The advertisement is a static asset that is available on demand to clients and the live stream is being made periodically available to clients as part of a live event.

The advertisement may be of any duration desired and is not associated with any conditioning or markers in the live stream.

Following the playout of the advertisement, the client will join the live stream and no longer be able to access the original advertisement.

1.1.1.6 Obfuscation of Inserted Ads

In this case a service provider wishes to present an advertisement with a content stream, but does not wish for the advertisement to be detectable by the client. To accomplish this the advertisement may be stitched into content prior to packaging and manifest generation such that there is a single asset produced containing the stitched assets.

This use case is not currently in the scope of this document as the single asset will result in less interoperability challenges. However, the DASH-IF Working Group is continuing to study effective obfuscation methods and practices within DASH and will provide information in future editions of this document.

1.1.1.7 Changes that may happen at Transitions of Main content and Ads

A complex issue in the playback of ad content in combination with main content is the transition between the two contents. This transition should happen in a smooth and seamless manner such that the user does not observe discontinuities, quality changes, audio glitches, rebuffering or other artefacts. DASH provides different signaling mechanisms to indicate how content is offered. In many times, it is then a question on the capability of the underlying playback platform, whether it can handle such content in a smooth and seamless manner or if issues and problems are expected to occur. At such splice points, different issues may happen in general, some of them listed below:

- Timeline discontinuities: in order to avoid rewriting content, the inserted content may not follow the timeline of the main content. However, this can be handled in DASH at Period boundaries.
- Overlaps or possibly even gaps or of content on the master timeline: The content may not exactly be matching the envisaged insertion instructions and hence content may be overlapping at the splice points or there may be gaps. DASH permits signaling of such properties and playback platforms can handle the playback of content with such properties.
- Encryption and key changes: In case of DRM protected content, changes of the encryption or of keys may happen at splice points. DASH permits signaling of such properties and playback platforms can handle the playback of content with such properties.
- Codecs changes: Ads may be prepared with different codecs than the main content. This may result in complex codec change operations and not all platforms can handle such operations. DASH permits signaling of such changes, but also allows playback platforms to identify their capabilities, whether they can handle such changes or not.
- Codec profile/level changes: Similarly, to the above, ads may be prepared with different codec profiles or levels. Again, DASH permits signaling of such changes, but also allows playback platforms to identify their capabilities, whether they can handle such changes or not.
- Signal changes (HDR/SDR, 4K/HD, Stereo/5.1): Ad content may be offered with different signal properties, for example the resolution of the video may changes, the color space or transfer charactistics may changes, or in audio, the channel configuration may change. Again, DASH permits signaling of such changes, but also allows playback platforms to identify their capabilities, whether they can handle such changes or not.
- Addition or removal of a track (e.g. a language, subtitle): At ad or program boundaries, certain tracks or sub-assets may not be available, for example a specific language may not be available, the content may not provide subtitles, or even the offering in a certain format

or codec may not be available. Again, DASH permits signaling of such changes, but also allows playback platforms to identify their capabilities, whether they can handle such changes or not.

This specification addresses three aspects in the context of the above:

1) The signalling of the DASH formatted content at splice points on what changes may happen
2) Certain requirements on DASH formatted content in order to support playback on a majority of devices
3) The ability of signaling the required capabilities for a playback platform in order to seamlessly playback the content.

1.1.2. Definitions

ABR Encoder: live encoder that converts a broadcast stream or mezzanine into a ladder of different bit-rate tracks.

Ad Avail Processor: logical service that, given cue data, determines the placement of advertisement content within a stream and describes the necessary ad decision service communication

Ad Content Server: server storing the ad content and serving it on a per request basis.

Ad Creative: linear visual and auditory asset that represents the content of an advertisement

Ad Decision Service: functional entity that decides which ad(s) will be shown to the user. It interfaces deployment-specific and are out of scope for this document.

Ad Insertion MPD Manipulator: functional entity that proxies a DASH MPD and may change it to insert the ad creative in the streaming presentation. It may also embed other ad related metadata, or remove ad related metadata in the mpd.

Ad Pod: location or point in time where one or more ad slots may be scheduled for delivery; same as ad break, avail, and placement opportunity; pre-, mid-, and post- prefix may be used to denote pod location relative to content as before, during, and after respectively.

Ad Reporting Server: functional entity for collecting viewer impressions of advertisement content.

Ad Slot: single ad creative that is one of possibly many others that make up an ad pod

CDN node: functional entity returning a segment on request from DASH client. There are no assumptions on location of the node.

CMAF packager: functional entity, often residing with the ABR Encoder, which packages the adaptive bit-rate tracks into CMAF tracks.

DASH Ad resolver: functional entity which returns one or more remote elements on request from DASH client.

DASH Access Client: client consuming the DASH stream, possibly also contains functionality for client side ad insertion and viewer impression reporting.

DASH Ad resolver: functional entity which returns one or more ad creatives in a dash formatted construct on request from a DASH Access client.

DASH Packager: functional entity that processes conditioned content and produces media segments suitable for consumption by a DASH client. This entity is also known as fragmenter, encapsulater, or segmenter.

DASH-IF Ad Content: Content that follows specific restrictions and requirements according to this specification to be independently produced and inserted into well-formated main content by simple MPD manipulation processes.

MPD Generator: functional entity returning an MPD on request from DASH client. It may be generating an MPD on the fly or returning a cached one.

Origin: functional entity that contains all media segments indicated in the MPD, and is the fallback if CDN nodes are unable to provide a cached version of the segment on client request.

Reference Playback Platform: reference platform for playback (e.g. HTML-5 MSE/EME)

Server-Side Ad Insertion (SSAI): ad serving architecture that interleaves content and ad assets prior to the stream reaching the client.

Server-Guided Ad Insertion (SGAI): ad serving architecture that fully describes ad opportunities within content prior to the stream reaching the client, but has the client resolve opportunities as needed.

Splice Point: point in media content where its stream may be switched to the stream of another content, e.g. to an ad.

Tracking Event: data payload associated with an ad creative that is emitted by an application when a specific time point or criteria is met during the creative playout.

1.1.2 Architectures

In the context of DASH-IF guidelines, primarily two architectures are considered. In the Server-Side Ad Insertion (SSAI) architecture, the ad is inserted in the network before reaching the DASH Client. In the Server-Guided Ad Insertion (SGAI) architecture, information about ad placement and resolution is inserted in the network, but final resolution is done on demand by the DASH client. The architectures share a significant amount of the functions and interfaces documented in Figure 1.

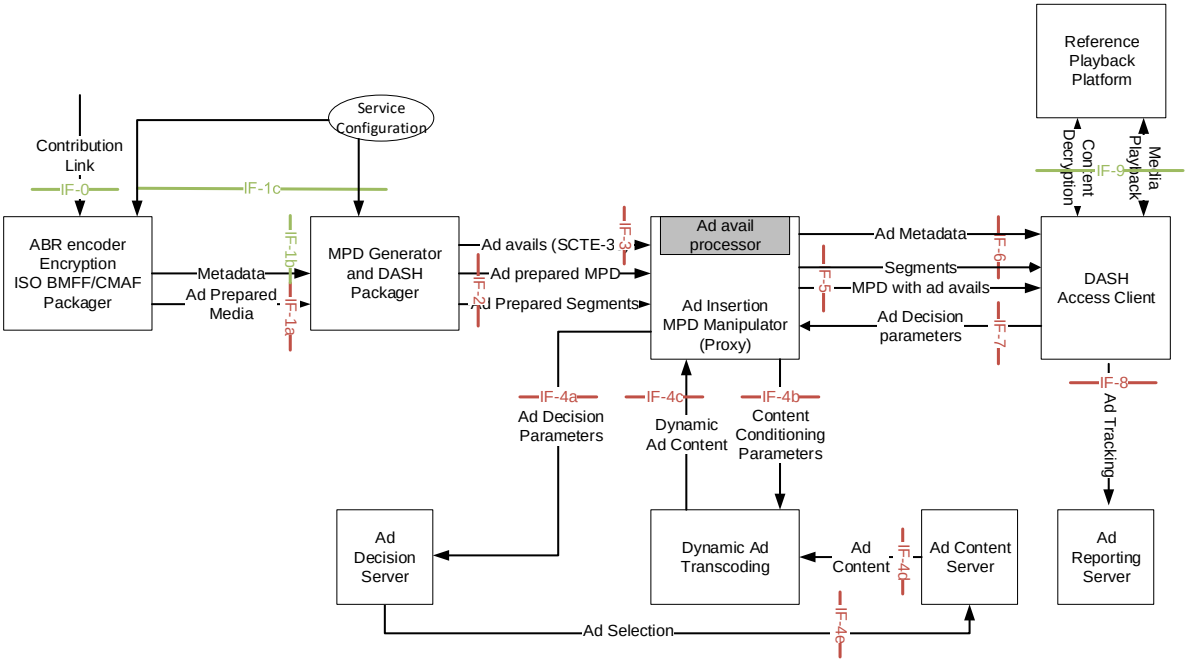

Figure 1 DASH-IF Ad Insertion Architecture

In this document, requirements and recommendations are provided for different interfaces. The main focus of the work are the interfaces to and from the DASH client. However, network interfaces and functions are also discussed as they impact the processing in certain functions.

