Specification of Live Media Ingest

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1. Specification: Live Media Ingest§

1.1. Abstract§

This document presents the DASH-IF Live Media Ingest Protocol Specification. Two protocol interfaces are defined. The first, interface 1, CMAF ingest, is based on fragmented MPEG-4 as defined by the common media application track format (CMAF). The second interface is based on MPEG DASH and HLS. Both Interfaces use the HTTP POST Method to transmit media objects from the ingest source to the receiving entity. Examples of live streaming workflows using these protocol interfaces are also presented. The protocol interfaces also support carriage of timed metadata and timed text. Guidelines for redundancy and failover are also included.

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documents and/or technologies controlled by third parties. Those third party documents and technologies may be subject to third party rules and licensing terms. No intellectual property license, either implied or express, to any third party material is granted to you by this document or DASH-IF. DASH-IF makes no any warranty whatsoever for such third party material.

2. Introduction§

The main goal of this specification is to define the interoperability point between an Ingest Source and a Receiving entity that typically reside in the cloud or the network. This specification does not impose any new constraints or requirements to clients that consume streams using any defined streaming protocol, with a preference for [MPEGDASH]

Live media ingest happens between an Ingest source, such as a live video encoder live encoder and a Receiving entity. Examples of such a Receiving entity include media packagers,streaming origins and content delivery networks. The combination of ingest sources and distributed media processing entities is common in practical video streaming deployments. It allows media processing functionality to be distributed between entities.

Nevertheless, in such deployments, interoperability between ingest sources and downstream processing entities can sometimes be challenging. This challenge comes from the fact that there are multiple levels of interoperability. This challenge also comes from the fact that each vendor has a different view of what is expected/preferred as well as how various technical specifications apply.

For example, the network protocol for transmission of data and the setup of the connectivity are important. This includes schemes for establishing the ingest connection, handling disconnects and failures, providing procedures for reliably sending and receiving the data, and timely resolution of hostnames.

A second level of interoperability lies in the media container and coded media formats. The Moving Picture Experts Group defined several media container formats such as [ISOBMFF] and [MPEG2TS] which are widely adopted and well supported. However, these are general purpose formats, targeting several different application areas. To do so, they provide many different profiles and options. Detailed interoperability is often achieved through other application standards such as those for the broadcast, storage or video on demand. For interoperable live media ingest, this document provides guidance on how to use [ISOBMFF] and [MPEGCMAF].

In addition, the codec and profile used, e.g. [MPEGHEVC] are important interoperability points that itself also have different profiles and different configurations. This specification provides some guidance on how encoded media should be represented and transmitted.

A third level of interoperability, lies in the way metadata is inserted in streams. live content often needs such metadata to signal opportunities for ad insertion, or other attributes like timed graphics or general information relating to the broadcast. Examples of such metadata include [SCTE35] markers which are often found in broadcast streams and other metadata such as ID3 tags [ID3v2] relating to the media presentation. In fact, many more types of metadata relating to the live event might be ingested and passed on to an OTT workflow.

Fourth, for live media, handling the timeline of the presentation consistently is important. This includes sampling of media, avoiding timeline discontinuities and synchronizing timestamps attached by different ingest sources such as audio and video. In addition, media timeline discontinuities must be avoided as much as possible in normal operation. Further, when using redundant ingest sources, ingested streams must be sample accurately synchronized. Last, streams may need to be started at the same time as to avoid miss alignment between audio and video tracks.

Fifth, in streaming workflows it is important to have support for failovers of both the ingest sources and media processing entities. This is important to avoid interruptions of 24/7 live services such as Internet television where components may fail.

In practical deployments, multiple ingest sources and media processing entities are often used. This requires that multiple ingest sources and media processing entities work together in a redundant workflow where some of the components might fail. Well defined failover behavior will help interoperability.

This document provides a specification for establishing these interoperability points. The approaches are based on known standardized technologies that have been tested and deployed in several large scale streaming deployments.

Two key interfaces and their protocol specification have been identified. One mainly aims as a ingest format to packager or active media processor, while the second works mainly to ingest media streaming presentations to origin servers and or storage or content delivery network facilities. The section on interfaces and profiles provides more background and motivation around these two interfaces that both use HTTP POST.

We further motivate the specification in this document supporting HTTP 1.1 [RFC7235] and [ISOBMFF] a bit more. We believe that Smooth streaming MS-SSTR and HLS [RFC8216] have shown that HTTP usage can survive the Internet ecosystem for media delivery. In addition, HTTP based ingest fits well with current HTTP based streaming protocols including [MPEGDASH]. In addition, there is good support for HTTP middleboxes and HTTP routing available making it easy to debug and trace errors. The HTTP POST provides a push based method for delivery for pushing the live content when it becomes available.

Regarding the transport protocol, in future versions, alternative transport protocols could be considered advancing over HTTP 1.1 or TCP. We believe the proposed media format and protocol interfaces will provide the same benefits with other transports protocols. Our view is that for current and near future deployments using [RFC7235] is still a good approach.

The document is structured as follows, in section 3 we present the conventions and terminology used throughout this document. In section 4 we present use cases and workflows related to media ingest and the two profiles/interfaces presented. Sections 5-9 will detail the protocol and the two different interfaces defined.

3. Conventions and Terminology§

The following terminology is used in the rest of this document.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14, RFC 2119 [RFC2119].

ISOBMFF: the ISO Base Media File Format specified in [ISOBMFF].

CMAF Ingest: Ingest interface defined in this specification for push based [MPEGCMAF]

DASH Ingest: Ingest interface defined in this specification for push based [MPEGDASH]

HLS Ingest: Ingest interface defined in this specification for push based [RFC8216]

Ingest Stream: The stream of media pushed from the ingest source to the media processing entity

Live stream event: The total live stream for the ingest relating to a broadcast event.

Live encoder: Entity performing live encoding of a high quality Ingest stream, can serve as ingest source

Ingest source: A media source ingesting live media content to a receiving entity , it is typically a live encoder but not restricted to this, e.g. it could be a stored media resource.

Publishing point: Entry point used to receive an ingest stream, consumes/receives the incoming media ingest stream, typically via a publishing URL setup to receive the stream

Manifest objects Objects ingested that represent streaming manifest e.g. .mpd in MPEG DASH, .m3u8 in HLS

Media objects Objects ingested that represent the media, and or timed text, or other non manifest objects, typically these are CMAF addressable media objects such as CMAF chunks, fragments or segments.

Objects [=Manifest objects] or Media objects

Streaming presentation set of Objects composing a Streaming presentation based on a streaming protocol such as for example [MPEGDASH]

Media processing entity: Entity used to process the media content, receives/consumes a media [=Ingest stream].

Receiving entity: Entity used to receive the media content, receives/consumes an [=Ingest stream].

CMAFstream : bytestream that follows the CMAF track format structure format defined in [MPEGCMAF]

Media fragment Media fragment, combination of moof and mdat in ISOBMFF structure (MovieFragmentBox and mediaDataBox), can be a CMAF fragment or chunk

CMAF Header : CMAF track header defined in [MPEGCMAF]

CMAF Media object : CMAF media object defined in [MPEGCMAF]

CMAF fragment : CMAF fragment defined in [MPEGCMAF]

CMAF chunk : CMAF chunk defined in [MPEGCMAF]

CMAF segment : CMAF segment defined in [MPEGCMAF]

CMAF Track CMAF Track defined in [MPEGCMAF]

HTTP POST : Command used in the Hyper Text Transfer Protocol for sending data from a source to a destination [RFC7235]

POST_URL : Target URL of a POST command in the HTTP protocol for posting data from a source to a destination.

TCP: Transmission Control Protocol (TCP) as defined in [RFC793]

Event Received Time: The time a metadata item is seen/observed by the application for the first time, e.g. an announcement/avail. The time the event is received (event received time). This could for example be the time an EventMessageBox becomes available

Event Presentation Time : The time a metadata event is applied to a stream (if applicable), correspond to the presentation_time of a dash event [MPEGDASH] (event presentation time)

Connection: A connection setup between two hosts, typically the media Ingest source and [=Receiving entity].

Switching set: Group of tracks corresponding to a switching set defined in [MPEGCMAF] or an adaptationset in [MPEGDASH]

ABR : Adaptive Bit-Rate

RTP : Real Time Protocol

OTT : Over the top transmission, i.e. HTTP based video streaming

moof: The MovieFragmentBox "moof" box as defined in the ISOBMFF base media file format [ISOBMFF] that defines the metadata of a fragment.

ftyp: The FileTypeBox "ftyp" box as defined in the ISOBMFF [ISOBMFF]

moov: The container box for all metadata MovieBox "moov" defined in the ISOBMFF base media file format [ISOBMFF]

mdat : The mediaDataBox "mdat" box defined in ISOBMFF [ISOBMFF].

mfra: The movieFragmentRandomAccessBox "mfra" box defined in the ISOBMFF [ISOBMFF] to signal random access samples (these are samples that require no prior or other samples for decoding) [ISOBMFF].

tfdt : The TrackFragmentBaseMediaDecodeTimeBox box "tfdt" defined in [ISOBMFF] used to signal the decode time of the media fragment signalled in the moof box.

basemediadecodetime : Decode time of first sample as signalled in the tfdt box

mdhd : The MediaHeaderBox "mdhd" as defined in [ISOBMFF], this box contains information about the media such as timescale, duration, language using ISO 639-2/T [iso-639-2] codes [ISOBMFF]

elng : Extended language tag box "elng" defined in [ISOBMFF] that can override the language information

nmhd : The nullMediaHeaderBox "nmhd" as defined in [ISOBMFF] to signal a track for which no specific media header is defined, used for metadata tracks

4. Media Ingest Workflows and Profiles§

Two key workflows and interfaces have been identified for which media ingest interface protocols are defined.