Note 1: The above diagram combines the MPD and Segment servers, in a refined version they may be separated.

Note 2: The latency of each function/interface may be provided in a revised version. Input is welcome.

Note 3: The interface names are only numeric. Should DASH-IF provide more instructive names and if so, feedback is welcome on commonly agreed names for each of the interfaces. This is discussed in https://github.com/Dash-Industry-Forum/AdInsertion/issues/40, please join the discussion.

An overview of the functions and interfaces are provided in clause 1.1.3.

1.1.3 Overview on Interfaces and Functions

The Ad Insertion architectures start with the ingest of an input stream over IF-0 which is processed by an ABR Encoder and output as well-formed CMAF content over the IF-1 interface. A DASH Packager / MPD Generator uses IF-1 input to generate a conformant DASH content presentation that is sent over IF-2 and additional opportunity metadata that is sent (IF-3).

An Ad Insertion MPD Manipulator uses the inputs of IF-2 and IF-3 to generate a DASH presentation that is a mixture of content and advertisements. In the SSAI architecture, the manipulator uses IF-4 to ask an Ad Decisioning / Content Server to provide advertisement placements for the content stream before generating the final DASH MPD for IF-5 which contains metadata about the inserted ads via IF-6. In the SGAI architecture, the manipulator does not immediately use IF-4, instead it embeds opportunity information from IF-3 into the DASH MPD IF-5 output so that the DASH Client may later use IF-7 to retrieve the proper ad placements.

The DASH Client utilizes the reference media pipeline provided by IF-9 to perform seamless playout of the mixed content and ad presentation obtained via IF-5. Ad measurement and tracking is enabled in the client by IF-8 utilizing the ad metadata embedded as part of IF-6.

In Table 1 the interfaces defined are detailed with section references and some example instantiations. Each interface section will provide an informative overview of said interface and where aspects of the interface falls within the scope of this document, normative requirements will be provided.

Table 1 Interfaces identified in the ad insertion architecture, example instantiations and references within the document

Interface	Function	Example instantiations	Reference
IF-0	ABR Stream Source	MPEG-2 TS, RIST	1.2.1
IF-1a	Packager Ingest Media	DASH Ingest interface 1, azure smooth ingest, CMAF	1.2.2
IF-1b	Packager Ingest Metadata	DASH Ingest interface 1 metadata, azure smooth ingest metadata	1.2.2
IF-1c	Configuration Parameters	See for example DASH-IF IOP v4.3 and LL-DASH extensions	1.2.2
IF-2	Content Preparation	MPEG DASH, IOP v4.3.	1.2.4
IF-3	Ad Avail Signalling	SCTE-214.X, CableLabs	1.2.5
IF-4a	Ad Decisioning Parameters	This specification	1.2.6
IF-4b	Ad Content Conditioning Parameters	This specification	1.2.6
IF-4c	Dynamic Ad Content Format	This specification	1.2.6
IF-4d	Ad Storage Format	This specification	1.2.6
IF-4e	Ad Selection Result	VAST/VMAP, SCTE-130	1.2.6
IF-5	MPD and Segments with Ad Placement	MPEG DASH, IOP v4.3, this specification	1.2.7
IF-6	Ad Metadata Signalling	MPEG DASH, IOP v4.3	1.2.8
IF-7	Remote Resolution with Decisioning Parameters	MPEG DASH, IOP v4.3	1.2.9
IF-8	Ad Tracking and Measurement	VAST, Open Measurement SDK	1.2.10
IF-9	Reference Media Playback and Content Decryption	HTML-5 video, MSE, EME, CTA WAVE Device Playback Platform	1.2.3

1.2. Interface definitions

1.2.1. IF-0: ABR Stream Source

1.2.1.1 General

The formatting and delivery of media input to the ABR encoder is described by IF-0. The ad insertion architectures in this document are agnostic to the choice of this interface instantiation and as such information in this section shall be considered informational.

Example interface instantiations may differ depending on the type of media input being supplied to the architecture. For example, a VOD workflow may utilize a mezzanine delivery format such as the CableLabs Video-On-Demand Content Specification [93], while a LIVE workflow may utilize a contribution feed delivery format such as MPEG-2 TS [94], RIST [99].

For any instantiation, it is usually beneficial for the media input to contain descriptive metadata about the media input such that the ABR encoder may provide conditioning of the encoded output and pass-through said information to components later in the ad insertion streaming architecture. As the format of descriptive metadata may be workflow specific, the examples provided below should be considered informational only.

1.2.1.2 LIVE Workflow Descriptive Metadata

In a LIVE workflow, the descriptive metadata may consist of program, segmentation, and splicing information, we will refer to this information as *broadcast events*. Examples of what *broadcast events* signal are program start/end, chapter start/end, interstitial, distributor start/end, provider break start/end, content identification, and many others. SCTE-35 or SCTE-104 are examples of standards to insert such *broadcast events* aligned with the media presentation in IF-0. In Figure 3, we show a segmentation of a live input based on SCTE-104/35 [54].

Figure 3 shows a live broadcast with segmented broadcast information based on *broadcast events*. In this case broadcast events are used to segment and can optionally be used to signal ad breaks. Nevertheless, more information is carried about the broadcast streams. The placement opportunities are shown in green. For more information relating to the commands supported we refer to [54].

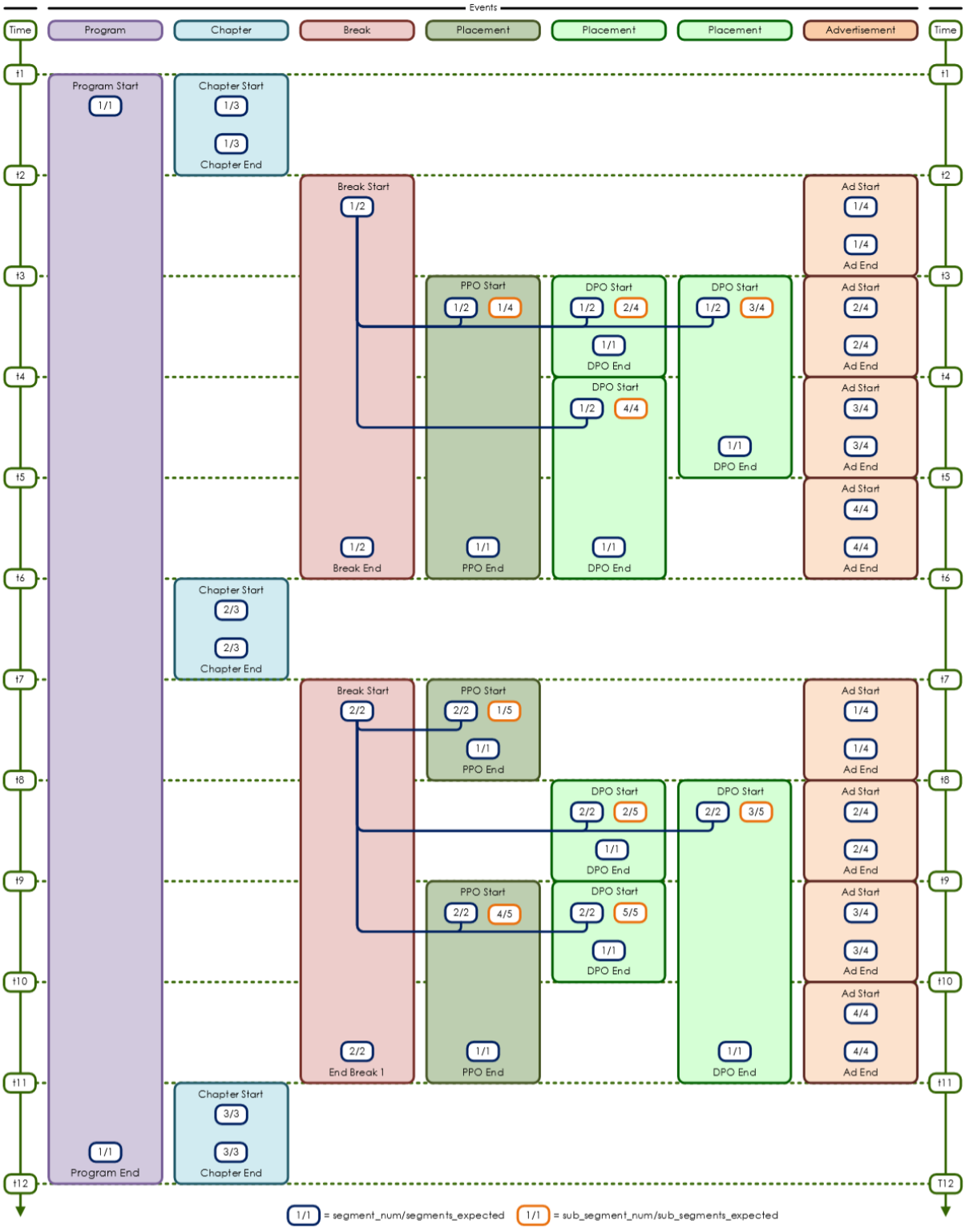

Figure 3: segmented live broadcast with broadcast events [54]

1.2.1.3 VOD Workflow Descriptive Metadata

In a VOD workflow, content is delivered to a service provider by a content provider as a package of various assets and metadata that make up the full description of the content. This package contains mezzanine assets that streamable assets may be produced from, but may also contain still image cover art, promotional assets, and preview trailer assets. The metadata provided alongside assets include basic information such as title, genre, and rating, but also includes advanced metadata such as chapter locations, distribution subscriber

requirements, and distributor ad preservation requirements. One format of this package is described by the CableLabs Video-On-Demand Content Specification [93], which we defer to for further information about package structure and data.

1.2.1.4 Abstracted Model

Media provided in mezzanine or ingest is assumed to have a continuous media time and the timestamp of the media carries through the ABR encoder for each media type as shown in Figure 2. In addition, splice points are defined and at these splice points, at a specific media time t_{splice}, the ABR encoder is expected to prepare the content accordingly in order to permit splicing. The reason and details of each splice point and the conditions may be carried through but are irrelevant for the media preparation.

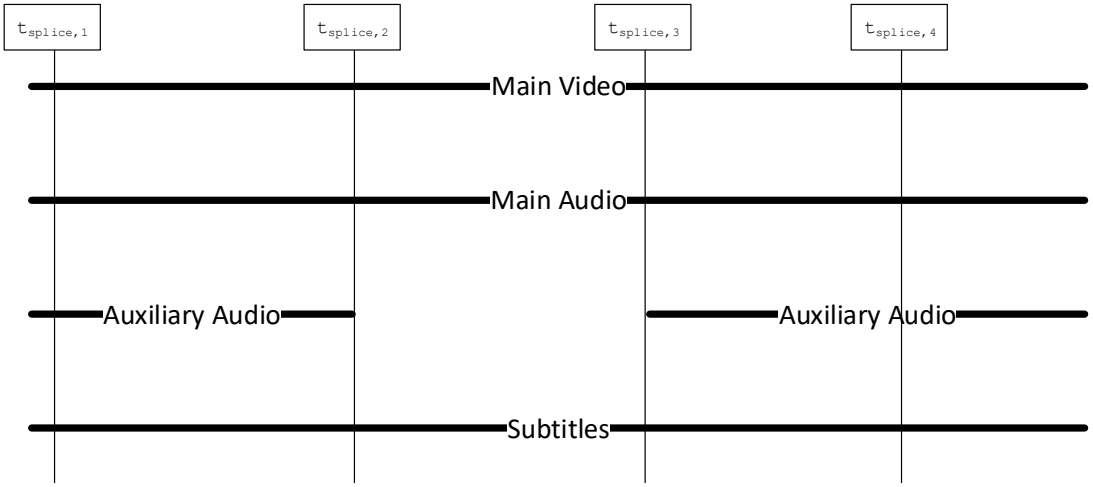

Figure 2 Abstracted Media Model with splice points.

1.2.2. IF-1: Packager Ingest

The ABR encoder provides encoded variants of the media input and prepares CMAF conforming headers, chunks and fragments as defined in ISO/IEC 23000-19 [99] , organized in CMAF structures such as CMAF Tracks and Switching Sets. The content may also be provided together with an MPD that follows the DASH Profile for CMAF content as defined in ISO/IEC 23001-9 [101]. This reflects what is documented with IF-1a inFigure 1.

Those CMAF prepared content is assumed to be properly annotated through metadata. The metadata carries information that can be used by the DASH packager for specific information. This reflects what is documented with IF-1a in Figure 1. A recommended protocol for the combination of the two, IF-1a and IF-1b interface, is the DASH-IF Ingest Spec [92] (CMAF ingest interface).

In addition, the service follows certain service configuration options that are provided by external means. The configuration may include information such as the nominal CMAF fragment duration (DASH segment duration), CMAF chunk duration, number and bitrates in a CMAF Switching Set, codec configurations and media profiles, etc. This reflects what is documented with IF-1c in Figure 1.

The definition of this interface IF-1 is outside of the scope of this document, but in the following several assumptions on the generated media being provided to the DASH packager are taken, predominantly that the encoder produces well-formated CMAF conforming content [99]. Note that these assumptions are not a requirement for this specification, but a service provider should understand the downstream system effects if the packager ingest does not follow these assumptions. For example a transcoding or timeline corrections needs to be done in the DASH packager to meet

the output requirements for following interfaces, or a specific addressing scheme may have to be used.

The following assumptions are taken:

- The ABR encoder produces continuous content with a single CMAF Header for each CMAF Track. There may be instances that in between two potential splice points at media times $t_{splice,i}$ and $t_{splice,i+1}$ not all Tracks/Switching Sets are provided. However, at least a minimum set of Switching Sets are always present.
- For those CMAF tracks that are present for the entire program, the media time is continuous, also across splice points. This means that the subset of continuously present CMAF Switching sets of the entire program conforms to a CMAF presentation as defined in ISO/IEC 23000-19, clause 7.3.6.
    - Note: this assumption may be relaxed, but if done, there needs to be a signaling for such a discontinuity. Input on this subject would be welcome.
- There are three options for content in between two potential splice points at media times $t_{splice,i}$ and $t_{splice,i+1}$.
    - For Option 1 referred to as "Splice-Conditioned Packaging", the following holds:
        - The output of the ABR encoder in between two potential splice points at media times $t_{splice,i}$ and $t_{splice,i+1}$ is CMAF conforming, i.e. it conforms to a CMAF presentation as defined in ISO/IEC 23000-19 [99], clause 7.3.6.
        - The first splice point at $t_{splice,i}$ is the *timeline origin* of all CMAF tracks in the CMAF presentation as defined in ISO/IEC 23000-19 [99], clause 7.3.6.

            Note: this does not imply that each splice point resets the timeline. Indeed this would contradict the first assumption above that media is time-continous.
        - The ABR encoder provides content that can be converted to conforming DASH content, for example consistent CMAF Fragment duration to enable proper usage of DASH Segment duration signaling, bitrate characteristics for signaling in the MPD, event messages, etc.
        - The ABR encoder creates a CMAF Fragment boundary for all CMAF Tracks at $t_{splice,i}$ and resets the CMAF Fragment duration from here on.

            Note: This permits Period boundary insertion at $t_{splice,i}$ without modification of the CMAF content.

        - The ABR encoder creates media for *all* samples of *all* CMAF tracks in between $t_{splice,i}$ and $t_{splice,i+1}$ with $t_{splice,i}$ being included and $t_{splice,i+1}$ being excluded.

            Note: This permits to create a Period that is fully covered by content.

        - The ABR encoder creates a CMAF Fragment boundary for all CMAF Tracks at $t_{splice,i+1}$ and resets the CMAF Fragment duration from here on.

            Note: This permits Period boundary insertion at $t_{splice,i+1}$ without modification of the CMAF content.

    - For Option 2 referred to as "Splice-Conditioned Encoding", the following holds:

        - The ABR encoder creates a SAP type 1 or 2 at $t_{splice,i}$ with T_{SAP} set to $t_{splice,i}$. The placement of the SAP type 1 or 2 may not and typically does not co-incide with a CMAF Fragment boundary.

        - The ABR encoder creates a SAP type 1 or 2 at $t_{splice,i+1}$ with T_{SAP} set to $t_{splice,i+1}$. The placement of the SAP type 1 or 2 typically does not co-incide with a CMAF Fragment boundary.

    - For Option 3 referred to as "Splice Point Signaling", no specific encoding and packaging is done at the splice points.

        - It may be the case that an exact alignment of a SAP type with the splice point may not be possible, for example due to the codec or format properties. However, additional SAP types may be available, or the the media can be accessed quickly by other means, for example by accelerated decoding.

- The ABR encoder passes through timed metadata (from contribution/production feed IF-0) related to the provided descriptive metadata and content conditioning, including the signaling and timing of each splice point $t_{splice,i}$.

- The content may be provided at once, for example as part of a VoD Asset generation, or the content may be provided by the ABR encoder on a continuous timeline, for which real-time and media time advance in concurrently.

Note: Slice points are defined independent whether you enter or exit the content. Please provide feedback if this differentiation should be added in the final version of the document.

It may be also the case that within one content generation work flows, certain media encoding follows option 1 whereas others may follow option 2 or option 3. For example, video may follow option 1, and audio may be encoded based on option 3.

The three options for encoder and packager configuration are shown in Figure 3. In option 1, CMAF Fragment boundaries are aligned with splice points, and in option 2, splice points may occur in the middle of a CMAF Fragment, but are supported by a SAP type 1/2 for random access. In option 3, no SAP type 1 or 2 is necessarily provided at the splice point.

Note: As an example, please note that CMAF Fragment#3 in Option1 may be shorter or it may be even longer than CMAF Fragment #2 in order to align Splice Points with CMAF Fragment Boundaries.