The first workflow uses a separate live encoder as Ingest source and packager as Receiving entity. In this case, interface 1, [MPEGCMAF] (CMAF) Ingest may be used. This interface uses [MPEGCMAF] to ingest a live encoded stream to the packager. The Receiving entity in this case may do the pacakging, encryption, or other active media processing on the stream. This interface is defined in a way that it will be possible to generate streaming presentation based on [MPEGDASH] or HLS [RFC8216] based on the ingested stream.

The second workflow, constitutes ingest to a passive delivery system, such as a cloud storage or a content delivery network. In this case the stream needs to be formatted as close as possible to the final stream for consumption by a client. This interface is defined in the second part, interface 2 DASH Ingest or HLS Ingest. It enables a push based version of these commonly used streaming protocols. In this case, besides the media object, also manifest objects are ingested to the Receiving entity.

Diagram 1: Example with CMAF Ingest

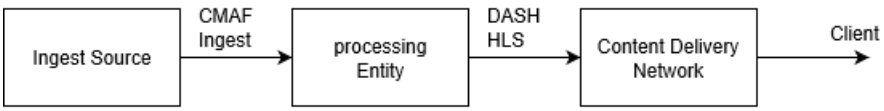


Diagram 2: Example with DASH Ingest

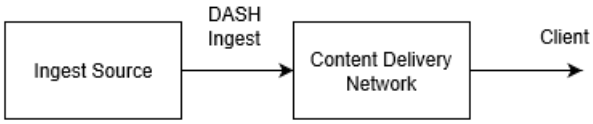


Diagram 1 shows the workflow with a live media ingest from an ingest source towards a media processing entity. In the example in diagram 1, the media processing entity prepares the final media presentation for the client that is delivered by the Content Delivery Network to a client. The media processing entity could be a live packager for DASH or HLS streams.

Diagram 2 shows the example in workflow 2 were content is ingested directly into a Content Delivery Network. The content delivery network enables the delivery to the client.

An example of a media ingest protocol for the first workflow is the ingest part of the Microsoft Smooth Streaming protocol MS-SSTR. This protocol connects live encoders/ingest sources to the Microsoft Smooth Streaming server

and to the Microsoft Azure cloud. This protocol has shown to be robust, flexible and easy to implement in live encoders. In addition, it provided features for high availability and server side redundancy.

The DASH-IF CMAF Ingest protocol defined in this document, advances over the smooth ingest protocol including lessons learned over the last ten years after the initial deployment of smooth streaming in 2009 and several advances on signaling metadata and timed text.

In addition, the current specification incorporates the latest media formats and protocols, making it ready for current and next generation media codecs such as [MPEGHEVC] and protocols like MPEG DASH [MPEGDASH]. In addition, to support the sub profiling of existing media containers CMAF [MPEGCMAF] is referenced.

The second interface referred as DASH and HLS ingest is included for ingest of media streaming presentations to entities where the media is not altered actively. A key idea of this part of the specification is to re-use the similarities of MPEG DASH [MPEGDASH] and HLS [RFC8216] protocols to enable a simultaneous ingest of media presentations of these two formats using common media fragments such as based on [ISOBMFF] and [MPEGCMAF] formats. In this interface naming is important to enable direct processing and storage of the presentation.

We present these two interfaces separately. We made this decision as it will reduce a lot of overhead in the information that needs to be signalled compared to having both interfaces combined into one, as was the case in a draft version of this document.

However, both use the HTTP POST method defined in [RFC7235] and similar mechanisms for authentication and failure handling leaving a shared protocol core. Therefore, in some practical implementations, the two interfaces might be combined into one, when the DASH or HLS is also using the Common Media Application Track Format. But this is not assumed in this specification.

Table 1 highlights some of the key differences and practical considerations of the interfaces. In CMAF Ingest, the ingest source can be simple as the Receiving entity can do many of the operations related to the delivery such as encryption or generating the streaming manifests. In addition, the distribution of functionalities can make it easier to scale a deployment with many live media sources and media processing entities.

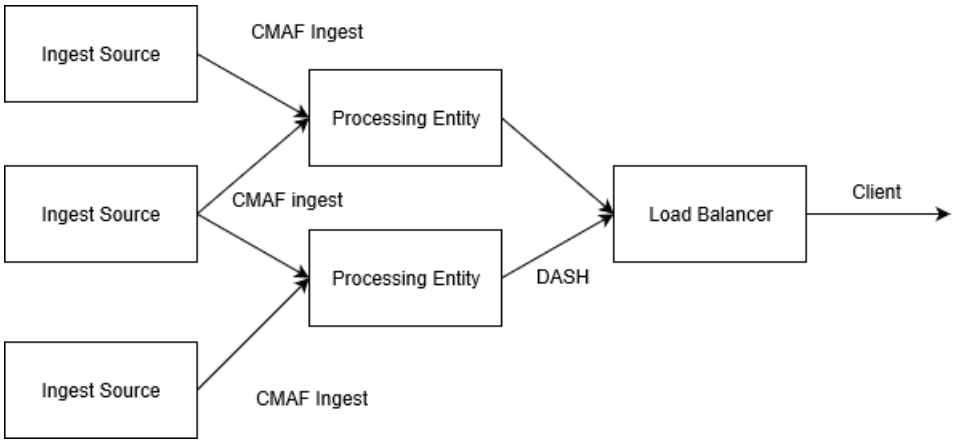
In some cases, an encoder has sufficient capabilities to prepare the final presentation for the client, in that case content can be ingested directly to a more passive media processing entity that provides a pass through like functionality. In this case also Manifest objects and other client specific information needs to be ingested. Besides these factors , choosing a workflow for a video streaming platform depends on many other factors. This specification does not provide guidance on what workflow is best to use in which cases. Yet, the live ingest specification covers the two interfaces suitable for different types of workflows, or in some cases the interfaces may be combined into a live streaming workflow.

The best choice for a specific platform depends on many of the use case specific requirements, circumstances and the available technologies.

Table 1: different ingest use cases

Profile	*Ingest source*	*Media processing*
CMAF Ingest	Limited overview, simpler encoder, multiple sources	re-encryption, transcode, stitching, watermark, packaging
DASH/HLS Ingest	Global overview, targets duplicate presentations, limited flexibility no redundancy	manifest manipulation, transmission, storage

Diagram 3: workflow with redundant Ingest sources and receiving entities



Finally, Diagram 3 highlights another aspect that was taken into consideration for large scale systems with many users. Often content owners would like to run multiple ingest sources, multiple receiving entities and make them available to the clients in a seamless fashion for maximum resiliancey. This approach is common when serving web pages, and this architecture also applies to video streaming platforms. In Diagram 3 it is highlighted how one or more Ingest Sources can be sending data to one or more processing entities. In such a workflow it is important to handle the case when one ingest source or media processing entity fails. Both the system and client behavior is an important consideration in practical video streaming systems that need to run 24/7 such as Internet Television. Failovers must be handled robustly and without causing service interruption. This specification details how this failover and redundancy support can be achieved.

5. General Ingest Protocol Behavior§

The media ingest follows the following general requirements for both target /interfaces.

1. The Ingest source SHALL communicate using the HTTP POST method as defined in the HTTP protocol, version 1.1 [RFC7235]
2. The Ingest source SHOULD use HTTP over TLS, if TLS is used it SHALL support atleast TLS version 1.2, higher version may also be supported additionally [RFC2818]
3. The Ingest source SHOULD repeatedly resolve the hostname to adapt to changes in the IP to Hostname mapping such as for example by using the domain naming system DNS [RFC1035] or any other system that is in place.
4. The Ingest source MUST update the IP to hostname resolution respecting the TTL (time to live) from DNS query responses, this will enable better resilience to changes of the IP address in large scale deployments where the IP address of the media processing entities may change frequently.
5. In case HTTP over TLS [RFC2818] protocol is used, basic authentication HTTP AUTH [RFC7617] or TLS client certificates MUST be supported.
6. Mutual authentication SHALL be supported. Client certificates SHALL chain to a trusted CA , or be self assigned.
7. As compatibility profile for the TLS encryption the ingest source SHOULD use the mozzilla intermediate compatibility profile MozillaTLS.
8. In case of an authentication error, the ingest source SHALL retry establishing the Connection within a fixed time period with updated authentication credentials
9. The Ingest source SHOULD terminate the HTTP POST request if data is not being sent at a rate commensurate with the MP4 fragment duration. An HTTP POST request that does not send data can prevent the Receiving entity from quickly disconnecting from the ingest source in the event of a service update.
10. The HTTP POST for sparse data SHOULD be short-lived, terminating as soon as the data of a fragment is sent.
11. The POST request uses a POST_URL to the basepath of the publishing point at the media processing entity

and SHOULD use an additional relative path when posting different streams and fragments, for example, to signal the stream or fragment name.