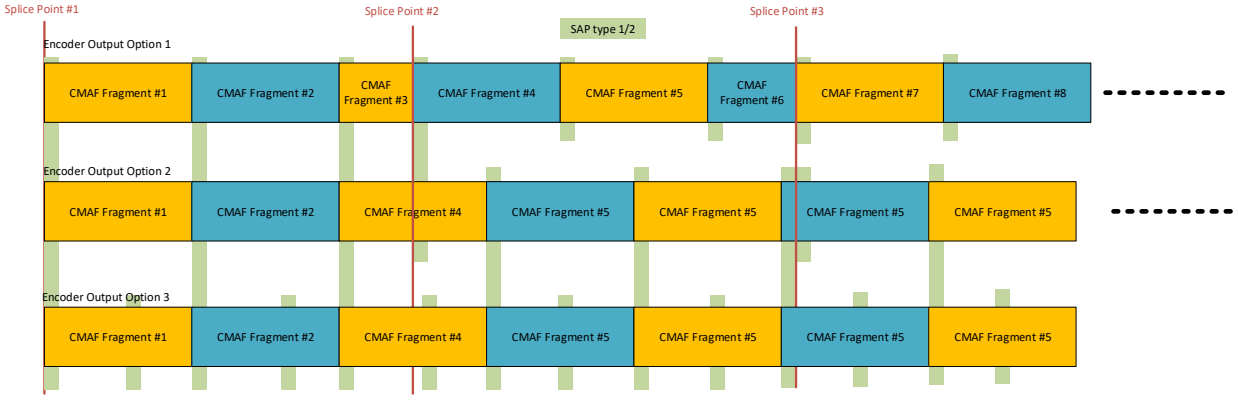

Figure 3 CMAF Encoder and Packager options

1.2.3. IF-9: Reference Media Playback and Decryption

Another important assumption in the context of this specification is the availability of a reference playback platform that enables a DASH client to use for media playback and decryption. Without limiting the usage of any DASH player, this assumption permits that content is authored such that platforms with certain restrictions can be used.

The DASH Client interacts with the media pipeline on the reference platform via the IF-9 interface. The definition of this interface is out of the scope of this document, but the general assumption of the DASH-IF IOP is an MSE [96] / EME [97] reference pipeline.

Furthermore, it is assumed, for interoperability and/or robustness of this interface, that the reference playback platform supports the playback requirements defined by the Consumer Technology Association Web Application Video Ecosystem Project (CTA Wave) Device playback specification [98].

Specifically, in the context of this specification, a playback platform is expected to support playback requirements as documented in clause 8 of CTA-WAVE 5003 [98] for any content conforming to a CMAF Switching Set according to CMAF media profile included in an MPD, namely

- 8.2 Sequential Track Playback
- 8.3 Random Access to Fragment
- 8.4 Random Access to Time
- 8.5 Switching Set Playback
- 8.8 Playback over WAVE Baseline Splice Constraints
- 8.13 Restricted Splicing of Encrypted Content
- 8.14 Sequential Playback of Encrypted and Non-Encrypted Baseline Content

If a playback platform wants to consume content authored according to encoding and packaging option 2 or 3, ("Splice-Conditioned Encoding" and "Splice Signaling", respectively) as defined in clause 1.2.2 for content conforming to a CMAF Switching Set according to CMAF media profile included in an MPD, is expected to support the following playback requirements as documented in clause 8 of CTA-WAVE 5003 [98].

- 8.9 Out-Of-Order Loading
- 8.10 Overlapping Fragments

Finally, it is assumed that the reference playback platform can be used in order to query proper capabilities such that MPD information can be transformed into capability queries, e.g. if a codec is supported. Device Capability queries is discussed in clause 6.4 of CTA-WAVE 5003 [98].

> Note: A revised version will add more details on device capabilities requirement are expected in an updated version.

1.2.4. IF-2: Content Preparation

The format and requirements of the DASH manifests and segments output by the DASH Packager / MPD Generator for use later in the ad insertion architecture is described by IF-2. The DASH IOP Guidelines provide the general normative requirements on the DASH output and we will assume those as a baseline set of requirements. Here we will provide further normative requirements for the ad insertion architectures.

Generally, for each known ad splice point, the DASH Packager/MPD Generator should insert a Period boundary.

The recommendation of Period boundary generation at splice points within the DASH Packager / MPD Generator is made such that the downstream Ad Insertion MPD Manipulator can perform replacements and insertions on the MPD-level only without accessing the content segments. Should the DASH Packager / MPD Generator not be aware of what splice points are appropriate for ad insertion, the Period boundaries may be omitted and instead be created by the downstream Ad Insertion MPD Manipulator, further details of this operation are provided as part of IF-5.

In the following it assumed that at least one media type (typically video) follows the content generation according to clause 1.2.2, option 1 ("Splice-Conditioned Packaging") and furthermore it is assumed:

- Each CMAF fragment generates one DASH Segment
- The content is provided in a live session, i.e. CMAF fragments are made available to the DASH packager once completed.
    - NOTE: Low-Latency operation will be added in the final version of the document in alignment with the Low-Latency DASH extensions.
- The minimum splice point advance notice time is known, i.e. the DASH packager gets a pre-notification or ad avail for a splice point that will be added to the media. This allows the DASH Packager to configure the minimum update period of the MPD properly. By this, the DASH client or MPD proxy requests the MPD in high enough frequency such that none of the announced Periods in the MPD are missed. For example, in SCTE-35, it is recommended to provide an advance notice of at least 4s [54]
    - NOTE: please provide feedback on practicability and other examples during community review phase. This is discussed in https://github.com/Dash-Industry-Forum/AdInsertion/issues/46, please join the discussion.

then a DASH packager produces content by (i) generating an initial MPD, and (ii) dynamic operation of the packager including MPD processing/updates and Segment offering.

The initial MPD is generated as follows:

- The CMAF data is mapped to the MPD using the DASH profile for CMAF content as defined in ISO/IEC 23009-1 [101].
- For every CMAF Switching Set that is known to be offered in the MPD, an Initialization Set as defined in ISO/IEC 23009-1 [101], clause 5.12 should be added that describes all known static parameters for the CMAF Switching Set, preferably based on the information in the CMAF Master Header (i.e. a CMAF Header that is sufficient to initialize the media pipeline for continuous playback, see CTA WAVE 5003 [98] for details) for this CMAF Switching Set.
    - Every Initialization Set gets assigned a unique id.
    - For every CMAF Switching Set that is not known to be offered on a continuous basis, the `@inAllPeriods` of the Initalization Set is set to `false`.
    - For every CMAF Switching Set that is known to be offered on a continuous basis, the `@inAllPeriods` of the Initalization Set is set to `true` or the attributed is omitted.
- The **`MPD`**`@availabilityStartTime` is set to an arbitrary value.
- The `@mininumUpdatePeriod` is set sufficiently small such that DASH clients and MPD proxies do not miss Periods created for announced splice points taking into account the minimum splice point advance notice time.
- The initial MPD follows the Main content in Table 1.

For every splice point `i` at time $t_{splice,i}$, a new Period is generated as follows:

- If it is the first Period in the presentation and the media is "starting" to be produced, then
    - `@start` of the Period is set to `NOW - @availabilityStartTime` with some possible margins to address different Segment availability times, for example due to publication delay on a CDN.
- If it is not the first Period in the presentation
    - `@start` of the Period is set to the sum of the value of **`Period`**`@start` of the previous period and the interval between the two splice points ($t_{splice,i} - t_{splice,i-1}$)
    - Period continuity is signaled across all Adaptation Sets that are continuing across the Period boundary. Preferably the same signaling and track structure is used.
- Every available CMAF Switching Set in the CMAF Presentation is mapped to one Adaptation Set using the DASH profile for CMAF content as defined in ISO/IEC 23009-1 [101]. Within one Adaptation Set the following parameters are set
    - The `@timescale` attribute is set to the timescale of the CMAF Track
    - The `@presentationTimeOffset` is set to $t_{splice,i}$ normalized by the `timescale`.
    - The `@eptDelta` and, if applicable, the `@startNumber` or **`SegmentTimeline`** is set to indicate the placement of the first Segment in the Period. Note if the content follows option 1, then `@eptDelta` is set to 0 and can be absent.

- Period continuity is signaled to indicate, which Adaptation Set follows continously the previous one.
- If the CMAF switching set is identical to one for which an Initialization Set was set, then all parameters from the Initialization Set are copied into this Adaptation Set and the `@initializationRefId` is set to the one referred to.

Note 1: Instead of assumption, this content may be changed into requirements. These requirements may then be signalled with a specific profile.

Note 2: This operation does not consider aspects such as inconsistent/variable segment durations within a CMAF Presentation, upstream losses or errors, etc. Any of such occurrences may result in additional Periods that may be added according to the DASH-IF IOP guidelines.

The mapping is shown in Figure 4.