12. Both the Ingest source and Receiving entity MUST support IPv4 and IPv6 transport.

6. Ingest Interface 1: CMAF Ingest Protocol Behavior§

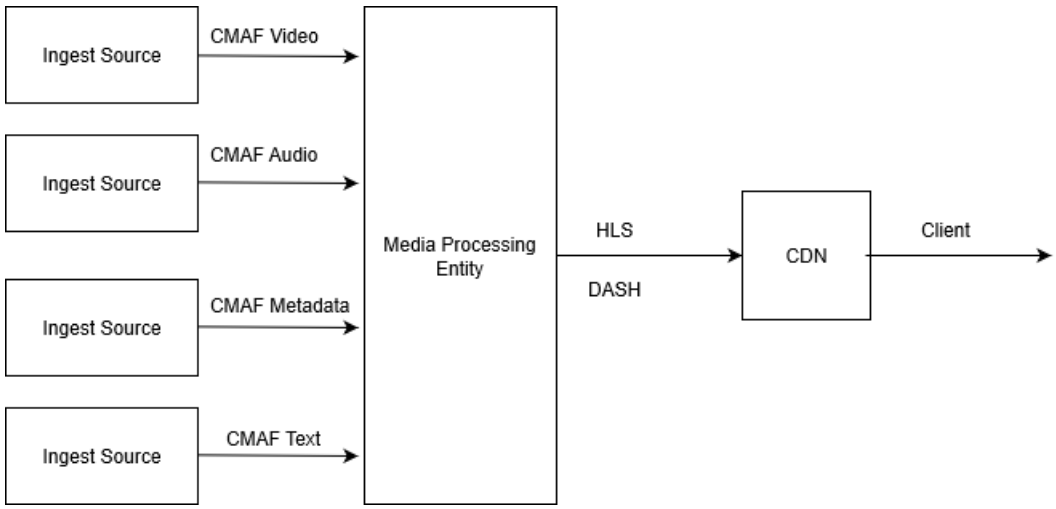
This section describes the protocol behavior specific to interface 1: CMAF Ingest. Operation of this profile MUST also adhere to the general requirements.

6.1. CMAF Ingest General Considerations§

The binary media format for conveying the media is based on CMAF track constraints as specified in [MPEGCMAF]. A key benefit of this format is that it allows easy identification of stream boundaries, enabling switching, redundancy, re-transmission resulting in a good fit with the current Internet infrastructures. Many problems in practical streaming deployment often deal with issues related to the binary media format. We believe that the CMAF track format will make things easier and that the industry is already heading in this direction following recent specifications like [MPEGCMAF] and HLS [RFC8216].

CMAF Ingest typically assumes ingest to an active media processing entity. It advances over the ingest part of the smooth ingest protocol MS-SSTR by only using standardized media container formats and boxes based on [ISOBMFF] and [MPEGCMAF]. In addition, this enables extension towards codecs like [MPEGHEVC] and timed metadata ingest of subtitle and timed text streams. The workflow ingesting multiple media ingest streams with CMAF Ingest is illustrated in Diagram 4. Discussions on the early development have been documented fmp4git.

Diagram 4: CMAF ingest with multiple ingest sources



Diagrams 5-7 detail some of the concepts and structures. Diagram 5 shows the data format structure of the CMAF Track format [ISOBMFF] and [MPEGCMAF]. In this format media meta data such as playback time, sample duration and sample data (encoded samples) are interleaved. The MovieFragmentBox moof box as specified in [ISOBMFF] is used to signal the information to playback and decode the samples stored in the following mdat box. The ftyp and moov box contain the track specific information and can be seen as a CMAF Header of the stream, sometimes referred as a [MPEGCMAF] header. The combination of moof mdat can be referred as a CMAF fragment or CMAF chunk or a CMAF segment depending on the structure content and the number of moof mdat structures in the addressable object.

The combination of ftyp and moov can be referred to as a CMAF header. These CMAF Addressable media objects can be jointly referred to as CMAF Media object

Diagram 5: CMAF Track stream:

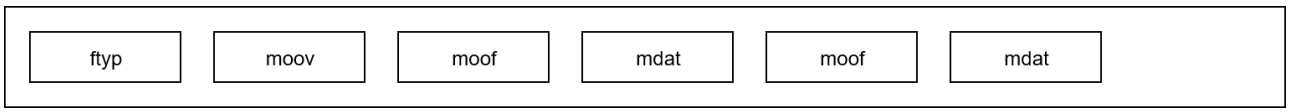


Diagram 5 illustrates the synchronization model, that is based on the synchronization model proposed in [MPEGCMAF]. Different bit-rate tracks and/or media streams are conveyed in separate CMAF tracks. By having the boundaries to the fragments time aligned for tracks comprising the same content stream at different bit-rates, bit-rate switching can be achieved. By using a common timeline different streams can be synchronized at the receiver, while they are in a separate CMAF Track, send over a separate connection, possibly from a different Ingest source. For more information on the synchronization model we refer to section 6 of [MPEGCMAF]. For synchronization of tracks coming from different encoders, sample time accuracy is required. i.e. the same samples need to be mapped to the sample time on the timescale used for the track. Further, in case multiple redundant ingest sources are used they must present sample accurately synchronized streams.

In diagram 7 another advantage of this synchronization model is illustrated, the concept of late binding. In the case of late binding, streams are combined on playout in a presentation. By using the fragment boundaries and a common timeline it can be received by the media processing entity and embedded in the presentation. Late binding is useful for many practical use cases when broadcasting television content with different types of media and metadata tracks originating from different sources. Also it allows storage of each track separately, and combining them later in a presentation based on user/operator preferences. Contrary, to multiplexed content, with late binding, the combination of media tracks is decided at playout.

Note that it is important, as defined in MPEG CMAF that different CMAF Tracks have the same starting time sharing an implicit timeline. A stream becoming available late or from a different source needs to be synchronized and time aligned with other streams ingested avoiding miss alignment and other issues.

Diagram 6: CMAF Track synchronization:

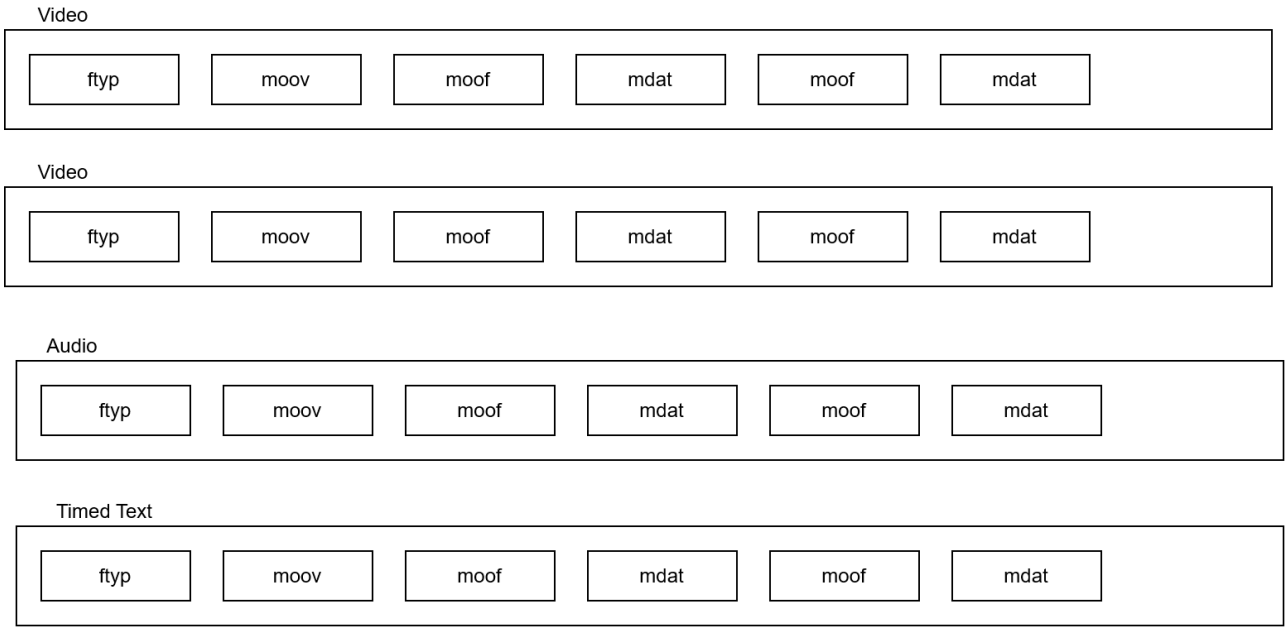


Diagram 7: CMAF late binding:

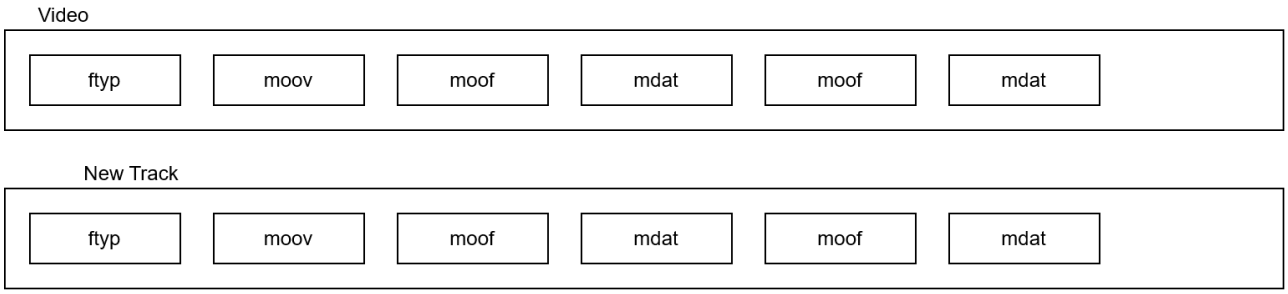
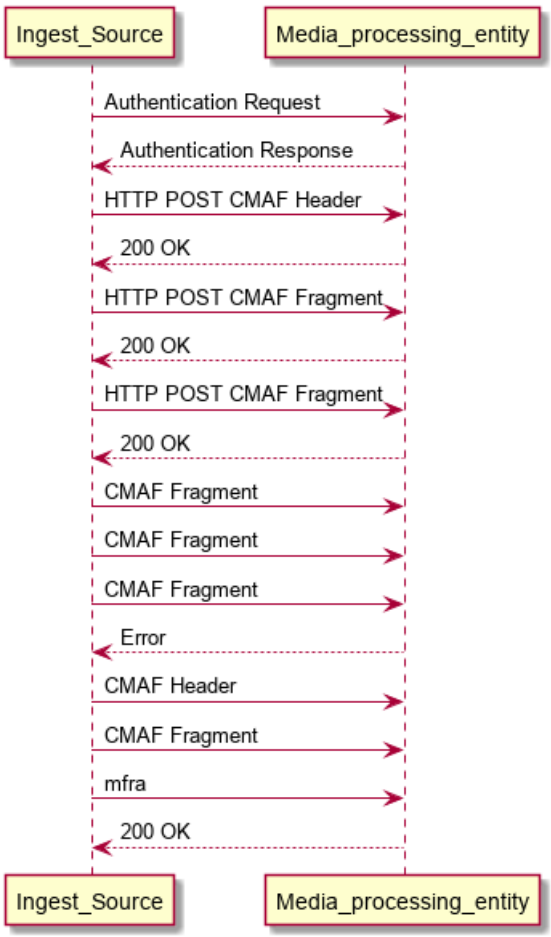


Diagram 8 shows the flow of the media ingest. It starts with a DNS resolution (if needed) and an authentication step (using Authy, or TLS certificates) to establish a secure TCP connection. While this specification promotes TLS certificates, in future versions using token based authentication may be considered. In some private datacenter deployments where nodes are not reachable from outside, a non authenticated connection may also be used. The ingest source then issues a POST to test that the media processing entity is listening. This POST contains the moov + ftyp box (the init fragment or CMAF Header or could be empty. In case this is successful this is followed by the rest of the fragments in the CMAFstream. At the end of the session, for tear down the source may send an empty mfra box to close the connection and Publishing point. This is then followed with a zero length chunk, allowing the receiver to send a response, the encoder can follow up by closing the TCP connection using a FIN command as defined in HTTP RFC2616.

Diagram 8: CMAF ingest flow



6.2. General Protocol Requirements§

1. The Ingest source SHALL start by sending an HTTP POST request with the CMAF Header, or an empty request, by using the POSTURL This can help the ingest source to quickly detect whether the publishing point is valid, and if there are any authentication or other conditions required.

2. The Ingest source MUST initiate a media ingest connection by posting the CMAF header after step 1
3. The Ingest source SHOULD use the chunked transfer encoding option of the HTTP POST command [RFC2626] when the content length is unknown at the start of transmission or to support use cases that require low latency
4. If the HTTP POST request terminates or times out with a TCP error, the Ingest source MUST establish a new connection, and follow the preceding requirements. Additionally, the Ingest source MAY resend the fragment in which the timeout or TCP error occurred.
5. The Ingest source MUST handle any error responses received from the media processing entity, by establishing a new connection and following the preceding requirements including retransmitting the ftyp and moov boxes or the CMAF Header.
6. In case the Live stream event is over the ingest source SHALL signal the stop by transmitting an empty mfra box towards the media processing entity. After that it SHALL send an empty HTTP chunk, Wait for the HTTP response before closing TCP session RFC2616 when this response is received
7. The Ingest source SHOULD use a separate TCP connection for ingest of each different CMAF track
8. The Ingest source MAY use a separate relative path in the POST_URL for ingesting each different track by appending it to the POST_URL, this can make it easy to detect redundant streams from different ingest sources.
9. The base media decode timestamps basemediadecodetime in tfdt of fragments in the CMAFstream SHOULD arrive in increasing order for each of the fragments in the different tracks/streams that are ingested.
10. The fragment sequence numbers seq_num of fragments in the CMAFstream signalled in the tfhd SHOULD arrive in increasing order for each of the different tracks/streams that are ingested. Using both timestamp basemediadecodetime and seq_num based indexing will help the media processing entities identify discontinuities in the ingest stream.
11. Stream names MAY be signalled by adding the relative path Stream(stream_name) to the POST_URL, this can be useful for identification when multiple ingest sources send the same redundant stream to a receiver
12. The average and maximum bitrate of each track SHOULD be signalled in the btrt box in the sample entry of the CMAF header or init fragment
13. In case a track is part of a Switching set, all properties section 6.4 and 7.3.4 of [MPEGCMAF] MUST be satisfied, enabling the receiver to group the tracks in respective switching sets
14. Ingested tracks MUST conform to CMAF track structure defined in [MPEGCMAF]
15. CMAF Tracks SHOULD NOT use segmentTypeBox to signal CMAF Media object brands like chunk, fragment, segment.

> Note, in case a media processing entity cannot process a request from an ingest source correctly, it can send respective HTTP error code. Please see the section for the usage of these codes in Failover and error handling. Please also read this section for a complete understanding of the general protocol behavior.

6.3. Requirements for Formatting Media Tracks§

1. Media tracks SHALL be formatted using boxes according to section 7 of [MPEGCMAF] except for section 7.4. which dictates boxes that are not compliant to [ISOBMFF] relating to encryption and DRM systems
2. The trackFragmentDecodeTime box tfdt box MUST be present for each fragment posted.
3. The ISOBMFF media fragment duration SHOULD be constant, the duration MAY fluctuate to compensate for non-integer frame rates. By choosing an appropriate timescale (a multiple of the frame rate is recommended) this issue should be avoided.
4. The fragment durations SHOULD be between approximately 1 and 6 seconds.
5. The CMAF Tracks SHOULD use a timescale for video streams based on the framerate and 44.1 KHz or 48 KHz for audio streams or any another timescale that enables integer increments of the decode times of

fragments signalled in the "tfdt" box based on this scale. If necessary, integer multiples of these timescales could be used.

6. The language of the CMAF Track SHOULD be signalled in the mdhd box or elng boxes in the init fragment, cmaf header and/or moov headers (mdhd).
7. Media CMAF tracks SHOULD contain the bitrate btrt box specifying the target average and maximum bitrate of the fragments in the sample entry container in the init fragment/CMAF header
8. The CMAF track MAY comprise CMAF chunks [MPEGCMAF] which are moof mdat structures that may not be an IDR or switching point
9. For video tracks, profiles like avc1 and hvc1 MAY be used that signal the sequence parameter set in the CMAF Header. In this case codec parameters do not change dynamically during the live event.
10. Alternatively, video tracks MAY use profiles like avc3 or hev1 that signal the parameter sets (PPS, SPS, VPS) in in the media samples.
11. In case the language of a track changes a new init fragment with update mdhd and or elng SHOULD be send.
12. Track roles SHOULD be signalled in the ingest by using a kind box in userData udta box. The kind box MUST contain a schemeIdUri MPEG urn:mpeg:dash:role:2011 and a value containing a Role as defined in [MPEGDASH]. In case this signalling does not occur processing entity can define the role for the track independently from the media ingest source.

Note: [MPEGCMAF] has the notion of a segment, a fragment and a chunk. A fragment can be composed of one or more chunks, while a segment can be composed of one or more fragments. The Media fragment defined here is independent of this notion and can be a chunk, a fragment containing a single chunk or a segment containing a single fragment containing a single chunk. In this text we use Media fragment to denote the structure combination moof mdat, corresponding to a CMAF fragment or chunk.

6.4. Requirements for Signalling Switching Sets§

In live streaming a bundle of streams corresponding to a channel is ingested by posting to a publishing point. CMAF has the notion of a switchingsets [MPEGCMAF] which map to similar streaming protocol concepts like adaptationset in [MPEGDASH]. To signal a switching set CMAF media tracks MUST correspond to the constraints defined in [MPEGCMAF] section 7.3.4 . Table 2 summarizes the CMAF Switching set constraints.

Table 2: Switching set constraints

Box	*General CMAF header constraints in a CMAF switching set*
ftyp	Shall be identical except for media profile brands (see 1 in 7.3.4.1)
mvhd	Shall be identical except for creation_time, and modification_time
tkhd	Shall be identical except for width, height, creation_time, and modification_time. See NOTE 1.
trex	identical
elst	Shall be identical except for video CMAF track files with a different composition offset
mdhd	Shall be identical except for creation_time, and modification_time
mehd	Global overview, targets duplicate presentations
meta	May contain different boxes and data
udta	May contain different boxes and data

cprt	identical
kind	identical
elng	identical
hdlr	identical
vmhd	identical
smhd	identical
sthd	identical
dref	identical
stsd	Sample entries shall have the same codingname (four-character code)

NOTE 1: Track width and height can differ, but picture aspect ratio is the same for all CMAF tracks. NOTE 2: Sample entry constraints for CMAF switching sets are defined by each CMAF media profile

For additional signalling of CMAF tracks belonging to the same switching set, the ingest source MAY set the alternate_group value in the TrackHeaderBox tkhd to a value that is the same for tracks belonging to the same switching set. This allows explicit signalling of tracks that do apply to switchingset constraints but do not belong to the same switching set. Alternatively one could signal switching explicitly by means outside of this specification.