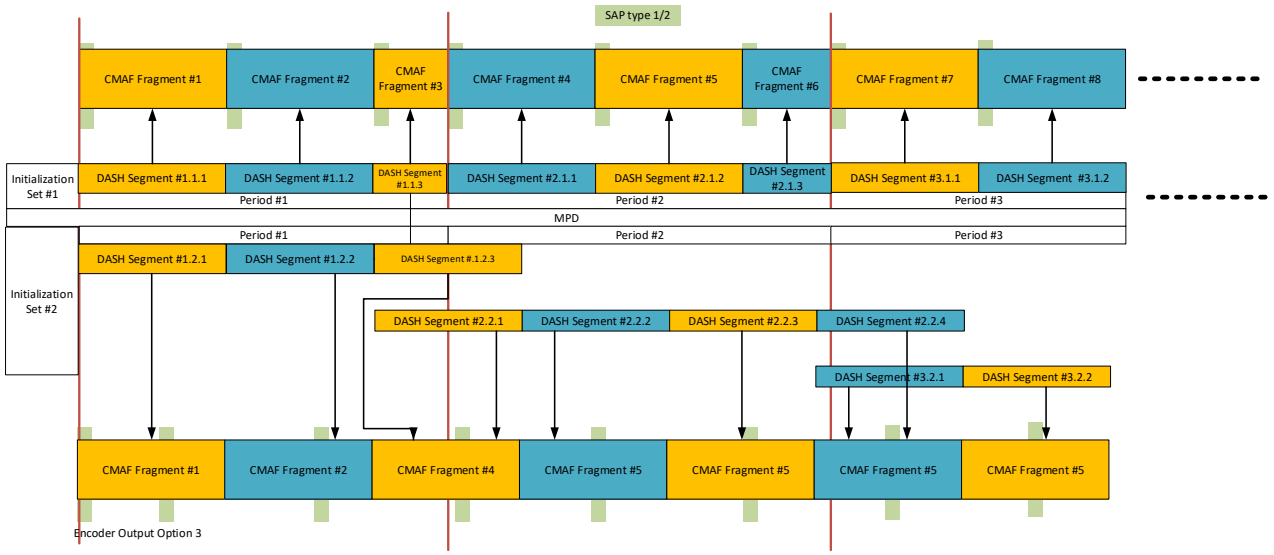

Figure 4 CMAF Fragment to DASH Mapping for Option 1 and 3

NOTE 3: Signaling of content encoding options 1 and 3 is for further study. Examples are how to signal `@eptDelta`, `@presentationTimeOffset`, etc.

Table 1 defines the Main live content MPD. More details need to be added.

Table 1 DASH-IF Main live content MPD

Element or Attribute Name	Use	Description
MPD		Provides the requirements for DASH-IF main content. Any not specified value is identical to what is provided in ISO/IEC 23009-1 [10x], clause 5.3.1.
ServiceDescription	0 ... N	
Latency@TargetLatency	0	A target latency may be provided

Element or Attribute Name	Use	Description
@profiles	M	should include a profile indicator signaling http://dashif.org/guidelines/dashif-main-live-content (hopefully v5 defines this) and should include a profile identifier for the DASH CMAF profile "urn:mpeg:dash:profile:cmaf:2019" profile if all content is encoded following option 1.
@type	M	Shall be set to dynamic
@minBufferTime	M	Shall be present
@suggestedPresentationDelay	R	Shall not be present
@maxSegmentDuration	R	Shall not be present
InitializationSet	1 … N	At least one shall be present
ProgramInformation	0…N	This should be used to describe information about the main content. More details may be provided
Period	1 … N	One or more Periods shall be present. Provides the requirements for main live content. Any not specified value is identical to what is provided in ISO/IEC 23009-1, clause 5.3.2.
@xlink:href	R	Shall be absent.
@xlink:actuate	R	Shall be absent.
@start	M	Shall be present.
@duration	R	Shall not be present
BaseURL	0	Shall not be present
EventStream	0…N	specifies an event stream. <What can we say about this? Event Streams that go across Periods?> This is discussed in https://github.com/Dash-Industry-Forum/AdInsertion/issues/45, please join the discussion.
AdaptationSet	1…N	At least one Adaptation Set shall be present.
@xlink:href	R	Shall be absent
@xlink:actuate	R	Shall be absent
SegmentBase@presentationTimeOffset	OD default: 0	shall be set to the correct value of the presentation time of the Adaptation Set at the start of the Period, if the presentation time is not equal to 0.
@contentType	M	Shall be present
SegmentList	0	Shall be absent

Element or Attribute Name	Use	Description
Representation	1 … N	specifies a Representation. At least one Representation element shall be present in each Adaptation Set. Any not specified value is identical to what is provided in ISO/IEC 23009-1, clause 5.3.3.
Subset	0	Shall be absent.
EmptyAdaptationSet	0	Shall be absent
UTCTiming	1 … N	At least one shall be present
Key For attributes: M=mandatory, O=optional, R=removed For elements: <minOccurs>…<maxOccurs> (N=unbounded) Elements are **bold**; attributes are non-bold and preceded with an @.		

1.2.5. IF-3: Ad Avail Signalling

1.2.5.1 Introduction

Opportunity metadata is made up of the original descriptive metadata of the input media related to signalling of ad opportunities and the content segmentation information generated by the DASH Packager. Carriage of opportunity metadata in the presentation output by the DASH Packager / MPD Generator is done via IF-3.

The following normative statements on opportunity metadata carriage are made:

- Opportunity metadata shall be carried through DASH MPD Events

The requirement of MPD Events over other carriage mechanisms is made such that the downstream Ad Insertion MPD Manipulator can perform insertions without accessing the content segments.

Note: Please check the above requirement during community review and comment if this overconstrains deployments.

While the carriage method is considered normative, the format of the metadata is workflow dependent. Examples of known schemes are provided in the subsequent sub-sections of this interface. For the purposes of this document, we will consider the carriage of opportunity metadata via SCTE-35 signalling sufficient, but other methods of equivalent means may be used.

1.5.2.2 Opportunity Signalling via SCTE-35

SCTE-35 describes a set of command messages that can be utilized to describe ad opportunities within a presentation. Typically, the broadcast events for a LIVE presentation are already signalled as SCTE-35 commands which may be directly used, but a VOD workflow may optionally synthesis a series of SCTE-35 commands to describe the conditioning and opportunities in a VOD presentation as well.

The SCTE 214 specification defines a set of event schemes for carrying SCTE-35. The appropriate event scheme to use depends on the utilized DASH mechanism, DASH MPD Events may use either `urn:scte:scte35:2013:xml` or `urn:scte:scte35:2014:xml+bin`.

An example of carrying SCTE-35 with MPD Events using the `urn:scte:scte35:2014:xml+bin` scheme is shown in Table 2. The timing described within the SCTE-35 payload provide the event properties `@id`, `@presentationTime`, and `@duration` properties. The id may be used to filter out duplicate events. In this example the payload is encoded using Base64 enclosed in the `<Binary>` tag per SCTE 214.

Table 2 Example of a SCTE-35 message embedded as an MPD event using SCTE 214

```
<EventStream
  schemeIdUri="urn:scte:scte35:2014:xml+bin"
  timescale="1">
  <Event
    presentationTime="1540809120"
    duration="24"
    id="1999">
    <Signal xmlns="http://www.scte.org/schemas/35/2016">

<Binary>/DAhAAAAAAAAAP/wEAUAAAfPf+9/fgAg9YDAAAAAAAA/APOv</Binary>
    </Signal>
  </Event>
  </EventStream>
```

1.2.6. IF-4: Ad Decisioning and Exchange Interfaces

1.2.6.1. Introduction

Information about ad content to insert into a presentation is retrieved from the Ad Decision and Ad Content server(s) via the IF-4 interfaces. The request from the Ad Insertion MPD Manipulator for ad content provides all the information needed to perform ad decisioning, including content metadata and opportunity descriptions. The response is then translated by the Ad Insertion MPD Manipulator into the DASH structures detailed in IF-5.

There are many details corresponding to the functions of ad requests and ad decisioning, as such this document identifies 5 different sub-interfaces that outline primary interactions of ad requests and decisioning.

The identified 5 sub-interfaces are:

- Interface IF-4a: Ad Decision request parameters. For details see 1.2.6.2.
- Interface IF-4b: Content Conditioning request parameters. For details see 1.2.6.3.
- Interface IF-4c: Recommended Dynamic Ad Content response format. For details see 1.2.6.7.
- Interface IF-4d: Recommended Ad Content Storage format. For details see 1.2.6.6.
- Interface IF-4e: Ad Selection Result format. For details see 1.2.6.5.

1.2.6.2. IF-4a: Ad Decision request parameters

1.2.6.2.1. Decisioning Parameters

A *decisioning parameter* is a piece of information about the content stream, consumption medium, or end user that is used by the Ad Decisioning Server as part of the advertisement qualification and selection process. The Ad Insertion MPD Manipulator collects and sends this information to the Ad Decisioning Server as part of IF-4a.