6.5. Requirements for Timed Text, Captions and Subtitle Streams§

The live media ingest specification follows requirements for ingesting a track with timed text, captions and/or subtitle streams. The recommendations for formatting subtitle and timed text track are defined in [MPEGCMAF] and [MPEG 4-30] and are re-iterated here for convenience to the reader. Note that the text in [MPEGCMAF] prevails the text below when different except for the notion of 9, 10 and 11.

1. The track SHOULD be a sparse track signalled by a null media header nmhd containing the timed text, images, captions corresponding to the recommendation of storing tracks in CMAF [MPEGCMAF], or a sthd for an ISOBMFF subtitle track (e.g. TTML)
2. Based on this recommendation, the trackhandler "hdlr" SHALL be set to "text" for WebVTT and "subt" for TTML following [MPEG4-30]
3. In case TTML is used the track MUST use the XMLSampleEntry to signal sample description of the sub-title stream [MPEG4-30]
4. In case WebVTT is used the track must use the WVTTSampleEntry to signal sample description of the text stream [MPEG4-30]
5. These boxes SHOULD signal the mime type and specifics as described in [MPEGCMAF] sections 11.3 ,11.4 and 11.5
6. The boxes described in 2-4 must be present in the init fragment (ftyp + moov) or cmaf header for the given track
7. subtitles in CTA-608 and CTA-708 format SHOULD be conveyed following the recommendation section 11.5 in [MPEGCMAF] via Supplemental Enhancement Information SEI messages in the video track [MPEGCMAF]
8. The ftyp box in the CMAF Header for the track containing timed text, images, captions and sub-titles MAY use signalling using CMAF profiles based on [MPEGCMAF]

   8a. WebVTT Specified in 11.2 ISO/IEC 14496-30 [MPEG4-30] *cwt*

   8b.TTML IMSC1 Text Specified in 11.3.3 [MPEG4-30] IMSC1 Text Profile *im1t*

   8c.TTML IMSC1 Image Specified in 11.3.4 [MPEG4-30] IMSC1 Image Profile *im1i*

9. The BitRateBox btrt SHOULD be used to signal the average and maximum bitrate in the sample entry box, this is most relevant for bitmap or xml based timed text subtitles that may consume significant bandwidths (e.g. im1i)
10. In case the language of a track changes, a new init fragment or CMAF Header with updated mdhd and/or elng SHOULD be send from the ingest source to the media processing entity.
11. Track roles can be signalled in the ingest, by using a kind box in udta box. The kind box MUST contain a schemeIdUri MPEG urn:mpeg:dash:role:2011 and a value containing a Role as defined in [MPEGDASH]

> Note: [MPEGCMAF] allows multiple kind boxes, hence multiple roles can be signalled. By default one should signal the DASH role urn:mpeg:dash:role:2011. A receiver can derive corresponding configuration for other streaming protocols such as HLS [RFC8216]. In case this is not desired, additional kind boxes with corresponding schemeIdUri and values can be used to explicitly signal this kind of information. Subschemes can be signalled in the schemeIdURI as schemeIdURI@value.

An informative scheme of defined roles in MPEG DASH and respective corresponding roles in HLS [RFC8216] can be found below, additionally the forced subtitle in HLS might be derived from a DASH forced subtitle role

Table 3: Roles for subtitle and Audio tracks and HLS Characteristics

Characteristic [RFC8216]	*urn:mpeg:dash:role:2011*
transcribes-spoken-dialog	subtitle
easy-to-read	easyreader
descripes-video	description
descripes-music-and-sound	caption

MPEG DASH roles are defined in urn:mpeg:dash:role:2011 [MPEGDASH]. Additionally another example for explicitly signalling roles could b e DVB DASH [DVB-DASH]. One could use schemeiduri@value and role as defined there. e.g. kind.schemeIdUri="urn:tva:metadata:cs:AudioPurposeCS:2007@1 kind.value=Alternate

6.6. Requirements for Timed Metadata§

This section discusses the specific formatting requirements for CMAF Ingest of timed metadata related to events and markers for ad insertion or other timed metadata. An example of these are opportunities for splice points and program information signalled by SCTE-35 markers. This type of event signalling is different from regular audio/video information because of its sparse nature. In this case, the signalling data usually does not happen continuously, and the intervals can be hard to predict.

Examples of timed metadata are ID3 tags [ID3v2], SCTE-35 markers [SCTE35] and DASH emsg messages defined in section 5.10.3.3 of [MPEGDASH]. In addition, any other metadata can be signalled in this scheme by providing a URI to identify the scheme, and the metadata embedded as samples in mdat.

Table 4 provides some example urn schemes to be signalled i Table 5 illustrates an example of a SCTE-35 marker stored in a DASH emsg, that is stored as a metadata sample.

The presented approach enables ingest of timed metadata from different sources, possibly on different locations by embedding them in sparse metadata tracks. In this approach metadata are not interleaved with the media as for example the case in emsg boxes in [MPEGCMAF].

Example metadata messages include inband event message box as used in [MPEGDASH], [DVB-DASH], or alternatively direct embedding of [SCTE35] or [ID3v2] which might in some cases be used.

For Example, by embedding the emsg structure in samples the benefits of its usages in DASH and CMAF are kept.

In this case the URIMetasample entry will be mpeg:dash:event:2012, while the SchemeIdUri could be used to signal schemes of the messageData payload in the EventMessage.

Table 4: Example URN schemes for timed metadata tracks

SchemeIdURI	*Reference*
urn:mpeg:dash:event:2012	[MPEGDASH], 5.10.4 subtitle
urn:dvb:iptv:cpm:2014	[DVB-DASH], 9.1.2.1
urn:scte:scte35:2013:bin	[SCTE214-1]] SCTE-35
www.nielsen.com:id3:v1	Nielsen ID3 in MPEG-DASH [ID3v2]

Table 5: Example of a SCTE-35 marker embedded in a DASH eventmessagebox

Tag	*Value*
scheme_uri_id	urn:scte:scte35:2013:bin
Value	value used to signal subscheme
Timescale	positive number, ticks per second, similar to track timescale
presentation_time_delta	non-negative number, splice time compared to tfdt
event_duration	duration of event "0xFFFFFFFF" if unknown
id	unique identifier for message
message_data	splice info section including CRC

Alternatively, a version 1 of the eventmessagebox with absolute timing could be used, where the presentation time is added as a 64 bit integer. In this case care must be taken not to signal events in the past or or far in the future.

The active media processing entity can insert metadata in any of the switching sets, embedded as DashEventMesageBoxes. The metadata is assumed to relate to the media presentation (e.g. program information, splice information , chapter information) and not to a specific track. For track specific metadata other structures like the CMAF header can be used. Configuration of the Receiving entity on how to handle the metadata is out of scope of current document. More information about this will be given in supplementatal documents on implementation guidelines and best practices, that specify some recommended practices and example implmeentation. For example, a default behavior could be to embed the metadata events as eventmessages in each audio track in the switching sets for delivery.

The following steps are recommended for timed metadata ingest related to events, tags, ad markers and program information:

1. Metadata SHALL be conveyed in a CMAF track, where the media handler (hdlr) is "meta", the track handler box is a null media header box nmhd.
2. The metadata track applies to the media streams ingested to a Publishing point entry at the media processing entity or origin server
3. The URIMetaSampleEntry entry SHALL contain, in a URIbox, the URI following the URI syntax in [RFC3986] defining the form of the metadata (see the ISO Base media file format specification [ISOBMFF]).
4. The URIMetaSampleEntry MAY contain the urn urn:mpeg:dash:event:2012 or an equivalent urn to signal the presence of event message boxes

5. The timescale of the metadata SHOULD match the value specified in the media header box "mdhd" of the metadata track.
6. The Event Received Time is signalled in the "tfdt" box of the track fragment as the basemediadecode time, this is the time when the metadata will be first received.
7. The Event Presentation Time can be signalled as a difference to the Event Received Time by an empty sample with duration delta, the application time is the time when the metadata or event is applied. It is equal to the media presentation time of the sample containing the event/metadata. In such as sparse fragment contains 3 samples, and empty sample to signal the difference, a sample that contains the Data, and an optional empty sample to fill the timeline
8. The duration of the sample SHOULD correspond to the duration of the metadata if the metadata is valid for a duration of time (if applicable), however, sometimes this is not the case and alternative durations can be used.
9. Empty samples, and fragments with empty samples SHOULD be used to fill the timeline to avoid timeline gaps or 32 bit duration overflow for large timescales
10. All Timed Metadata samples SHOULD be sync samples [ISOBMFF], defining the entire set of metadata for the time interval they cover. Hence, the sync sample table box SHOULD not be present.
11. The payload is conveyed in the mdat box as sample information.
12. In some cases, the duration of the metadata may not be known, in this case the sample duration could be set to zero and updated later when the timestamp of the next metadata fragment is received.
13. The Ingest source SHOULD not embed inband event message boxes emsg in the ingest stream

> Note: [MPEGCMAF] has the notion of an inband event message box to convey metadata and event messages. In the current specification a separate track is used instead to convey such information. Advantages include avoiding sending duplicate information in multiple tracks, and avoiding a strong dependency between media and metadata by interleaving them. The Ingest source SHOULD NOT send inband emsg box and the receiver SHOULD ignore it. However, event message box can be embedded as samples in the timed metadata track.