The transmission of decisioning parameters is highly integration dependent, but examples of commonly used industry parameters are:

- Content Unique Identifier
- Content Genre
- Content Language
- Service Provider Identifier
- Device Type (TV, SetTop, Mobile, Computer, etc)
- Device Manufacturer
- Device Model
- End User IP Address
- End User Zip Code

1.2.6.2.2. Decisioning Modes

The *decisioning mode* of an Ad Decisioning Server dictates how the server chooses to fulfill ad requests made by a caller. The Ad Insertion MPD Manipulator must specify the decisioning mode for the Ad Decisioning Server to use via IF-4a based on the implemented ad insertion architecture. There are two general modes of ad decisioning that the SSAI and SGAI architectures respectively enable: *stream level decisioning* and *pod level decisioning*.

With *stream level decisioning*, all advertisement opportunities are decided prior to DASH client receiving the stream. A SSAI architecture accomplishes this by having the Ad Insertion MPD Manipulator send the IF-3 supplied opportunity metadata to the Ad Decision server via IF-4a. The result of the ad decision request will contain advertisements for the entirety of the stream which the Ad Insertion MPD Manipulator transforms into an IF-5 manifest a mixture of content and advertisements.

After a DASH client receives a stream produced from an SSAI architecture, the stream will remain fixed for the duration of the playback session, e.g. the same advertisements will play again should the user choose to rewind the stream.

With *pod level decisioning*, advertisement opportunities are decided just as the DASH client reaches the opportunity within the stream. A SGAI architecture accomplishes by having the Ad Insertion MPD Manipulator use the IF-3 supplied opportunity metadata to generate an IF-5 manifest with a mixture of content and remote entities that represent opportunities. As the client reaches remote entities during playout, the client utilizes IF-7 to return the opportunity metadata to the Ad Insertion MPD Manipulator which then sends the data to the Ad Decision server via IF-4a. The result of the ad decision request will contain advertisements for this single opportunity which the Ad Insertion MPD Manipulator transforms into an IF-7 response for the client to consume.

After a DASH client receives a stream produced from an SGAI architecture, the stream can continue to change for the duration of the playback session, e.g. the advertisements can be re-decisioned should the user choose to rewind the stream.

1.2.6.3. IF-4b: Content Conditioning request parameters

A *conditioning parameter* is a piece of information about the encoding/packaging of the content stream or a client player capability that is used by the Ad Content Server to ensure an ad creative is compatibly encoded for inclusion in the generated presentation. The Ad Insertion MPD Manipulator collects and sends this information to the Ad Content Server as part of IF-4b.

The transmission of conditioning parameters is highly integration dependent, but examples of commonly used industry parameters are:

- Video / Audio Codecs
- Player Splice Condition Robustness
- Encryption Schemes

1.2.6.4. DASH-IF Query scheme for Decision (IF-4a) and Conditioning Parameters (IF-4b)

Editor's Note: <this will normative, but optional/recommend. Expected to be identical/similar to IF-7, so reference from here to IF-7 expected>

Note: The final version is expected to include well-defined query parameters. Inputs are welcome. This is discussed in https://github.com/Dash-Industry-Forum/AdInsertion/issues/47, please join the discussion.

1.2.6.5. IF-4e: Ad Selection Result format

1.2.6.5.1. Overview

The response of the Ad Decision Server identifies the advertisements decisioned by the server and provides information associated with the advertisement such as general metadata, viewability requirements, media files, mezzanines, and tracking events. The actual ad content is provided by the Ad Content Server, preferably following the DASH-IF Ad Content format as defined in clause 1.2.6.6. Depending on the decisioning mode, the decision response may optionally contain the placement and ordering of advertisements as well.

While the general information carried in the response is described above, the explicit format of this response is workflow dependent. Examples of known industry formats are given in the subsequent sub-sections of this interface. For the purposes of this document we will assume VAST/VMAP is used, but other formats with equivalent data communication may be used.

1.2.6.5.2. IAB VAST and VMAP

An instantiation of IF-4e is standardized by the Interactive Advertising Bureau (IAB) as the Digital Video Ad Serving Template (VAST) [53] and Video Multiple Ad Playlist (VMAP) [52] specifications.

The VAST specification provides structure definitions for representing a variety of ad types, including linear, non-linear, and companion. A single VAST response may contain a stand-alone ad slot or a whole pod of ad slots, and each ad structure can provide general metadata, viewability requirements, media files, mezzanines, and tracking events.

The VMAP specification is a complement to the VAST specification as it describes a playlist structure that wraps one or more VAST ad responses to provide ad decisions for an entire stream. A VMAP response will provide the order and position that ad pods should occur in the content stream and may also provide additional tracking events for pod level tracking.

1.2.6.5.3. SCTE-130

Another instantiation of IF-4e is standardized by the Society of Cable Telecommunications Engineers (SCTE) as the response of the Ad Decision Service (ADS). The ADS is responsible for determining how advertising content is combined with non-advertising content. The exact format and schema of the ADS response is normatively defined within SCTE-130 Part 3 [103], which we defer to for further information.

1.2.6.6. IF-4d: Recommended Ad Content Storage format

This interface provides a recommended content format for ad content that is expected to be dynamically inserted into a DASH live or on demand Media Presentation.

Ad content is recommended to follow the DASH-IF Ad content format as defined in the following. This specification does not exclude the use of other content, but the content author should be aware of any differences to the DASH-IF Ad Content format.

DASH-IF Ad follows the restrictions and requirements according of this specification and may produced independently of the main content for insertion into well-formated main content by simple MPD manipulation processes.

If content is offered conforming to the DASH-IF Ad content format and follows the following requirements and recommendations, then it may annotate with a `@profiles` parameter: `"http://dashif.org/guidelines/dashif-ad-content"`.

The following requirements for DASH-IF Ad Content apply:

- The content shall be provided as a DASH Media Presentation, i.e. a complete MPD with referenced Segments and shall follow the semantics in Table 2.
- The DASH Media Presentation shall conform to the DASH profile for CMAF content as defined in ISO/IEC 23009-1 [101].

  Note: An important assumption for the above profile is the availability of content for CMAF Tracks over the entire Period. Content may be overlapping at the start of the Period or at the end of the Period.
- The DASH Media Presentation shall contain exactly one Period.
- The **`MPD`**`@type` shall be set to `'static'`.

NOTE: Please provide comments if additional restrictions and requirements would be considered useful. Please join the discussion here: https://github.com/Dash-Industry-Forum/AdInsertion/issues/48.

The following recommendations for DASH Ad Content apply:

- The MPD should contain a profile indicator signaling `"http://dashif.org/guidelines/dashif-ad-content"`
- The content should be offered using the Segment timeline.
- The Segment durations within on Adaptation Set should be approximately identical.

- The content may and typically should include multiple variants for the same ad, for example different codecs, formats and resolutions in order for the Dynamic Conditioning, the MPD proxy or a DASH client to adjust the ad to the current playback conditions.

NOTE: Please provide comments if additional recommendations would be considered useful or if any of the recommendations should be removed or made a requirement. Examples are guidelines for exact duration signaling or encrypted content. Please join the discussion here: https://github.com/Dash-Industry-Forum/AdInsertion/issues/48.

Table 2 DASH-IF Ad content MPD

Element or Attribute Name	Use	Description
MPD		Provides the requirements for ad insertion content. Any not specified value is identical to what is provided in ISO/IEC 23009-1 [10x], clause 5.3.1.
`@profiles`	M	should include a profile indicator signaling `http://dashif.org/guidelines/dashif-ad-content` and shall include a profile identifier for the DASH CMAF profile "`urn:mpeg:dash:profile:cmaf:2019`" profile. This also means that the content follows the CMAF Profile.
`@type`	M	Shall be set to `static`
`@mediaPresentationDuration`	R	Shall not be present.
`@minimumUpdatePeriod`	R	Shall not be present, implied by type static.
`@minBufferTime`	M	Shall be present
`@timeShiftBufferDepth`	R	Shall not be present
`@suggestedPresentationDelay`	R	Shall not be present
`@maxSegmentDuration`	R	Shall not be present
`@maxSubsegmentDuration`	R	Shall not be present
`ProgramInformation`	0…N	This should be used to describe information about the ad. More details may be provided
`BaseURL`	0	Shall not be present. If a Base URL is present, then it is as part of the Period
`Period`	1	Exactly one Period shall be present. Provides the requirements for ad insertion content. Any not specified value is identical to what is provided in ISO/IEC 23009-1, clause 5.3.2.
`@xlink:href`	R	Shall be absent.
`@xlink:actuate`	R	Shall be absent.
`@start`	R	Shall be absent, i.e. assumed to be 0.
`@duration`	O	is set to the duration of the ad content
`BaseURL`	1…N	At least one shall be present and refer to the BaseURL of the ad content.

Element or Attribute Name	Use	Description
EventStream	0...N	Event Streams are permitted in ad content, for example for beaconing. Note: more details need to be added on specific types. Please join the discussion here: https://github.com/Dash-Industry-Forum/AdInsertion/issues/49
AdaptationSet	1...N	At least one Adaptation Set shall be present.
@xlink:href	R	Shall be absent
@xlink:actuate	R	Shall be absent
InbandEventStream	0...N	Inband Event Streams are permitted in ad content, for example for beaconing. Note: more details need to be added on specific types. Please join the discussion here: https://github.com/Dash-Industry-Forum/AdInsertion/issues/49.
CommonAttributesElements	—	specifies the common attributes and elements (attributes and elements from base type ***RepresentationBaseType***). For details, see subclause
SegmentBase@presentationTimeOffset	OD default: 0	shall be set to the correct value of the presentation time of the Adaptation Set at the start of the Period, if the presentation time is not equal to 0. <we make a recommendation that we make it zero, ask for community review.>
@contentType	M	Shall be present
SegmentList	0	Shall be absent
Representation	1 ... N	specifies a Representation. At least one Representation element shall be present in each Adaptation Set. Any not specified value is identical to what is provided in ISO/IEC 23009-1, clause 5.3.3.
Subset	0	Shall be absent.
EmptyAdaptationSet	0	Shall be absent
UTCTiming	0	Shall not be present
LeapSecondInformation	0	Shall not be present

Key

For attributes: M=mandatory, O=optional, R=removed

For elements: <minOccurs>...<maxOccurs> (N=unbounded)

Elements are **bold**; attributes are non-bold and preceded with an @.

Figure 5 provides and overview of the DASH-IF Ad content format.

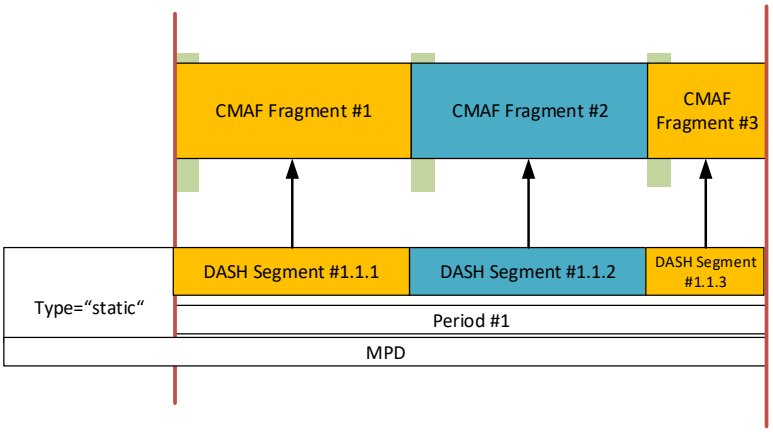

Figure 5 Recommended Ad Content Format

1.2.6.7. IF-4c: Recommended Dynamic Ad Content Response format based on conditioning parameters

The response format should follow the DASH-IF Ad Content format as defined in clause 1.2.6.2.

Note: Please provide feedback if the dynamic response should permit multiple Periods. If no clear use case is provided, single Period is restricted.

If ***no*** conditioning parameters are provided, the response should include multiple content variants, e.g. multiple codecs, resolutions, etc..

If codec conditioning parameters are provided, the response should include content options including at least one of the codecs.

If format conditioning parameters are provided, the response should include content options including at least one of the supported formats.

If encryption conditioning parameters are provided, the response should include content options including at least one of the supported encryption modes.

If the content needs to be obfuscated/blocked, then the response should be adjusted to the main content.

If the content needs to be served through xlink with Period, then only the Period of the main content is extracted.

If the content is used on live and especially low-latency live services, then the content in the Period should be adjusted to enable consistent playback including consistent join times.

Note: This clause will need more refinements and comments are welcome.

1.2.7. IF-5: MPD and Segments with Ad Placements

1.2.7.1. Overview

The format and requirements of the DASH manifest output by the Ad Insertion MPD Manipulator is described by IF-5 as shown in Figure 6. The Ad Insertion MPD Manipulator operates under the following assumptions:

1) It takes the DASH content provided by IF-2 as defined in clause 1.2.4.
2) Opportunity metadata is provided by IF-3 as defined in clause 1.2.5.
    a. The splice point timing is known as `tsplice-in` for when the opportunity starts media time level.
    b. The duration of the ad insertion opportunity is known as `ADDU`
    c. At `tsplice-in + ADDU`, another splice point exists in the main media to rejoin the main content.
    d. Each splice point is signaled with a Period boundary and `tsplice-in` matches the **`Period`**`@start` of the main content at the opportunity and `tsplice-out` matches the **`Period`**`@start` of the main content when transitioning back.
3) Properly conditioned ad content is received via communication on IF-4 as defined in clause 1.2.6.

Based on this input the MPD manipulator produces a Media Presentation such that the content on IF-5 can be played back by the DASH client. The transport of additional ad metadata along with linear ad creatives is described as part of IF-6.

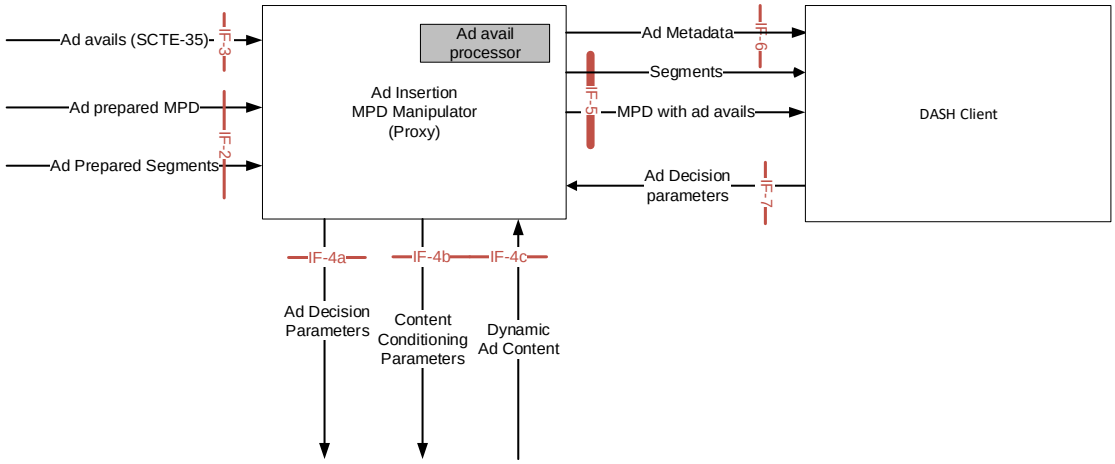

Figure 6 MPD Manipulator Operation: Conforming IF-5 output

In this first version of the document the following assumptions are taken:

1) The main content on IF-2 follows the definitions in clause 1.2.4 with the assumption of using option 1 for at least one continuous Switching set and option 3 for the remaining ones on IF-1. Note that all Switching Sets may follow option 1 conditioning.
2) The ad content on IF-4b follows the DASH Ad insertion content as defined in clause 1.2.6.6. In addition, the content may be conditioned, for example such that for any Initialization/Adaptation Set present in the MPD on IF-2, at least one Adaptation Set is provided in the ad content on IF-4b.
3) The ad content on IF-4b has at least the duration `ADDU`, but may be marginally longer. If longer, then it is expected that the content can be cut at the end.

Note that the above assumptions are not a requirement for this specification. However, MPD proxy implementation/implementer should be aware that if the content is not following the above requirements on what the consequences are for the operation of the service.

1.2.7.2. Media Presentation Requirements on IF-5

The DASH IOP Guidelines provide the general normative requirements on the DASH output and we will assume those as a baseline set of requirements. Here we will provide further normative requirements for the ad insertion architectures:

- The MPD shall contain multiple Period elements describing the content and advertisement(s) of the presentation
- Content and/or advertisement assets split across two or more Periods must have period-connectivity signaled

Note: this needs more detailed requirements. The final version will add this.

The ad content is spliced into the main content as a Period following Table 3.

<We need `TargetLatency`.>

Table 3 Ad Content spliced into main content

Element or Attribute Name	Use	Description
MPD		Provides the requirements for content that is combined between main content an ad content. Any not specified value is identical to what is provided in ISO/IEC 23009-1, clause 5.3.1.
ServiceDescription		
Latency@TargetLatency	0	Target Latency is provided
@profiles	M	More details need to be added
Period (Main content)		specifies the information of a Period. The information from the main content Period is reused except specified differently
@duration	R	Shall not be present, the duration is determined by the `@start` of the Ad Period.
EventStream	0…N	re-used from the main content.
AdaptationSet	1…N	re-used from the main content.
Period (Ad Content)		specifies the information of a Period. The information from the Ad content Period is reused except specified differently
@id	M	A unique identifier, preferably re-used the one already present in the main content.
@start	M	is set to `tsplice-in` from the main content
@duration	O	is set as follows: - if the value from the ad content is larger than or equal to the duration of the ad slot, i.e. `ADDU`, then this value is set to `ADDU`. - if the value from the ad content is smaller than the duration of the ad slot, i.e. `ADDU`, then <what to do?>.