6.7. Requirements for Media Processing Entity Failover and Connection Error Handling§

Given the nature of live streaming, good failover support is critical for ensuring the availability of the service. Typically, media services are designed to handle various types of failures, including network errors, server errors, and storage issues. When used in conjunction with proper failover logic from the ingest sources side, highly reliable live streaming setups can be build. In this section, we discuss requirements for failover scenarios. The following steps are required for an Ingest source to deal with a failing media processing entity.

The CMAF ingest source should implement the following recommendations to achieve failover support.

1. The Ingest source MUST use a timeout in order of segment duration (1-6 seconds) for establishing the TCP connection. If an attempt to establish the connection takes longer than the timeout, abort the operation and try again.
2. The Ingest source SHOULD resend media fragments for which a connection was terminated early, if the connection was down for less than 3 average segments durations. For connections that were down longer, ingest can resume at the live edge of the live media presentation instead.
3. The Ingest source SHOULD NOT limit the number of retries to establish a connection or resume streaming after a TCP error occurs.
4. After a TCP error: a. The current connection MUST be closed, and a new connection MUST be created for a new HTTP POST request. b. The new HTTP POST URL MUST be the same as the initial POST URL for the fragment to be ingested. c. The new HTTP POST MUST include stream headers (ftyp, and moov boxes) identical to the stream headers.
5. In case the Receiving entity cannot process the POST request due to authentication or permission problems then it SHALL return a permission denied HTTP 403

6. In case the media processing entity can process the request it SHALL return an HTTP 200 OK or 202 Accepted
7. In case the media processing entity can process the fragment in the POST request body but finds the media type cannot be supported it SHOULD return an HTTP 415 unsupported media type
8. In case an unknown error happened during the processing of the HTTP POST request a HTTP 400 Bad request SHALL be returned by the media processing entity
9. In case the media processing entity cannot process a fragment posted due to missing or incorrect init fragment, an HTTP 412 unfulfilled condition SHALL be returned
10. In case an ingest source receives an HTTP 412 response, it SHALL resend ftyp and moov boxes, or the CMAF Header.

6.8. Requirements for Live Media Source Failover§

Live encoder or Ingest source failover is the second type of failover scenario that needs to be supported for end-to-end live streaming delivery. In this scenario, the error condition occurs on the Ingest source side. The following expectations apply to the live ingestion endpoint when encoder failover happens:

1. A new Ingest source instance SHOULD be instantiated to continue the ingest
2. The Ingest source MUST use the same URL for HTTP POST requests as the failed instance.
3. The new Ingest source POST request MUST include the same CMAF Header or init fragment as the failed instance
4. The Ingest source MUST be properly synced with all other running ingest sources for the same live presentation to generate synced audio/video samples with aligned fragment boundaries. This implies that UTC timestamps for fragments in the "tfdt" match between decoders, and encoders. In addition, fragment boundaries need to be appropriately synchronized.
5. The new stream MUST be semantically equivalent with the previous stream, and interchangeable at the header and media fragment levels.
6. The new instance of Ingest source SHOULD try to minimize data loss. The basemediadecodetime tfdt of media fragments SHOULD increase from the point where the encoder last stopped. The basemediadecodetime in the tfdt box SHOULD increase in a continuous manner, but it is permissible to introduce a discontinuity, if necessary. Media processing entities can ignore fragments that it has already received and processed, so it is better to error on the side of resending fragments than to introduce discontinuities in the media timeline.

7. Ingest Interface 2: DASH and HLS Ingest Protocol Behavior§

Interface 2 defines the protocol specific behavior required to ingest a Streaming presentation composed of Manifest objects and Media objects to receiving entities that provide either pass-through functionality or limited processing of the content. In this mode, the Ingest source prepares and delivers to the receiving entity all the Objects intended for consumption by a client. These are complete Streaming presentation including all manifest and media objects.

This interface is intended to be used by workflows which do not require active media processing post encoding. It leverages the fact that many encoders provide HLS and DASH packaging capabilities and that the resulting packaged content can easily be transferred via HTTP to standard web servers. However, neither HLS nor DASH has specified how such a workflow is intended to work leaving the industry to self specify key decisions such as how to secure and authenticate ingest sources, who is responsible for managing the content life cycle, the order of operations, failover, robustness, etc. In most cases a working solution can be had using a readily available web server such as Nginx or Varnish and the standard compliment of HTTP Methods. In many cases Interface 2 simply documents what is considered industry best practice while attempting to provide guidance to areas less common.

The requirements below encapsulate all needed functionality to support Interface 2. The requirements listed for Interface 1 (CMAF Ingest) in section §6.2 General Protocol Requirements do not apply to Interface 2. General shared requirements are covered in section §5 General Ingest Protocol Behavior. In case [!MPEGCMAF] media is used, the

media track and segment formatting will be similar as defined in Interface 1.

7.1. General requirements§

7.1.1. Industry Compliance§

1. The Ingest source MUST be able to create a compliant Streaming presentation for MPEG-DASH [MPEGDASH] and/or HTTP live Streaming [RFC8216]. The Ingest Source MAY create both MPEG-DASH and HLS Streaming Presentations using common Media Objects (e.g., CMAF), but the Ingest Source MUST generate format specific Manifest Objects which describe the common Media Objects.
2. The Ingest source MUST support the configuration and use of Fully Qualified Domain Names (per RFC8499) to identify the Receiving entity.
3. The Ingest source MUST support the configuration of the path which it will POST or PUT all the Objects to.
4. The Ingest source SHOULD support the configuration of the delivery path which clients will use to retrieve the content. When provided, the Ingest source MUST use this path to build absolute URLs in the Manifest Files it generates. When absent, relative pathing is assumed and the Ingest Source MUST build the Manifest Files accordingly.

These capabilities are further illustrated in the Examples sections, and may be defined outside the scope of this specification.

7.1.2. HTTP connections§

1. The Ingest Source MUST transfer Manifest objects and Media objects to the Receiving entity via individual HTTP 1.1 [RFC7235] PUT or POST operations to the configured path. This specification does not imply any functional differentiation between a PUT or a POST operation. Either may be used to transfer content to the Receiving entity. Unless indicated otherwise, the use of the term POST can be interpreted as PUT or POST.
2. The Ingest Source SHOULD remove Media objects from the Receiving entity which are no longer referenced in the corresponding Manifest objects via an HTTP DELETE operation. How long the Ingest Source waits to remove unreferenced content SHOULD be configurable. Upon receipt of a DELETE request, the Receiving entity should:

   2a. delete the referenced content and return a 200 OK HTTP Response code

   2b. delete the corresponding folder if the last file in the folder is deleted and it is not a root folder but not necessarily recursively deleting empty folders.
3. To avoid delay associated with the TCP handshake, the Ingest Source SHOULD use Persistent TCP connections.
4. To avoid head of line blocking, the Ingest Source SHOULD use Multiple Parallel TCP connections to transfer the streaming presentation that it is generating. For example, the Ingest Source POSTs each bit rate in a Media Presentation over a different TCP Session.

7.1.3. Unique segment and manifest naming§

1. The Ingest Source MUST ensure all Media objects (video segments, audio segments, init segments and caption segments) have unique paths. This uniqueness applies across all ingested content in previous sessions, as well as the current session. This requirement ensures previously cached content (i.e., by a CDN) is not inadvertently served instead of newer content of the same name.
2. The Ingest Source MUST ensure all objects in a Live stream event are contained within the configured path. Should the Receiving entity receive Media Objects outside of the allowed path, it SHOULD return an HTTP 403 Forbidden response.

3. For each live stream event, the Ingest Source MUST provide unique paths for the Manifest objects. One suggested method of achieving this is to introduce a timestamp of the start of the live stream event in to the manifest path. An event is defined by the explicit start and stop of the encoding process.
4. When receiving objects with the same path as an existing object, the Receiving entity MUST over-write the existing objects with the newer objects of the same path.
5. The Ingest Source MUST include a number which is monotonically increasing with each new Media Object at the end of Media objects name. It MUST be possible to retrieve this numeric suffix via a regular expression. A common method is to use the time at which the Media Segment was created divided by the Media object duration. Note: to be further discussed
6. The Ingest Source MUST identify Media objects containing initialization fragments by using the .init file extension
7. The Ingest source MUST include a file extension and a MIME-type for all media objects. The following file extensions and mime-types are the ONLY permissible combinations to be used:

Table 6 outlines the formats that media and manifest objects are expected to follow based on their file extension. Segments may be formatted as MPEG-4 [ISOBMFF] .mp4, .m4v, m4a, CMAF [MPEGCMAF] .cmf[v.a.m.t], or [!MPEG2TS]] .ts (HLS only). Manifests may be formatted as [MPEGDASH] .mpd or HLS [RFC8216] .m3u8.

> NOTE: using MPEG-2 TS will break consistency with interface 1 which uses CMAF container format structure

Table 6:

File Extension	*Mime Type*
.m3u8	*application/x-mpegURL or vnd.apple.mpegURL*
.mpd	*application/x-mpegURL*
.cmfv	*video/mp4*
.cmfa	*audio/mp4*
application/mp4	
.cmfm	*application/mp4*
.mp4	*video/mp4 or application/mp4*
.m4v	*video/mp4*
.m4a	*audio/mp4*
.m4s	*video/iso.segment*
.init	*video/mp4*
.header	*video/mp4*
.key	*to be defined*

7.1.4. DNS lookups§

DNS lookup requirements are defined in the general protocol requirements section §5 General Ingest Protocol Behavior.

7.1.5. Ingest source identification§

1. The Ingest source MUST include a User-Agent header (which provides information about brand name, version number, and build number in a readable format) in all allowed HTTP messages. The Receiving entity MUST log the received User-Agent, along with other relevant HTTP Header data to facilitate troubleshooting.

7.1.6. Common Failure behaviors§

The following items define the behavior of an ingest source when encountering certain conditions.

1. When the ingest source receives a TCP connection attempt timeout, abort midstream, response timeout, TCP send/receive timeout or 5xx response when attempting to POST content to the Receiving entity, it MUST

   1a. For manifest objects: re-resolve DNS on each retry (per the DNS TTL) and retry indefinitely.

   1b. For media objects: re-resolve DNS on each retry (per the DNS TTL) and continue uploading for n seconds, where n is the segment duration. After it reaches the media object duration value, drop the current data and continue with the next media object, updating the manifest object with a discontinuity marker appropriate for the protocol format at hand. To maintain continuity of the time-line, the ingest source SHOULD continue to upload the missing media object with a lower priority. Once a media object is successfully uploaded, the ingest source SHOULD update the corresponding manifest object to reflect the now available media object. Note that many HLS clients do not like changes to manifest files, such as removing a previously present discontinuity, so care should be taken in choosing to make such updates.
2. Upon receipt of an HTTP 403 or 400 error, for all objects (manifest and non-manifest), the ingest source MUST not retry and stop attempting to ingesting objects and provide a log or fatal error condition.

7.2. HLS specific requirements§

7.2.1. File extensions and mime-types§

When ingesting prepared HLS content, the Ingest Source MUST:

1. use a .m3u8 file extension for parent and child playlists.
2. use a .key file extension for any keyfiles posted to the receiving entity for client delivery.
3. use a ".ts" file extension for segments encapsulated in a Transport Stream File Format.
4. use one of the allowed file extensions (per the table above) appropriate for the mime-type of the content encapsulated using [MPEGCMAF], it MUST NOT use a ".ts" file extension.

7.2.2. Upload order§

In accordance with the HTTP live Streaming [RFC8216] recommendation, ingest sources MUST upload all required files for a specific bitrate and segment before proceeding to the next segment. For example, for a bitrate that has segments and a playlist that updates every segment and key files, ingest sources upload the segment file followed by a key file (optional) and the playlist file in serial fashion. The encoder MUST only move to the next segment after the previous segment has been successfully uploaded or after the segment duration time has elapsed. The order of operation should be:

1. Upload media segment,
2. Optionally upload key file, if required,
3. Upload the .m3u8.

If there is a problem with any of the Steps, retry them. Do not proceed to Step 3 until Step 1 succeeds or times out as described in common failure behaviors above. Failed uploads MUST result in a stream manifest Discontinuity per [R

FC8216].

7.2.3. Encryption§

1. The ingest source MAY choose to encrypt the media segments and publish the corresponding keyfile to the Receiving entity.

7.2.4. Relative paths§

1. The ingest source SHOULD use Relative URL paths to address each segment within the stream level manifest.

7.2.5. Resiliency§

1. When ingesting media objects to multiple receiving entities, the ingest source MUST send identical media objects with identical names
2. To allow resumption of failed sessions and to avoid reuse of previously cached content, the ingest source MUST NOT restart object names or use previously used object names.
3. When multiple ingest sources are used, they MUST use consistent media object names including when reconnecting due to any application or transport error. A common approach is to use (epoch time)/(segment duration) as the object name.

7.3. DASH specific requirements§

7.3.1. File extensions and mime-types§

When ingesting prepared DASH content, the Ingest Source MUST:

1. use a ".mpd" file extension for manifest objects.
2. use one of the allowed file extensions (see table above) for Media objects. It MUST NOT use a ".ts" file extension.

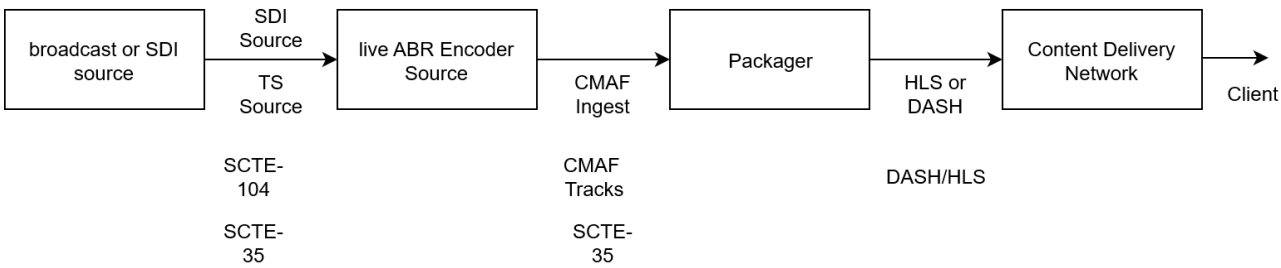
7.3.2. Relative paths§

1. The ingest source SHOULD use Relative URL paths to address each segment within the manifest object.

8. Illustrative Example of using CMAF and DASH ingest specification§

In this section we provide some example deployments for live streaming, mapping to the architecture defined in DASH-IF live Task Force. Diagram 9 shows an example where a separate packager and origin server are used.

Diagram 9: Example setup schema with CMAF ingest and DASH/HLS ingest



The broadcast source is used as input to the live ABR encoder. The broadcast sources can be original SDI signals from a broadcast facility or TS streams intercepted from a broadcast that need to be re-used in an OTT distribution workflow. The live ABR encoder source performs the ABR encoding of the tracks into CMAF tracks and functions as the ingest source in the CMAF ingest interface. Multiple live ABR encoder sources can be used, providing redundant inputs to the packager, which is the media processing entity consuming the CMAF ingest. The packager is receiving the different CMAF tracks. The ingest follows the CMAF Ingest specification in this document, allowing for failover, redundancy and many of the other features related to the content tracks. The live encoder source performs the following tasks:

- It demuxes and receives the MPEG-2 transport stream and/or HD SDI signal
- It formats the metadata in these streams such as SCTE-35 or SCTE 104 to timed metadata tracks
- It performs a high quality ABR encoding in different bit-rates with aligned switching points
- It packages all media and timed text tracks as CMAF compliant tracks and signals track roles in kind boxes
- It POSTs the addressable media objects composing the tracks to the live packager according to the CMAF ingest specification interface defined in this document.
- The CMAF ingest allows multiple live encoder sources and packagers to be deployed benefiting from redundant stream creation, avoiding timeline discontinuities due to failures as much as possible.
- In case the receiver fails, it will reconnect and resend as defined in the section on failover once it reconnects
- In case the live encoder source fails it will restart and perform the steps as detailed in the section on failover

The live encoder source can be deployed in the cloud or on a bare metal server or even as a dedicated hardware. The live encoder source may have some tools or configuration API's to author the CMAF tracks and feed instruction/properties from the original SDI or broadcast into the CMAF tracks. The packager receives the ingested streams, and performs the following tasks.

- It receives the CMAF tracks, grouping switching sets based on switching set constraints
- When packaging to MPEG DASH, an adaptationset is created for each switchingset ingested
- The near constant fragment duration is used to generate segmenttemplate based presentation using either $Number$ or $Time$
- In case changes happen, the packager can update the manifest and embed inband events to trigger manifest updates in the fragments
- The DASH Packager encrypts media segments according to key information available. This key information is typically exchanged by protocol defined in Content Protection Interchange Format (CPIX) this allows configuration of the content keys, initialization vectors and embedding encryption information in the manifest
- The DASH packager signals subtitles in the manifest based on received CMAF streams and roles signalled in kind box
- In case a fragment is missing and SegmentTimeline is used, the packager may signal a discontinuity in the Manifest presentation description
- In case a low latency mode is used, the packager may make output available before the entire fragment is received in the chunked transfer encoding
- The packager may also have a proprietary API similar to the live source, for configuration of aspects like the segmentTimeBuffer, DVR window, encryption modes enabled etc.
- The packager uses a DASH or HLS ingest to push content to an origin server of content delivery network. Alternatively, it could also make content directly available as DASH or HLS as an origin server. In this case DASH/HLS ingest is avoided, and the packager also serves as the origin server.
- The packager converts the timed metadata track and uses it to convert to either MPD Events or inband events signalled in the manifest.
- The packager may also generate HLS or other streaming media presentations based on the input.

- In case the packager crashes or fails, it will restart itself and wait for the ingest source to perform the actions as detailed in the section on failover

The content delivery network (CDN) consumes a DASH/HLS ingest, or serves as a proxy for content delivered to a client. The CDN, in case it is consuming the POST based DASH/HLS ingest performs the following tasks

- it stores all posted content and makes them available for HTTP GET requests from locations corresponding to the paths signalled in the manifest
- it occasionally deletes content based on instructions from the ingest source, in this setup the packager
- in case low latency mode is used, content could be made available before the entire pieces of content are available
- It updates the manifest accordingly when a manifest update is received
- It serves as a cache proxy for HTTP get requests forwarded to the packager

In case the CDN serves as a proxy, it only forwards requests for content to the packager to receive the content,and caches relevant segments for a duration N until it expires.