Element or Attribute Name	Use	Description
BaseURL	1…N	re-used from the remote Ad content Period unless the ad content is moved elsewhere.
@availabiltimeTimeOffset=<ad duration>		
EventStream	0…N	re-used from the remote Ad content Period unless proxy decides to remove based on business rules. Note: we also permit copying Event Streams from the main content during this ad Period and if so which ones Decisions which ones is an implementation logic. Please provide feedback on this.
AdaptationSet	1…N	re-used from the remote Ad content Period, but only a subset may be picked based on the main content or information from the client. For more details on how Adaptation Sets are added, please refer to Table 3.
Period (main content)		specifies the information of a Period. The information from the Ad content Period is reused except specified differently
@start	M	is set to tsplice-out from the main content
@duration	R	shall not be present
EventStream	0…N	Re-used from main content.
AdaptationSet	1…N	re-used from main content.

Key

For attributes: M=mandatory, O=optional

For elements: <minOccurs>…<maxOccurs> (N=unbounded)

The conditions only hold without using xlink:href. If linking is used, then all attributes are "optional" and <minOccurs=0>.

Elements are **bold**; attributes are non-bold and preceded with an @.

1.2.7.3. MPD Proxy Operation Guidelines

<Editor's Note: This clause needs some updates on MPD Proxy operation.>

In a SSAI architecture the Ad Insertion MPD Manipulator may utilize IF-4 to request an advertisement decision for part or all of the content stream. For some embodiments, the ad placements provided by an ad decision will be represented as a set of ad pods positioned within the content stream with each pod containing a series of one or more ad slots. In this case, the manipulator will create a new Period for each ad slot with a sequence of Periods representing a complete ad pod. In other embodiments, the ad placements for a stream may have only one creative for the entire pod, in this case the manipulator will create a single new Period for each pod.

The manipulator inserts the Period element(s) representing the pod(s) at the content stream position specified by the ad decisioning response. If the content MPD provided to the manipulator already

has Period boundaries created at the desired ad insertion points, it may directly insert the Period(s) representing the ad placements. If the manipulator is provided a content MPD without Period boundaries at the desired insertion points, the manipulator must split the content Period(s) utilizing the functions described in the Period Splitting section of the IOP [ref].

Splitting operations may require the manipulator to access the content segments in addition to the content MPD and for this reason it is recommended that the content MPD is provided with Period boundaries already generated. If the Ad Insertion MPD Manipulator does not perform an insertion, it may choose to remove Period boundaries by recombining the Periods, this may also be done by the manipulator to provide responses to DASH clients that cannot handle Multi-Period responses.

For scenarios where original in-stream ads are being replaced by the Ad Insertion MPD Manipulator instead of inserted into a clean stream, the manipulator would create the same Period(s) for ad creatives and replace sections of the content stream. If the ads are already delineated in the content MPD then the in-stream Periods are replaced by the generated ones, if the ads are not delineated in the content MPD then the manipulator must perform splitting operations prior to replacement.

In a SGAI architecture the Ad Insertion MPD Manipulator utilizes the opportunity metadata provided by IF-3 to embed signals into the MPD response that allow the DASH client to defer ad opportunity resolution until it is actively needed for the presentation.

> Note: The DASH-IF Working Group is actively studying the DASH mechanisms appropriate for enabling these signals and will provide further information in future IOP updates.

1.2.7.4. DASH Client Operation Guidelines for Playback on Reference Platform

<Editor's Note: This clause is expected to be completed in the final version.>

<Assume TargetLatency and document playback>

1.2.8. IF-6: Ad Metadata Signaling

1.2.8.1. Introduction

Ad metadata, such as creative descriptions, viewability requirements, and tracking events, is provided to the Ad Insertion MPD Manipulator as part of the IF-4 ad decisioning response. To enable client usage of this metadata, the manipulator may provide the metadata in the presentation via IF-6. Similar to IF-3, the following normative statements on ad metadata carriage are made:

- Ad metadata must be carried through one of the following mechanisms:
  - DASH MPD Events [ref]
  - DASH Inband Event Messages [ref]
- DASH MPD Events should be the preferred carriage mechanism

The recommendation of MPD Events over other carriage mechanisms is made such that the Ad Insertion MPD Manipulator can provide ad metadata to the DASH client without modifying the ad segments.

For both mechanisms, the DASH client aligns the surfacing of the event data to the client application with the timed playout of the Period, see DASH-IF Event Processing [ref] for further information.

The format and usage of ad metadata is integration specific and is therefore out of the scope of this document. Known metadata event schemes are provided in the subsequent sub-sections of this interface as informational examples.

1.2.8.2. DASH Callback Event

MPEG-DASH devices a basic callback event scheme denoted by the scheme id `"urn:mpeg:dash:event:callback:2015"` and `value=1`. When a DASH client encounters this scheme it will treat the message data payload of each event as a URI and perform a GET request ignoring the response. This functionality was designed to directly facilitate the requirements of basic timed tracking events, such as those establish in the IAB VAST specification.

1.2.9. IF-7: Remote Resolution with Decisioning Parameters

1.2.9.1. Introduction

In a SGAI architecture, instead of providing ad placements directly, the MPD provided via IF-5 contains information on how to resolve the ad placements as the DASH client needs them for playout of the presentation. The interface to enable this late resolution is provided via IF-7.

The DASH-IF Working Group is actively studying the DASH mechanisms appropriate for enabling this interface and will provide normative information in a future update of the IOP. The subsequent subsections of this interface detail initial thoughts on this interface and should be considered informational only.

1.2.9.2. Late Binding via Remote Periods

MPEG-DASH defines the XLink mechanism [ref] for enabling remote elements within an MPD. The Remote Period variant of remote elements can be used in a SGAI architecture to delay the resolution of ad opportunities. In particular a Remote Period with @xlink:actuate="onRequest" can be inserted into an MPD as an ad pod placeholder and the DASH client will perform resolution as the portion of the timeline containing the Remote Period is approached during presentation playout. The response for the resolution can contain one or more Periods to represent one or more ad slots within the ad pod.

Remote elements must be further studied for interoperability guidelines, in particular the usage of remote elements within a dynamic MPD has not been studied sufficiently to understand restrictions and constraints that such an MPD would impose on remote elements.

1.2.9.3. Decisioning Parameters via URL Parameters

Just as in a SSAI architecture, an SGAI architecture must provide the decisioning and conditioning parameters to the Ad Decisioning / Ad Content Server via IF-4, but unlike SSAI, the usage of IF-4 is done as needed instead of pre-emptively. This means that the service entity handling the late resolution of the ad opportunity must be made aware of the parameters that were previously known to the Ad Insertion MPD Manipulator.

MPEG-DASH defines the Flexible Insertion of URL Parameters mechanism to enable the dynamic creation of request parameters by the DASH client, combining information provided in the manifest and information available from other requests. As the Ad Insertion MPD Manipulator is constructing the MPD provided via IF-5, it may utilize the Flexible Insertion mechanism to embed the content decision and conditioning parameters known to it such that they are properly transmitted to the late resolution handler without the need for server-side state.

In addition to the parameters known at original MPD generation time, further investigation is being conducted by the DASH-IF Working Group to determine if player runtime conditions could be additionally included via this mechanism to provide greater detail around active seamless playout requirements.

1.2.10. IF-8: Ad Tracking and Measurement

1.2.10.1. Introduction

It is common practice for advertisements to utilize impression tracking from the client to report and measure the number of times an ad is viewed. IF-6 provides the carriage of metadata to enable tracking scenarios that are described by IF-8. Ad tracking and measurement integrations can be very workflow and client platform dependent and are therefore out of the scope of this document. Known tracking mechanisms are provided as informational references.

1.2.10.2. VAST View Tracking

The IAB VAST specification describes a `Tracking` element which provides a URI that should be requested when a named event occurs within a creative. A subset of these events describe progression through a linear creative by tracking points of time within the creative, such as start, end, first quartile, second quartile, etc. As these events are directly timed with the playout of the media, the DASH event mechanisms can be used to convey and align these events with the linear creative.

When translating these named events to timed events, the presentation time of the event should correlate to the same logical position as the VAST named event, for instance the start event should be a presentation time of 0 relative to the start of the Period containing the ad creative. If no client application processing is required of the event, the DASH Callback Event scheme may be used to have the DASH client directly perform requests, see section 1.2.8.2 for further details. Should a service provider wish to handle the request on their own, to further process the URI or provide it to a third-party library, a custom event scheme may be established by the provider and utilized by the client application.

1.2.10.3. Open Measurement SDK

The IAB Tech Lab has produced the Open Measurement SDK [95] as a way of facilitating third-party viewability and verification measurements without requiring SDKs from individual measurement providers. Service providers integrate the Open Measurement SDK into their client applications and the SDK facilitates the execution of measurement provider defined tracking parameters for each ad creative.

For each ad creative played the SDK must be instantiated with ad metadata describing the measurement providers and their parameters for the creative. This metadata may be carried via IF-6 using a custom event scheme and surfaced to the client application which can then initialize the SDK for the creative.

1.2.10.4. Alternative Tracking Methods

Other tracking services could be used to track viewer impressions, such as proprietary or open solutions, that enable reliable tracking of viewer impressions.