The client receives DASH or HLS streams, and is not affected by the specification of this work. Nevertheless, it is expected that by using a common media application format, less caching and less overhead in the network will result in a better user experience. The client still needs to retrieve license and key information by steps defined outside of this specification. Information on how to retrieve this information will typically be signalled in the manifest prepared by the packager.

This example aims to illustrate how the specification defined in this document can be used to provide a live streaming presentation to clients, this example does not preclude other ways of using the specification and protocols defined in this document.

A second example can be seen in Diagram 10. It constitutes the reference workflow for chunked DASH CMAF under development by DASH-IF and DVB. In this workflow a contribution encoder produces an RTP mezzanine stream that is transmitted to FFMPEG, an open source encoder/packager running on a server. Alternatively, a file resource may be used. In this workflow FFMPEG functions as the ingest source. FFMPEG produces the ingest stream with different ABR encoded CMAF tracks. In addition, it also sends a manifest that complies with DASH-IF and DVB low latency CMAF specification and MPD updates. The CMAF tracks also contain respective timing information (prft etc.). In this case the ingest source implements interface 2 DASH ingest. But as in this case the DASH presentation uses CMAF, the media and track constraints of interface 1 are also satisfied. By also resending CMAF Headers in case of failures both interfaces may be satisfied.

The origin server is used to pass the streams to the client, and may in some cases also perform a re-encryption or re-packaging of the streaming presentation as needed by the client (in case encryption is needed for example). The target client is DASH.js and an end-to-end latency of maximum 3500 ms is targeted.

This example DASH reference workflow uses DASH Ingest that does not employ encryption and timed metadata and uses CMAF formatting. This exploits the synergies between the two interfaces defined in this document hence the ingest between FFMPEG and the origin server may implement both interfaces simultaneously.

To receive the stream as a CMAF ingest for re-packaging at the origin the following steps can be applied. This is the case where interface 1 and interface 2 are used interchangeably, hence the live encoder can either ingest to an origin that supports interface 2 with CMAF formatting, including the requirements from interface 1.

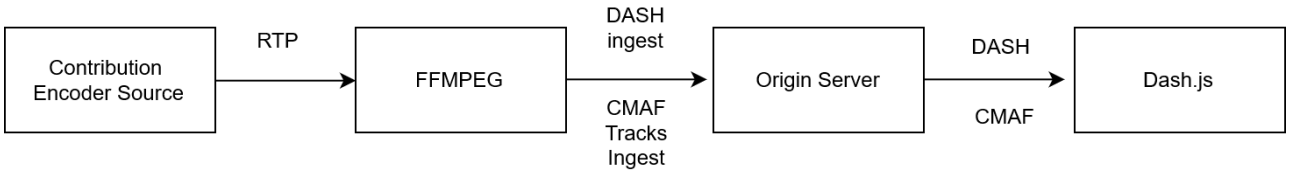
1. Ignore the DASH Manifest
2. Ignore the segment names, only look at the relative path to identify the stream names
3. Ignore the HTTP Delete commands

The approaches for authentication and DNS resolution are similar for the two profiles/interfaces, as are the track formatting in case CMAF based media are used. This example does not use timed metadata. The ingest source

may resend the CMAF header or init fragment in case of connection failures to conform to the CMAF ingest specification. The origin server can then be used to repackage or re-encrypt the streams.

To receive the stream as a DASH Ingest in this workflow, the steps described in DASH Ingest may be applied.

Diagram 10: DASH-IF Reference DASH-IF Live Chunked CMAF Production Workflow



9. IANA Considerations§

This memo includes no request to IANA.

10. Acknowledgements§

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11. References§

11.1. URL References§

fmp4git Unified Streaming github fmp4 ingest, "https://github.com/unifiedstreaming/fmp4-ingest".

MozillaTLS Mozilla Wikie Security/Server Side TLS https://wiki.mozilla.org/Security/Server_Side_TLS #Intermediate_compatibility_.28default.29 (last acessed 30th of March 2018)

MS-SSTR Smooth streaming protocol https://msdn.microsoft.com/en-us/library/ff469518.aspx last updated March 16 2018 (last acessed June 11 2018)

Conformance§

Conformance requirements are expressed with a combination of descriptive assertions and RFC 2119 terminology. The key words “MUST”, “MUST NOT”, “REQUIRED”, “SHALL”, “SHALL NOT”, “SHOULD”, “SHOULD NOT”, “RECOMMENDED”, “MAY”, and “OPTIONAL” in the normative parts of this document are to be interpreted as described in RFC 2119. However, for readability, these words do not appear in all uppercase letters in this specification.

All of the text of this specification is normative except sections explicitly marked as non-normative, examples, and notes. [RFC2119]

Examples in this specification are introduced with the words “for example” or are set apart from the normative text with `class="example"`, like this:

> EXAMPLE 1
> This is an example of an informative example.

Informative notes begin with the word “Note” and are set apart from the normative text with `class="note"`, like this:

> Note, this is an informative note.

Index§

Terms defined by this specification§

Objects

OTT

POST_URL

Publishing point

Receiving entity

RTP

Streaming presentation

Switching set

TCP

tfdt

References§

Normative References§

[DVB-DASH]
ETSI TS 103 285 V1.2.1 (2018-03): Digital Video Broadcasting (DVB); MPEG-DASH Profile for Transport of ISO BMFF Based DVB Services over IP Based Networks. March 2018. Published. URL: http://www.etsi.org/deliver/etsi_ts/103200_103299/103285/01.02.01_60/ts_103285v010201p.pdf

[ID3v2]
ID3 tag version 2.4.0 - Main Structure. URL: http://id3.org/id3v2.4.0-structure

[ISO-639-2]
ISO/TC 37/SC 2. Codes for the representation of names of languages -- Part 2: Alpha-3 code. 1998. International Standard. URL: https://www.iso.org/standard/4767.html

[ISOBMFF]
Information technology — Coding of audio-visual objects — Part 12: ISO Base Media File Format. December 2015. International Standard. URL: http://standards.iso.org/ittf/PubliclyAvailableStandards/c068960_ISO_IEC_14496-12_2015.zip

[MPEG2TS]
Information technology -- Generic coding of moving pictures and associated audio information -- Part 1: Systems. March 2018. Published. URL: https://www.iso.org/standard/74427.html

[MPEG4-30]
Information technology -- Coding of audio-visual objects -- Part 30: Timed text and other visual overlays in ISO base media file format. November 2018. Published. URL: https://www.iso.org/standard/75394.html

[MPEGCMAF]
Information technology -- Multimedia application format (MPEG-A) -- Part 19: Common media application format (CMAF) for segmented media. January 2018. Published. URL: https://www.iso.org/standard/71975.html

[MPEGDASH]
Information technology -- Dynamic adaptive streaming over HTTP (DASH) -- Part 1: Media presentation description and segment formats. May 2014. Published. URL: https://www.iso.org/standard/65274.html

[MPEGHEVC]
Information technology -- High efficiency coding and media delivery in heterogeneous environments -- Part 2: High efficiency video coding. October 2017. Published. URL: https://www.iso.org/standard/69668.html

[RFC1035]
P.V. Mockapetris. Domain names - implementation and specification. November 1987. Internet Standard. URL: https://tools.ietf.org/html/rfc1035

[RFC2119]
S. Bradner. Key words for use in RFCs to Indicate Requirement Levels. March 1997. Best Current Practice. URL: https://tools.ietf.org/html/rfc2119

[RFC2626]

P. Nesser II. The Internet and the Millennium Problem (Year 2000). June 1999. Informational. URL: https://tools.ietf.org/html/rfc2626

[RFC2818]

E. Rescorla. HTTP Over TLS. May 2000. Informational. URL: https://tools.ietf.org/html/rfc2818

[RFC3986]

T. Berners-Lee; R. Fielding; L. Masinter. Uniform Resource Identifier (URI): Generic Syntax. January 2005. Internet Standard. URL: https://tools.ietf.org/html/rfc3986

[RFC7235]

R. Fielding, Ed.; J. Reschke, Ed.. Hypertext Transfer Protocol (HTTP/1.1): Authentication. June 2014. Proposed Standard. URL: https://tools.ietf.org/html/rfc7235

[RFC7617]

J. Reschke. The 'Basic' HTTP Authentication Scheme. September 2015. Proposed Standard. URL: https://tools.ietf.org/html/rfc7617

[RFC793]

J. Postel. Transmission Control Protocol. September 1981. Internet Standard. URL: https://tools.ietf.org/html/rfc793

[RFC8216]

R. Pantos, Ed.; W. May. HTTP Live Streaming. August 2017. Informational. URL: https://tools.ietf.org/html/rfc8216

[SCTE214-1]

ANSI/SCTE 214-1 2016: MPEG DASH for IP-Based Cable Services Part 1: MPD Constraints and Extensions. 2016. URL: http://scte.org/SCTEDocs/Standards/ANSI_SCTE%2520214-1%25202016.pdf

[SCTE35]

SCTE 35 2019: Digital Program Insertion Cueing Message for Cable;. 2019. URL: https://www.scte.org/SCTEDocs/Standards/SCTE%252035%25202019r1.pdf